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NAVAL AIR MATERIAL CENTER

U. S. NAVAL BASE STATION

PHILADELPHIA, PA.

AERONAUTICAL MATERIALS LABORATORY
REPORT ON

OPERATION CROSSROADS, TARGET AIRPLANE,
MODEL TBM-3E, SERIAL NO. 69169;
TEST OF

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TL-011,012	Aeronautical Materials Laboratory Report on Operation Cross-roads, Target Airplane, Model TBM-3E, Serial No. 69169; Test of---dated 25 Apr 50. AML NAM AE 540001 RE: Naval Air Material Center, Naval Air Experimental Station U.S. Naval Base Station, Philadelphia, Pa.	SECRET

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AM-45-FMH:rmcg
(6667)

NAVAL AIR MATERIAL CENTER
NAVAL AIR EXPERIMENTAL STATION

[redacted]

Philadelphia, Pa.

25 APR 1950

From: Director, Naval Air Experimental Station
To: Chief, Bureau of Aeronautics

Subj: Report No. AML NAM AE 540001; Operation CROSSROADS; Target Airplane, TBM-3E Serial No. 69169; test of

Encl: (1) Twenty-three copies of subject report

1. Enclosure (1) is submitted as the final report of tests conducted on the subject airplane.

2. This report indicates that results of tests of the target airplane fell roughly into four categories: (1) Materials, equipment and structures that showed no change and met specification requirements; (2) components that could not be accurately evaluated due to results of severe and uncontrolled tropical weather exposure; (3) components that could not be accurately evaluated due to damage by blast; and (4) components that could not be tested in any manner due to excessive damage by blast.

3. Section A of the report is a final historical summary by the Naval Air Experimental Health Physics Detail, composed of the Radiological Health Officer, Aeronautical Medical Equipment Laboratory, and the Radiological Safety Engineer, Aeronautical Materials Laboratory, of arrangements made to house the test aircraft and conduct work safely. It contains a pictorial survey of the laboratory and history of the test airplane at the Naval Air Experimental Station.

4. Section B, final report by the Aeronautical Engine Laboratory on the engine and engine accessories, indicates that the few defects noted during inspection and test were definitely attributable to other than radiation effects.

5. Section C contains the report by the Aeronautical Instrument Laboratory. Sixteen instruments were inspected and tested against specifications. Although a number failed in one or more respects to meet optimum operating requirements, the discrepancies noted were in no way attributable to effects of atomic radiation.

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6. Section D is the report by the Aeronautical Materials Laboratory of tests conducted on the materials contained in the aircraft.

(a) The High Polymer Division of the Aeronautical Materials Laboratory reported: Textiles too badly weathered to test; rubber - no excessive damage and that present attributable to weathering; plastics - changes

[redacted] [redacted]

[redacted]

AM-45-FWH:rmcg
(6667)

normal for time of exposure to weather.

(b) The Metallurgical Division of the Aeronautical Materials Laboratory reported: All metal specimens met specifications.

(c) The Mechanical Equipment Division reported: Many equipments so damaged by blast and weathering that operation was impossible; those operable functioned normally.

(d) The Chemical Engineering Division reported: No change in paint properties other than that expected by excessive weathering; hydraulic fluid met specifications, engine lubrication oil met specifications.

7. Section E is the report by the Aeronautical Structures Laboratory of tests conducted on the engine mount, tail section and one wing panel of the aircraft. These tests were, in the main, inconclusive. The engine mount failure was as predicted from studies of the contractor's stress analyses (no comparable test data available); the rudder, after repair, failed normally; the tail section gave indication of normal failure; the wing, after extensive repair, failed at the repair, making the test inconclusive.

8. (a) The TBM-3E airplane tested had suffered some damage by blast, considerable damage by weather, and also some distinct damage by unknown means while unguarded and exposed to extreme tropical weather for about one year at Kwajalein. During this time the airplane remained totally unpreserved, and the non-blast damage to all components has been attributed mainly to this weather exposure. No airplane similar in all respects except exposure to atomic radiation was available for comparative test purposes, making any determination of cause of damage addedly difficult.

(b) It is, therefore, concluded that although damage due to exposure to atomic radiation might possibly have been present, no positive evidence of any materials being substantially altered in either a positive or negative fashion was found.

8. Authorized work on the subject project is complete. The project is considered closed and will be dropped from future progress report listings.

R. E. CLEMENTS
By direction

[redacted]

Q 1711

[redacted]

REPORT NO. AML NAM AE 540001
SECTION A

NAVY DEPARTMENT
BUREAU OF AERONAUTICS

REPORT ON

RADIOLOGICAL HEALTH-PHYSICS DETAIL INCLUDING GENERAL HISTORY OF PROJECT AND TEST AIRPLANE, TBM-3E BUNO 69169

BY

F. W. HEILMAN, JR.

AERONAUTICAL MATERIALS LABORATORY
NAVAL AIR EXPERIMENTAL STATION
NAVAL AIR MATERIAL CENTER PHILADELPHIA

Authorization . . . . BuAer Confidential ltr Aer-AE-45 C08267 of 29 Nov 1946

Approved by . . . . R. E. CLEMENTS, LCDR, USN — Superintendent, Aero. Matls. Lab.

Approved by . . . . R. S. SCOTT, CDR (MC), USN — Superintendent, Aero. Med. Eqpmt. Lab.

DATE ISSUED 1 Apr 1950

[redacted]

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REFERENCES

(a) BuAer Confidential ltr Aer-AE-45 C08267 of 29 Nov 46.
(b) BuAer Confidential ltr Aer-AE-54 011203 of 14 Dec 48.
(c) NAES ltr XG-3 HvR:rrt F41-6 Serial 292.
(d) BuMed Circular ltr 48-10 of 23 Jan 48.
(e) BuAer Confidential ltr Aer-AE-54 04233 of 9 May 49.
(f) NAES Confidential ltr XM-45-FWH:rmcg (5740) of 1 Aug 49.

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[redacted]

ABSTRACT

(a) A general history of the test airplane is outlined from the time of its inclusion as a target article at Operation CROSSROADS to its eventual burial at sea after test at the Naval Air Experimental Station.

(b) The Radiological Health-Physics Detail, Naval Air Experimental Station, reports on the arrangements made to house the airplane, conduct tests, maintain radiological safety and conduct physical examinations. It reports that no injury to personnel was sustained that could be attributed to exposure to radioactivity and that as a result of the strict supervision of mechanical and engineering personnel by the safety group during work on and near the airplane and associated jig work and scaffolding there was no lost-time injury to personnel during more than a year's time.

(c) Photographs of the laboratory and decontamination center are shown, along with views of various workmen and engineers wearing protective clothing and equipment. Photographs of the test airplane chronicling its history at the Naval Air Experimental Station from arrival to burial at sea are also included.

[redacted]

REPORT

I. 1 JULY 1946 TO 29 NOV 1946

(a) Test Able of Operation CROSSROADS occurred on 1 July 1946. During this test, on the hangar deck of the U.S.S. Saratoga, TBM-3E BuNo 69169 was located. At the completion of Able this airplane was relocated to the flight deck of the U.S.S. Independence. Test Baker occurred on 25 July 1946. The airplane and ship were both damaged considerably by the accompanying blast, in addition to being made dangerously radioactive due to both induced radioactivity and contamination by fission products and fissionable material. An attempt was made by Joint Task Force One to decontaminate the Independence and, in so doing, the airplane was sprayed with various materials and solutions including radioactive sea water and foamite.

(b) Upon completion of inspection and radioactive survey by the Ships Survey Group at Bikini, the target fleet including the Independence was towed to Kwajalein and anchored in the lagoon. There the ship and airplane were monitored and studied by Army and Navy Radiological Safety personnel, and also were inspected and visited by Ships Security Detail personnel.

II. 29 NOV 1946 TO 24 OCT 1947

(a) Ref (a) assigned the test of TBM-3E BuNo 69169 to NAES under Project TED NAM AE 450001 (changed to 540001 by ref (b)). Liaison with BuMed personnel at this time revealed that rather unique facilities would be necessary to accomplish such a project with minimum hazard to personnel involved. Assignment of the project to NAES was also meant to provide a basis for a training program for NAES personnel in the technique of handling and working with radioactive materials.

(b) The area assigned NAES in which to conduct this project was Bldg. 518, NAMC, a building that could be made secure and which was, relative to other possibly available areas, removed from main traffic and activities. Bldg. 518 was then being used as a paint-spraying area and had only rudimentary toilet and office facilities. The building was modified by building wooden structures across the two closed sides of the hanger. One structure housed the laundry and tool crib. The other housed, on the first deck, a tiled shower, wash-up and toilet room, a contaminated dressing room, a clean dressing room, and a clean laundry storage room. The second deck, with ventilation from clean outside air, housed the glass-walled office of the radiological detail. This office was in constant communication, either visual or voice, with all areas of the building. The remainder of the second deck space was used as a semi-clean storage area for construction and test material and equipment.

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(c) Marine green clothing, navy underwear, navy field shoes, socks and baseball-type caps were procured in a wide range of sizes along with chippers' eye-cup goggles, approved respirators and other gear such as gloves, soap, towels, etc. Signs were hung in prominent locations giving warning of the hazards involved and directing the workers in soon-memorized procedures.

(d) Thus the decontamination center was furnished to handle the personnel expected to work on the airplane. (See Plates 2 to 11, inclusive.)

(e) The Independence, during this time, had been towed from Kwajalein to San Francisco and was berthed at the San Francisco Naval Shipyard. The airplane was removed, packed in a crate and placed aboard the Hawaiian-American Lines' S.S. Victory for transportation through the Panama Canal to Philadelphia. Ship and plane arrived in Philadelphia on 29 Aug 1947. The crate housing the airplane was moved by barge to NAMC where it was placed in Bldg. 518. Film badges placed on the box by NRDL were removed and returned to NRDL for processing. A subsequent report from NRDL revealed that much less than a tolerable dose was received at the outside surface of the box during transit. After carboxide fumigation of the box on 16 Oct 1947, disassembly started on 18 Oct 1947, at which time the decontamination center was placed in operation.

(f) As each section of the crate was removed, it was monitored, washed off with water from a high pressure fire hose and monitored again. On 24 Oct 1947, the box was considered uncontaminated, completely removed from the hangar, and inspection of the airplane could commence. (See Plates 1, 2, 12 and 13.)

III. <u>25 OCT 1947 TO 31 MAY 1949</u>

(a) During this time the various laboratories of NAES were conducting tests on the airplane. These tests are described in Sections B, C, D and E of the report of which this portion is Section A.

(b) As stated in ref (e), the radiological health and safety detail during this time maintained safe and healthful working conditions in Bldg. 518, and also checked the health of the workers and other exposed personnel regularly. In this period, 485 physical examinations, 596 complete blood counts, 595 blood sedimentation rates, and 642 urinalyses were conducted on a total of 172 men associated with the project and exposed to radiation from the airplane. Cases revealing a disqualifying factor as defined in ref (d) were referred to the Dispensary for treatment or to the U. S. Naval Hospital for consultation and study. Investigation of all questionable cases revealed that no physically disqualifying effects were found that were a result of exposure to atomic radiation.

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(c) It is felt that the fine industrial safety record of this test is largely due to the close supervision and attention to detail by the health-safety personnel aimed at the decrease of primarily radiological hazards. There was not one instance of a lost-time accident in the prosecution of the various tests in Bldg. 518 during this or any other period of the test of the airplane. (See Plates 14 to 18, inclusive.)

IV. 1 JUNE 1949 TO 31 JAN 1950

(a) Ref (e) instructed NAES to dispose of the test airplane and all contaminated material associated therewith at sea. The airplane was placed on skids and then moved from Bldg. 518 to a barge for towing to sea. Ref (f) reported the sinking of the airplane. (See Plates 19 and 20.)

(b) The decontamination center and hangar area were subsequently monitored, washed down and re-monitored. No radiological contamination above normal background was found upon re-monitoring and the building was returned to NAMC use.

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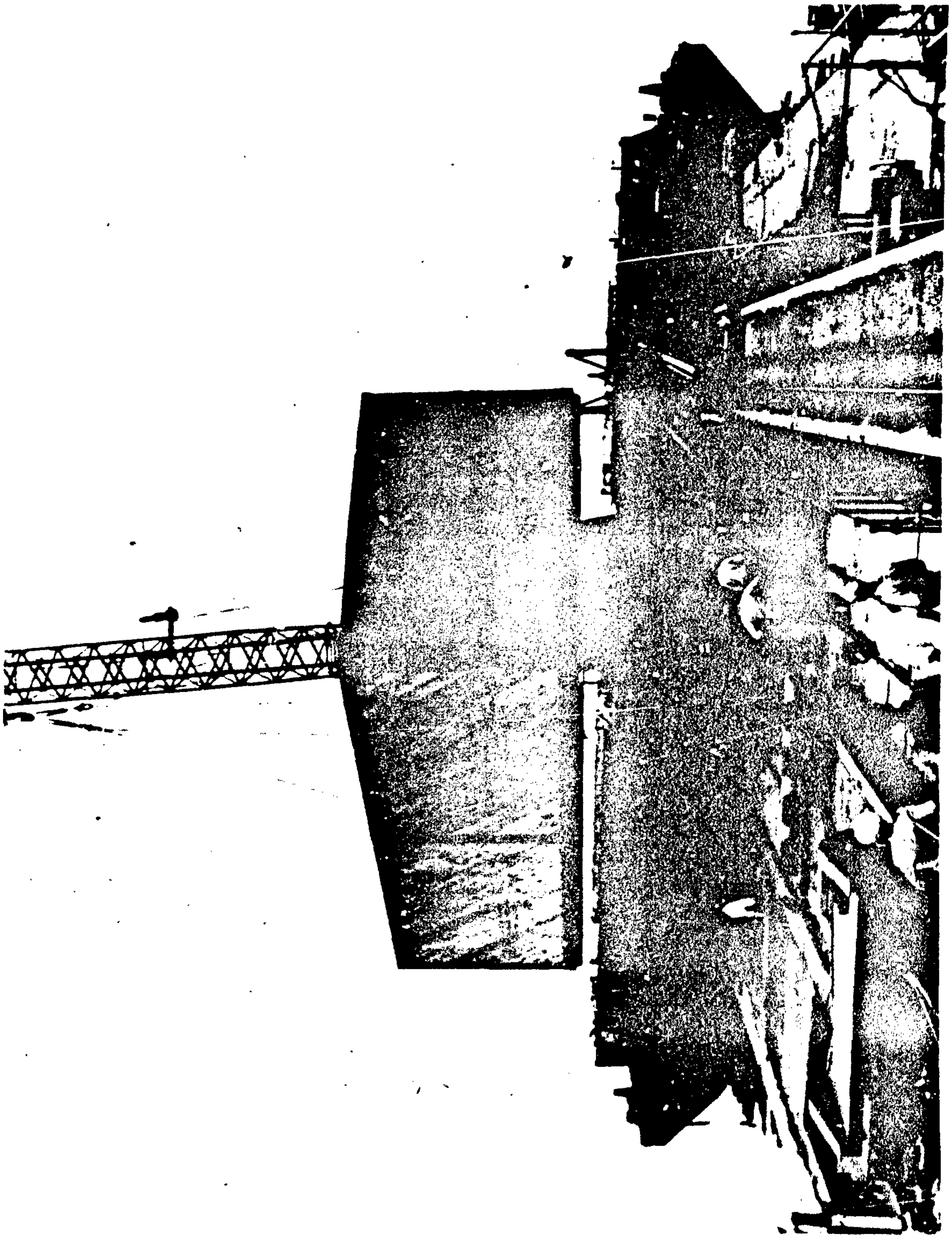

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NP(3)-262385(L)-9-47

CRATE CONTAINING TEST AIRCRAFT, TBM-3E BUNO 69169
ARRIVING AT NAMC

PLATE I

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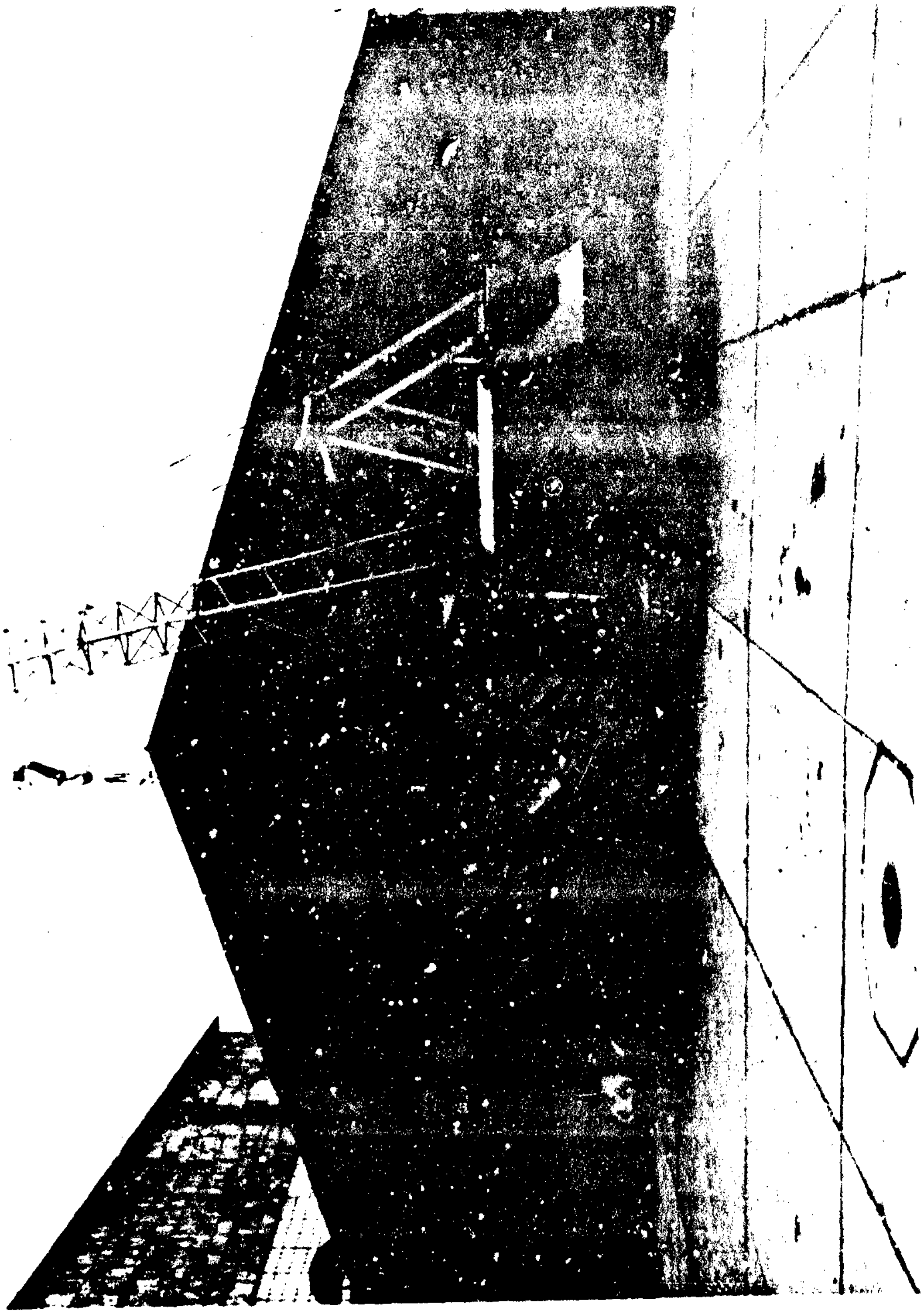

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NP(3)-262386(L)-9-47
CRATE CONTAINING TEST AIRCRAFT, TBM-3E BUNO 69169
BEING MOVED INTO RADIOLOGICAL LABORATORY, BLDG. 518 PLATE

[redacted]

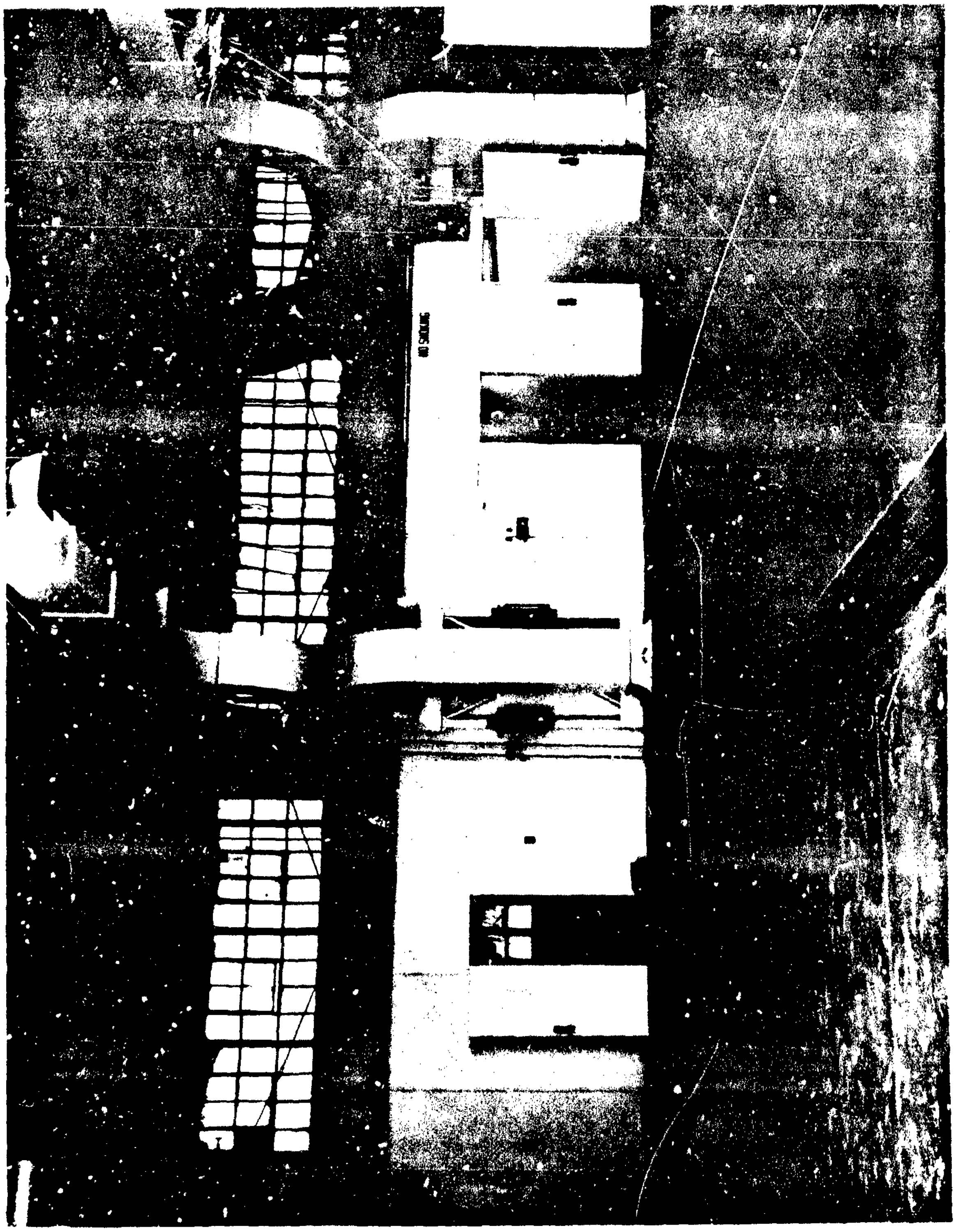
0 '711

NP(3)-252443(L)-9-47

VIEW OF DECONTAMINATION STATION AND OFFICE SPACES
SEEN FROM MAIN HANGAR AREA, BLDG. 518
PRIOR TO ARRIVAL OF TEST AIRPLANE

PLATE 3

[redacted]



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C NP(3)-252444(L)-9-47
VIEW OF LAUNDRY AND TOOL CRIB SEEN FROM MAIN HANGAR AREA, BLDG. 5
PRIOR TO ARRIVAL OF TEST AIRPLANE

PLATE

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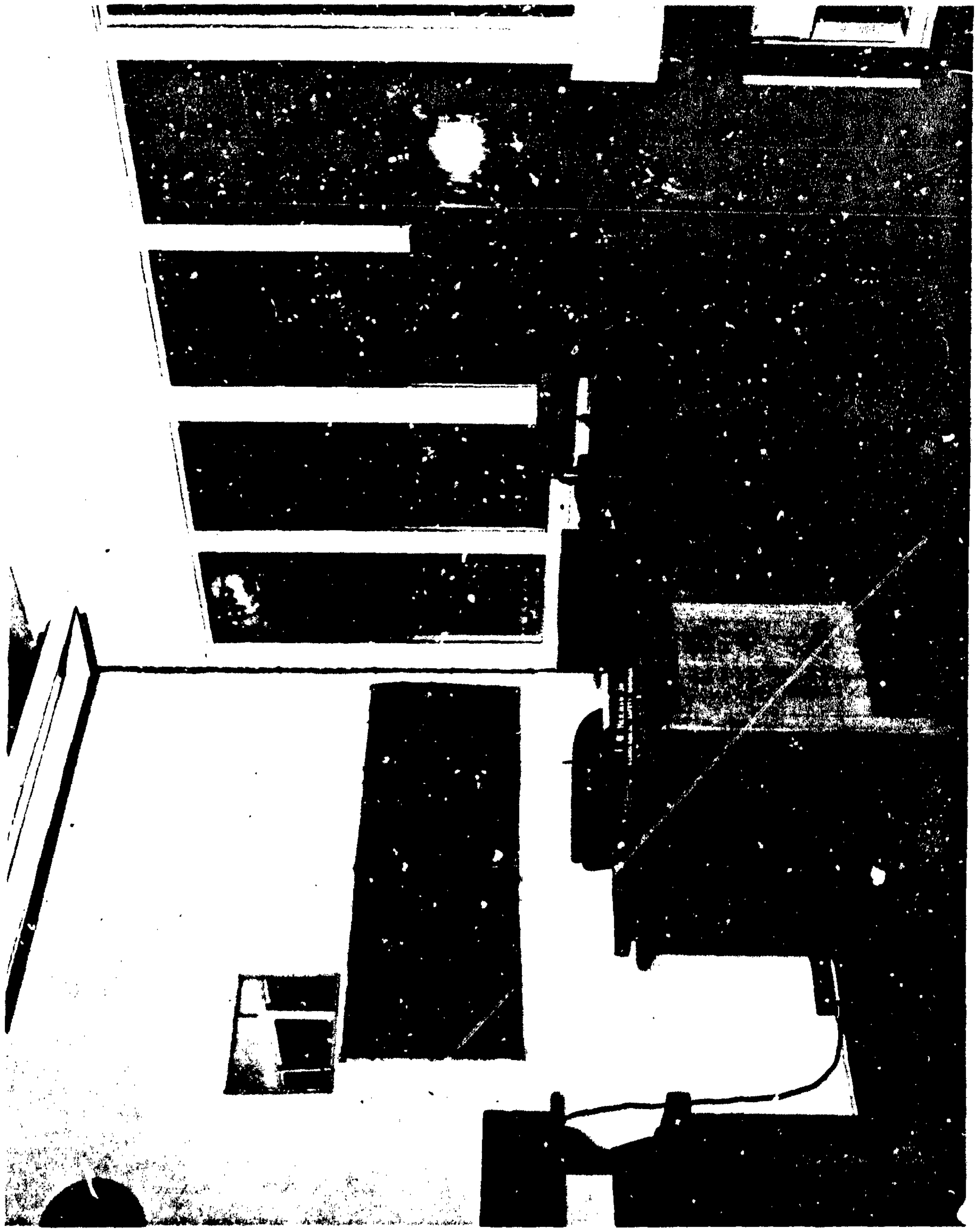

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NP(3)-262387(L)-2-48

VIEW OF OFFICE OF HEALTH AND SAFETY DETAILS ON SECOND-DECK LEVEL SHOWING WINDOWED WALL OVERLOOKING MAIN HANGAR AREA

PLATE

[redacted]

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NP(3)-260346(L)-7-49
CLEAN DRESSING ROOM SHOWING ENTRANCE TO CONTAMINATED DRESSING ROOM AND PASSAGEWAY FROM SHOWER ROOM

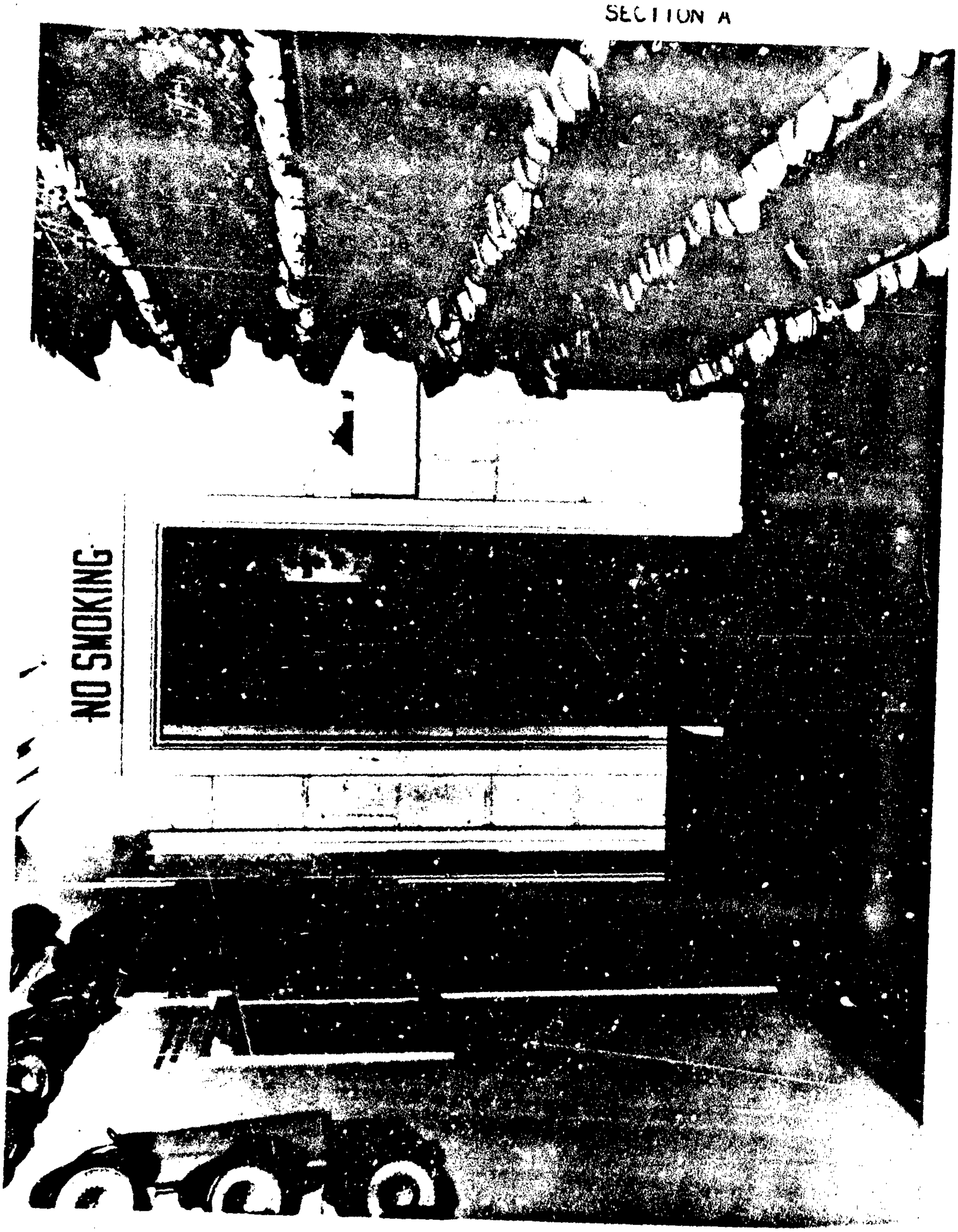
PLATE

[redacted]

NP(3)-260344(L)-7-49 Q 1711

CLEAN LAUNDRY STORAGE ROOM SHOWING STOCKS OF CLOTHING ARRANGED BY SIZES TO OUTFIT WORKERS "FROM THE SKIN OUT"

PLATE



NP(3)-262388(L)-7-49

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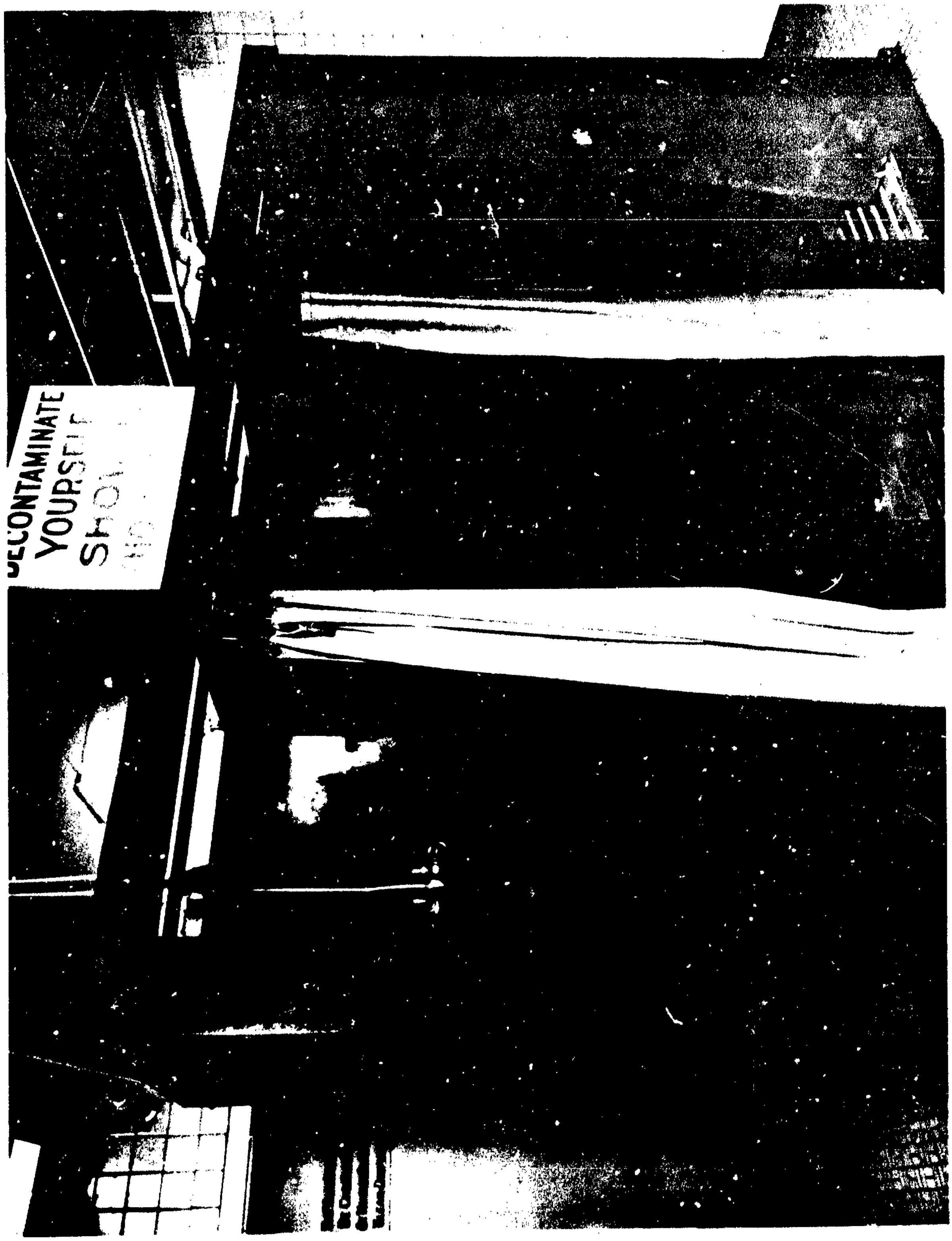
CONTAMINATED DRESSING ROOM SHOWING CONTAMINATED ENTRANCE TO SHOWER R
AND PORTION OF STOCKS OF INDIVIDUAL SHOES, RESPIRATORS AND FILM BADG

PLATE 8

[redacted]



NP(3)-260345(L)-7-49
SHOWER ROOM SHOWING STALL SHOWERS AND CLEAN EXIT FROM SHOWER ROOM TO CLEAN DRESSING ROOM 0 :711

PLATE

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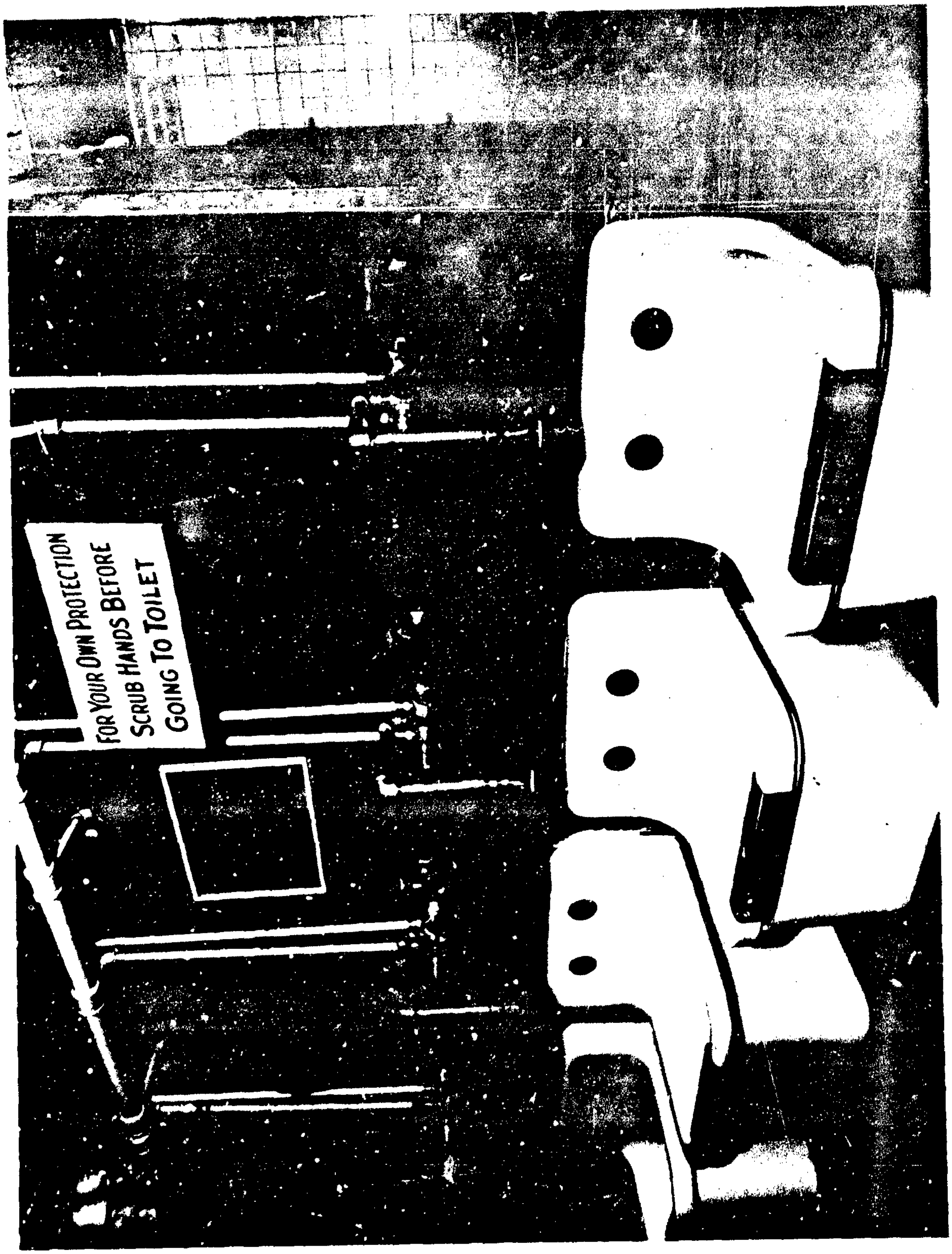


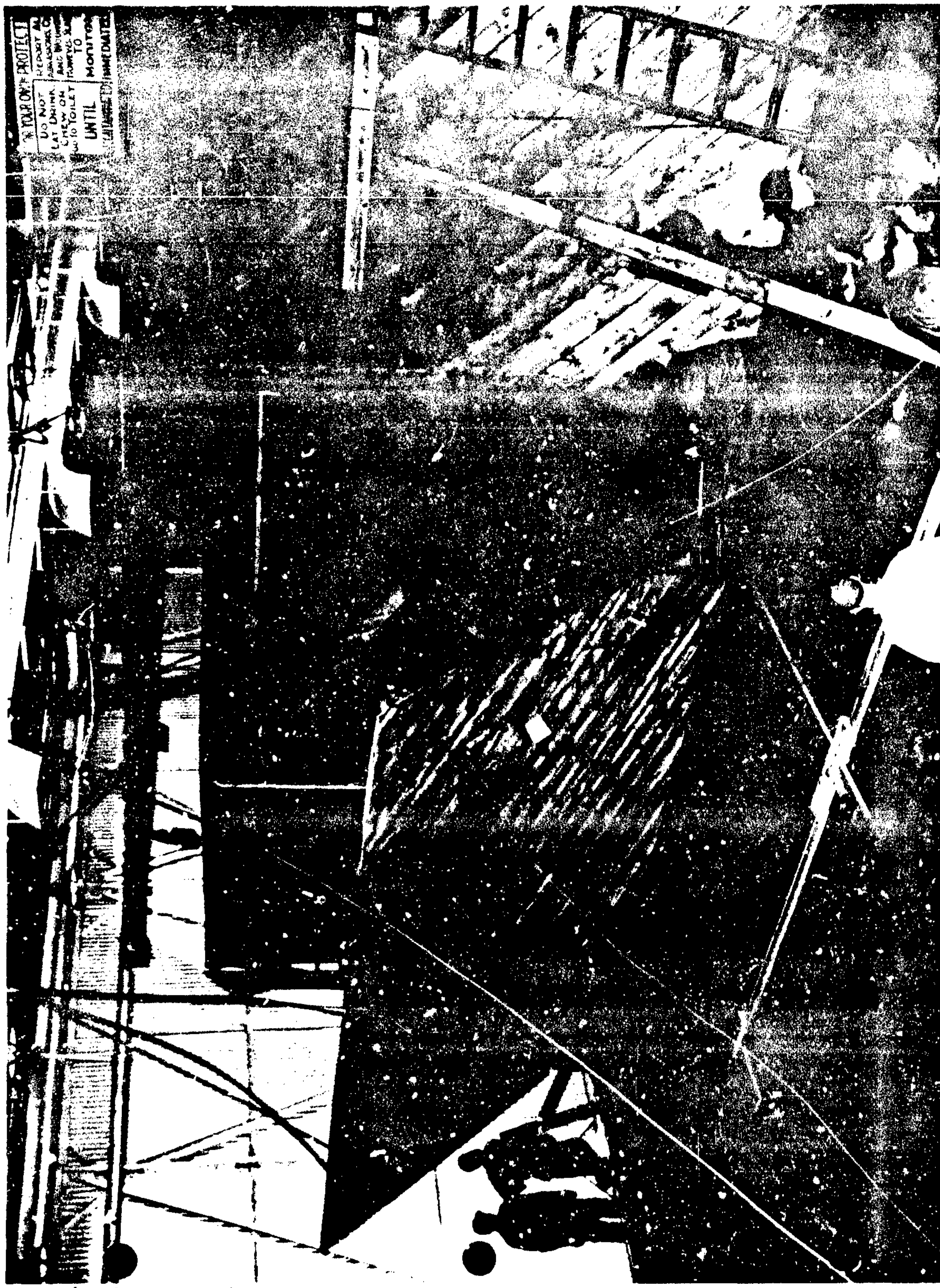
Q 1711

NP(3)-262396(L)-1-48

SHOWER ROOM SHOWING BASINS USED FOR HAND AND FACE WASHING BEFORE SHOWERING

PLATE

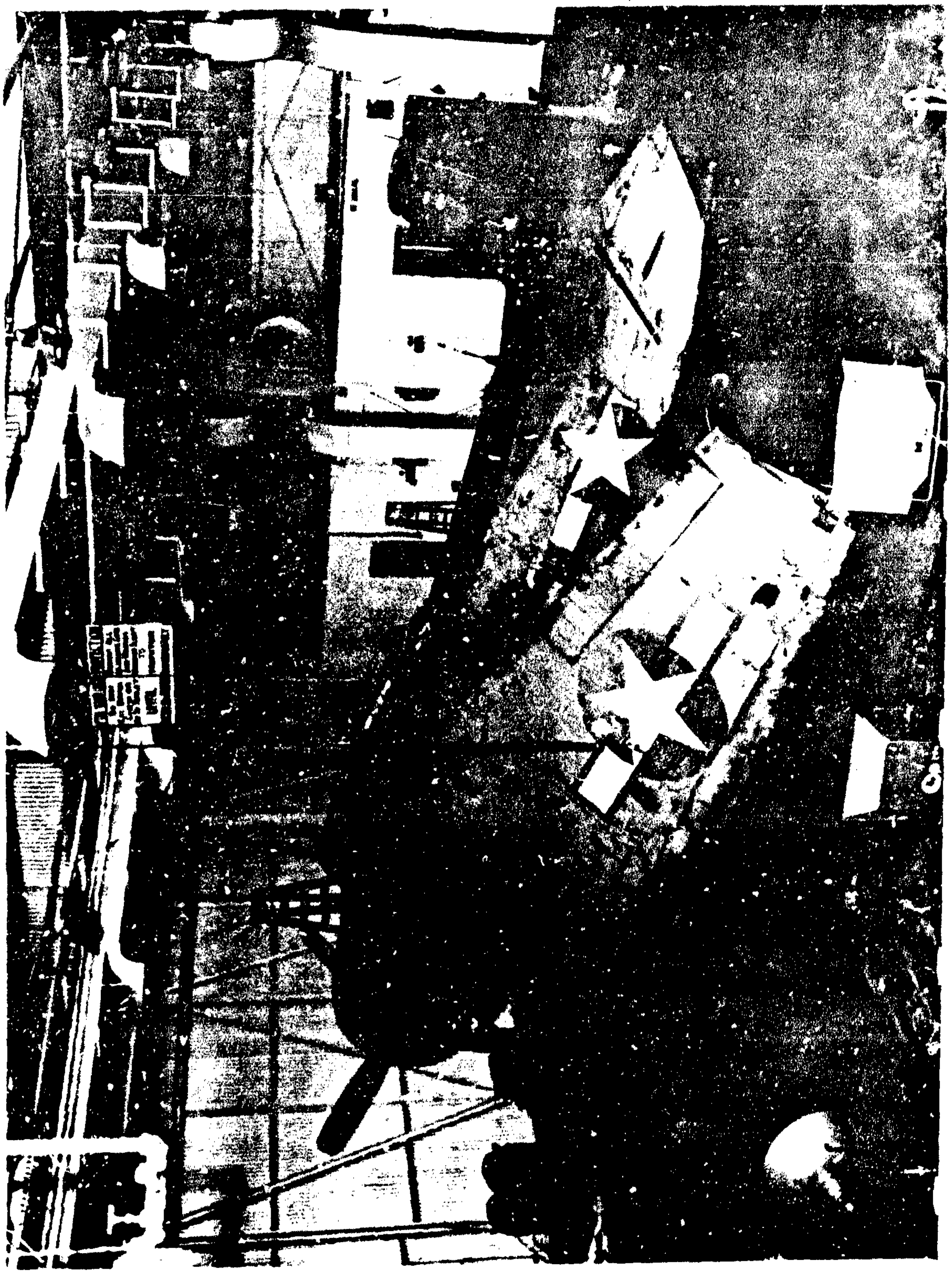
NP(3)-260347(L)-7-49
LAUNDRY ROOM SHOWING TWO AUTOMATIC LAUNDRIES AND DRYER
SHOWS BARRELS OF SOAP AND CARBOYS OF DISINFECTANT USED IN LAUNDRY
PLATE



NP(3)-262389(L)-9-47
INITIAL PHASE OF UNCRATING OF TEST AIRPLANE, TBM-3E BUNO 69169
SHOWING WORKMEN WEARING PROTECTIVE CLOTHING AND EQUIPMENT

Q 1711 PLATE

[redacted]



NP(3)-262390(L)-10-47
TBM-3E BUNO 69169 UNCRATED AND IN POSITION FOR EXAMINATION

PLAT

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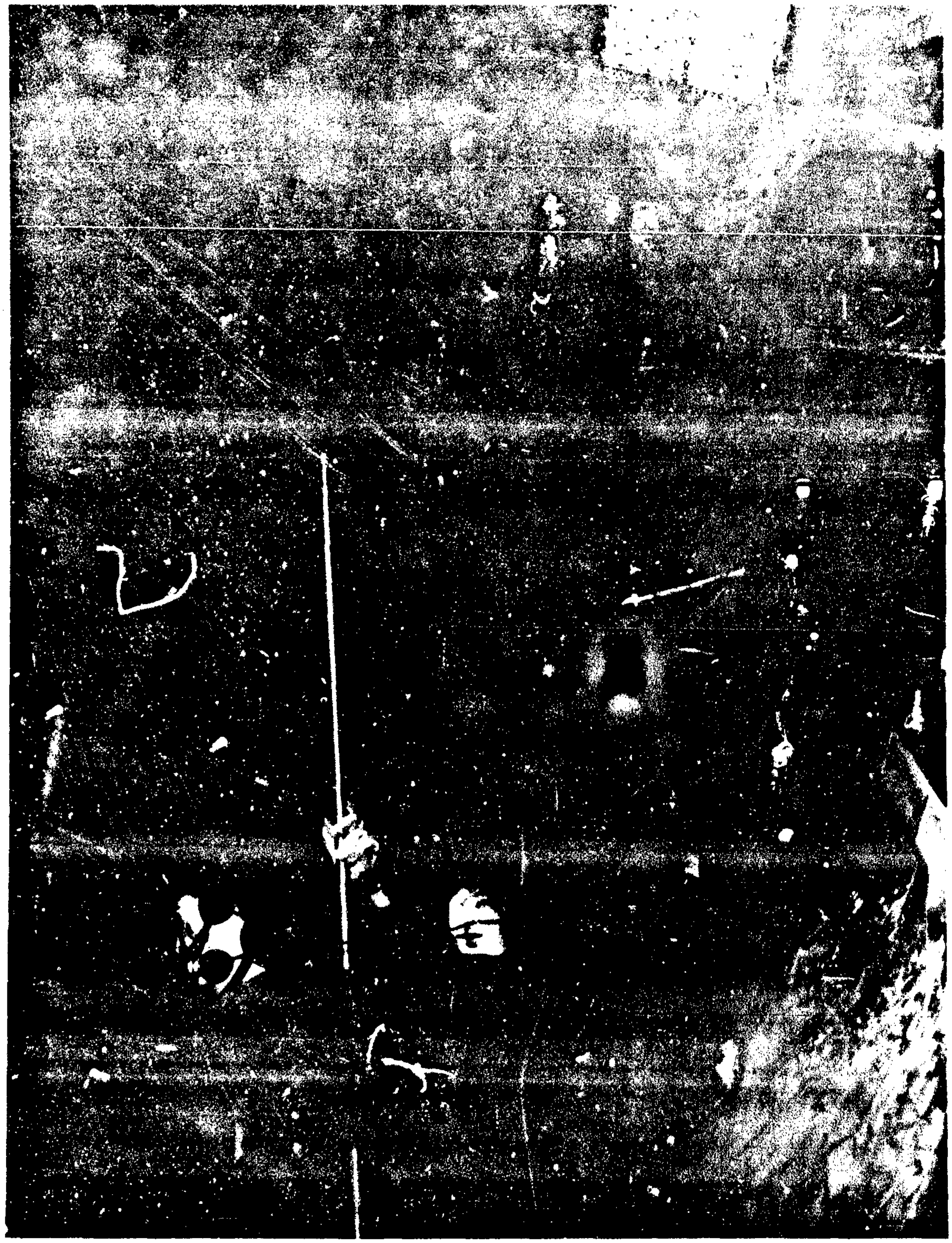

NP(3)-262391(L)-11-47
RADIOLOGICAL SAFETY ENGINEER CONDUCTING RADIOLOGICAL SURVEY OF AIRPLANE - SHOWS COMPLETE PROTECTIVE CLOTHING OUTFIT

PLATE 14

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[redacted]

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NP(3)-262392(L)-10-47
VIEW OF TBM-3E BUNO 69169 - SHOWS PORT WING BEING OPENED BY WORKMEN IN COMPLETE PROTECTIVE CLOTHING OUTFIT

PLATE 15

NP(3)-262393(L)-12-47
VIEW OF TBM-3E BUNO 69169 - SHOWS REMOVAL OF STARBOARD WING PANEL BY WORKERS IN COMPLETE PROTECTIVE CLOTHING OUTFIT

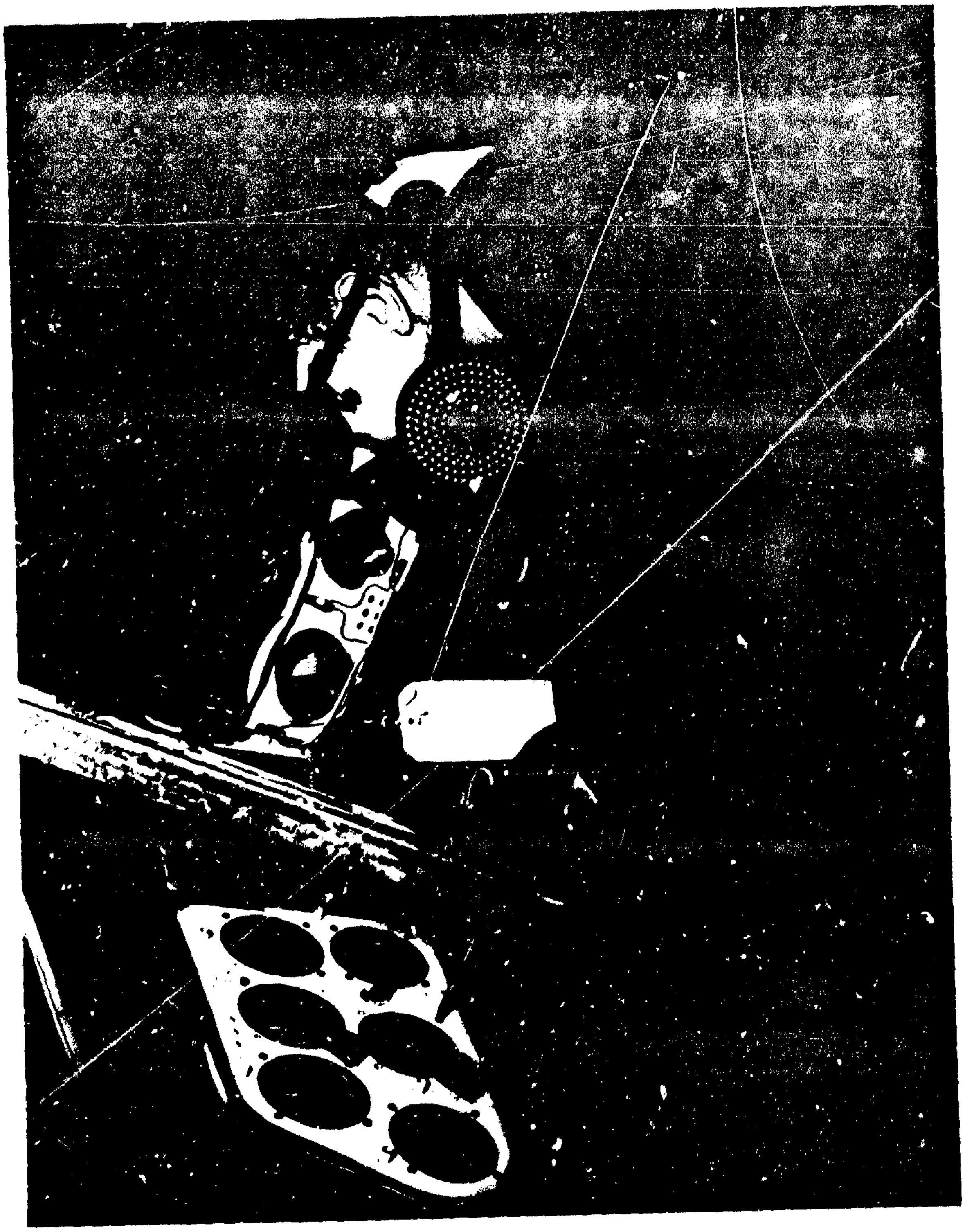
711

PLATE 16

NP(3)-262394(L)-10-47
VIEW OF TAIL SECTION OF TBM-3E BUNO 69169 - SHOWS PROTECTIVELY CLOTHED ENGINEER CONDUCTING INSPECTION OF RUDDER

PLATE 1

[redacted]



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NP(3)-262395(L)-10-47

VIEW OF COCKPIT OF TBM-3E BUNO 69169 - SHOWS PROTECTIVELY CLOTHED MECHANIC REMOVING INSTRUMENTS FROM PANEL PLATE I

[redacted]

P(3)-262415(L)-2-50
ENLARGEMENT OF FRAME FROM 16 MM. MOTION PICTURE
SHOWING AIRPLANE AS IT WAS PREPARED FOR TRANSPORT TO SEA FOR BURIAL

PLATE 19

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NP(3)-262416(L)-2-50
ENLARGEMENT OF FRAME FROM 16 MM. MOTION PICTURE
SHOWING TBM-3E BUNO 69169 BEING SUNK AT SEA

PLATE

[redacted]

REPORT NO. AEL NAM AE 540001
SECTION B

NAVY DEPARTMENT
BUREAU OF AERONAUTICS

REPORT ON

TESTS OF AIRCRAFT ENGINE FROM OPERATION CROSSROADS, TARGET AIRPLANE, TBM-3E, BUNO 69169

BY

G. R. SIMPSON

AERONAUTICAL ENGINE LABORATORY
NAVAL AIR EXPERIMENTAL STATION
NAVAL AIR MATERIAL CENTER PHILADELPHIA

Authorization . . . . BuAer Confidential ltr Aer-AE-45 C08267 of 29 Nov 46.

Dates of Test . . . . From 3 Nov 47 to 21 Mar 49.

Approved by . . . . K. E. Wright, CDR, USN — Superintendent, Aero. Engine Lab.

DATE ISSUED 1 Apr 1950

[redacted]

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[redacted]

REFERENCES

(a) BuAer Confidential ltr Aer-AE-45 C08267 of 29 Nov 46.
(b) NAES Confidential ltr EM-44-AH:rmcg (1790) of 5 Jun 47, with enclosure - Basic Outline of Proposed Test Work.
(c) BuAer Confidential Memorandum Aer-AE-45 of 8 Nov 46 (to various Division Directors, BuAer).
(d) AEL Secret Memorandum Report to Supt, AML, XE-1-GRS:cas of 26 May 48.
(e) AEL Secret Memorandum Report to Supt, AML, XE-1-GRS:cas of 4 Apr 49.

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[redacted]

ABSTRACT

(a) This is a report of investigations and tests conducted on the engine, and engine accessories and components (hereafter called the power plant) of an Operation CROSSROADS target airplane. The power plant was originally designed to withstand normal service usage, assuming periodic adjustments, cleanings and overhauls. This usage does not include either exposure to extreme blast damage, weathering or atomic radiation. The power plant was exposed to all three of these phenomena in addition to previous service usage.

(b) Testing of the power plant was made difficult due to the decision of the radiological safety group that actual operation of the engine would constitute a serious health hazard. The power plant was, therefore, stripped down, all parts inspected and only those parts actually operated that met two conditions: (1) Decontamination was possible and could not conceivably alter the operating condition as found upon arrival; (2) Inspection and, for instance, hand turning, would not suffice to evaluate the operability of a given component.

(c) The report describes the various inspections conducted, the actual tests checked against normal operation, and discloses that all discrepancies and excessively corroded or otherwise damaged parts are attributable to effects of phenomena other than atomic radiation.

(d) This report combines the findings reported in refs (d) and (e).

[redacted]

1. **AUTHORIZATION**

The subject investigation was authorized by ref (a).

2. **OBJECT**

These tests were conducted to determine the effects, if any, of atomic radiation on the power plant of an aircraft which had been exposed to atomic radiation.

3. **DESCRIPTION**

An inspection was made of the engine, engine components and accessories of a Model TBM-3E airplane, BuNo 69169. The engine was a Wright Aeronautical Corporation (WAC) R-2600-20 engine, BuNo 122086. Components inspected or tested were: Hamilton Standard, three blade, Model 23E50-489 propeller; Woodward Governor, Model 4G10-G 38 D1; Type JH4FR Ser. No. N-5035, Motor Ser. No. 73690, Jack and Heintz, Inc., combination inertia-direct cranking electric starter; spark plugs Aero LS4AD; PR48A2 carburetor Ser. No. 702568, Parts List No. 395600-2; Engine Driven Fuel Pump, Thompson Products, Inc., P/N TFD 100 Type AN 4101; Fuel Strainer, Aero Supply Mfg. Co. Assembly No. 13960-4; Fuel Selector Valve, Aero Supply Mfg. Co. Assembly No. 14300; Fuel Transfer Pump, PESCO Products Co., consisting of Type AN4101 PESCO fuel pump and PESCO Type 5421B electric motor.

4. **METHOD AND RESULTS**

(a) As stated in para 3 of ref (d), it was considered inadvisable to operate the engine, as suggested in refs (a) and (b), either in the airplane or in a test cell, since it would create a safety hazard by scattering radiologically-contaminated particles throughout the test area. The engine was carefully inspected for possible damage due to radioactivity before disassembly. A summary of the general condition (see also Plates 1 to 12, inclusive) based on this inspection follows:

(1) All exposed metal parts (particularly forward of the fire wall) were heavily corroded and rusted; Aluminum parts were coated with a thick layer of gray dust, probably aluminum oxides formed during exposure to the weather and salt atmosphere.

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(2) Exposed rubber parts (forward of the fire wall) such as push rod housing and intake manifold hoses were badly deteriorated.

(3) The engine rotated freely when pulled through with the propeller.

(b) As stated in para 4 of ref (d), information of interest noted during and after complete disassembly of the engine, is as follows:

(1) All intake pipe hose clamps were less than hand-tight.

(2) The rubber hoses on the push rod housings were rotted badly. Some of the rubber crumbled and the corded fabric ripped during removal of the hoses from the housings.

(3) Only 14 of the 28 spark plugs (Aero LS4AD) could be removed with less than 650 in. lbs. torque.

(4) A moderate amount of rust was also noted on many of the internal engine parts. This is attributed to the length of time the engine was stored without preservation or protection of any kind.

(5) The piston rings, pistons, cylinders, valves, bearings, etc. showed no evidence of damage or erosion other than that which would be caused by normal wear and long time unprotected storage.

(6) The engine impeller was coated with white flaky particles (see Plate 10) which were probably caused by the entrance of salt water into the engine induction system.

(c) Ref (d), para 6, reported that the Hamilton Standard, three-blade, Model 23E50-489, propeller was in a generally satisfactory condition except for the corrosion similarly noted on all other exposed metal parts of the airplane and engine. Although considerable difficulty was encountered removing the propeller-dome retaining nut, the blades were manually operated without difficulty. The propeller and Woodward Governor, Model 4G10-G33D1, were completely disassembled for inspection and found to be in satisfactory condition.

(d) Ref (d), para 7, reported that the engine was equipped with a combination inertia-direct cranking electric starter, Type JH4FR, (Ser. No. N-5035, Motor Ser. No. 73699) manufactured by Jack and Heintz, Inc., Cleveland, Ohio. Inspection of the starter revealed that, although covered with a film of engine oil, the mounting flange was slightly corroded. The starter jaw could not be engaged by means of the manually operated engaging lever but was easily pried free with a screwdriver. Subsequent inspection of the splines of the jaw and carrying arm assembly revealed these parts to be oil coated. The electric solenoid, which is also used for engagement, was checked independent of the remainder of the jaw engaging system and found to function satisfactorily. Except for the rear armature bearing which was very rough, all bearings were in good condition. Both sets of brushes were noted to be in reversed positions, the positive in the negative brush guides and vice versa; however, all brushes had formed good seats. Engine oil had penetrated into the reduction gearing; however, no evidence of excessive wear was noted.

(e) As reported in para 5, ref (e), the overall external appearance of the PR48A2 carburetor, Ser. No. 702568, Parts List No. 395600-2 from the subject airplane was satisfactory with the exception of the corrosive action (appeared to be salt water corrosion) which had taken place in the carburetor main venturi and around the manual mixture control unit. Plates 11 and 12 are general views of the carburetor showing the extent of this corrosion. Disassembly of the carburetor fuel regulator system and a visual inspection of the various component parts and diaphragms indicated these parts to be in good condition. Altitude chamber tests of the automatic mixture control unit showed the unit to be within the specified travel limits and less than 1.0 percent off from the flow bench specified setting at 20,000 ft. altitude. It is concluded that this carburetor is in operable condition and no detrimental effects were produced upon or within the carburetor other than the corrosive action.

(f) As reported in para 6, ref (e), the following fuel system accessories were disassembled for examination:

(1) Thompson Products, Inc., Engine Driven Fuel Pump
P/N TFD-100, Type AN4101

(2) Aero Supply Mfg. Co. Fuel Strainer
Assembly No. 13960-4

(3) Aero Supply Mfg. Co. Fuel Selector Valve
Assembly No. 14300

A Pesco Products Company Fuel Transfer Pump, which consists of a Type AN4101 Pesco fuel pump and a Pesco Type 5421B electric motor rated 7 amperes at 24 v, d-c, was tested for pressure regulation at 24 and 30 volts. Following these tests, the Type AN4101 Pesco fuel pump was disassembled for examination. The electric motor was not disassembled. The pressure regulation of the fuel transfer pump was satisfactory. However, a maximum of 14 drops per minute of fuel leaked from the shaft seal drain hole. This rate of leakage is not serious; however, it is undesirable. It is believed that the sealing surface of the bronze seal ring of the shaft seal assembly was not lapped sufficiently in production to provide a perfect seal. It is not believed that the leakage was caused by any effect of radioactivity. Examination revealed that the parts of each disassembled accessory mentioned in this paragraph were in good condition. Unusual conditions of the parts were not found.

(g) All other engine accessories were visually inspected in their assembled condition and showed only slight evidence of corrosion.

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5. **CONCLUSIONS**

No damage to the power plant was evident that could be attributed to its exposure to atomic radiation.

6. **RECOMMENDATIONS**

(a) In para 9, ref (d), it was recommended that if similar future tests are to be conducted, some form of preservation be applied to all exposed engine and propeller parts so that weather damage can be differentiated from bomb blast damage.

(b) It is further recommended that inspections be made by experienced personnel within a reasonable time after the blast or as soon as existing safety regulations allow.

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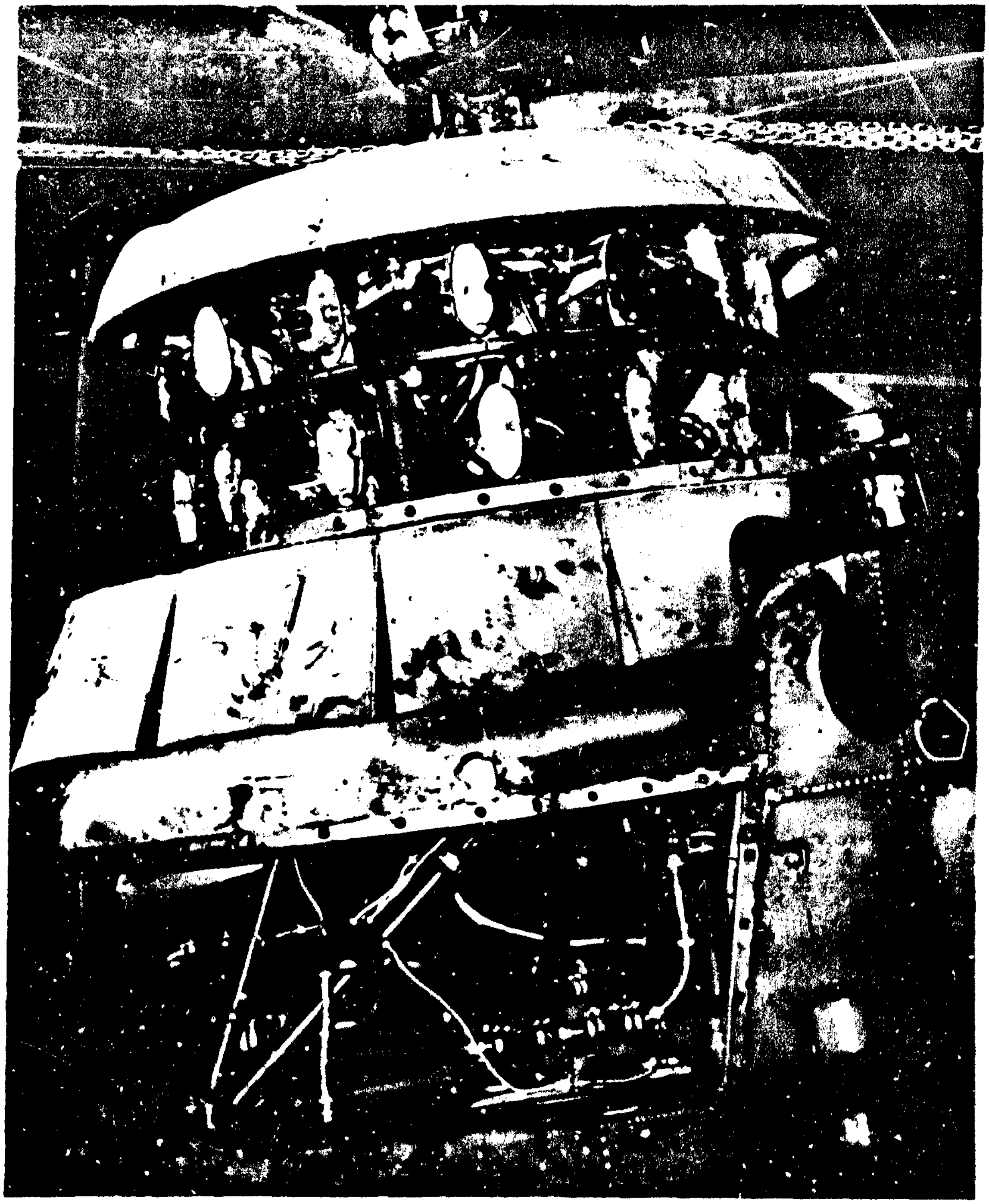

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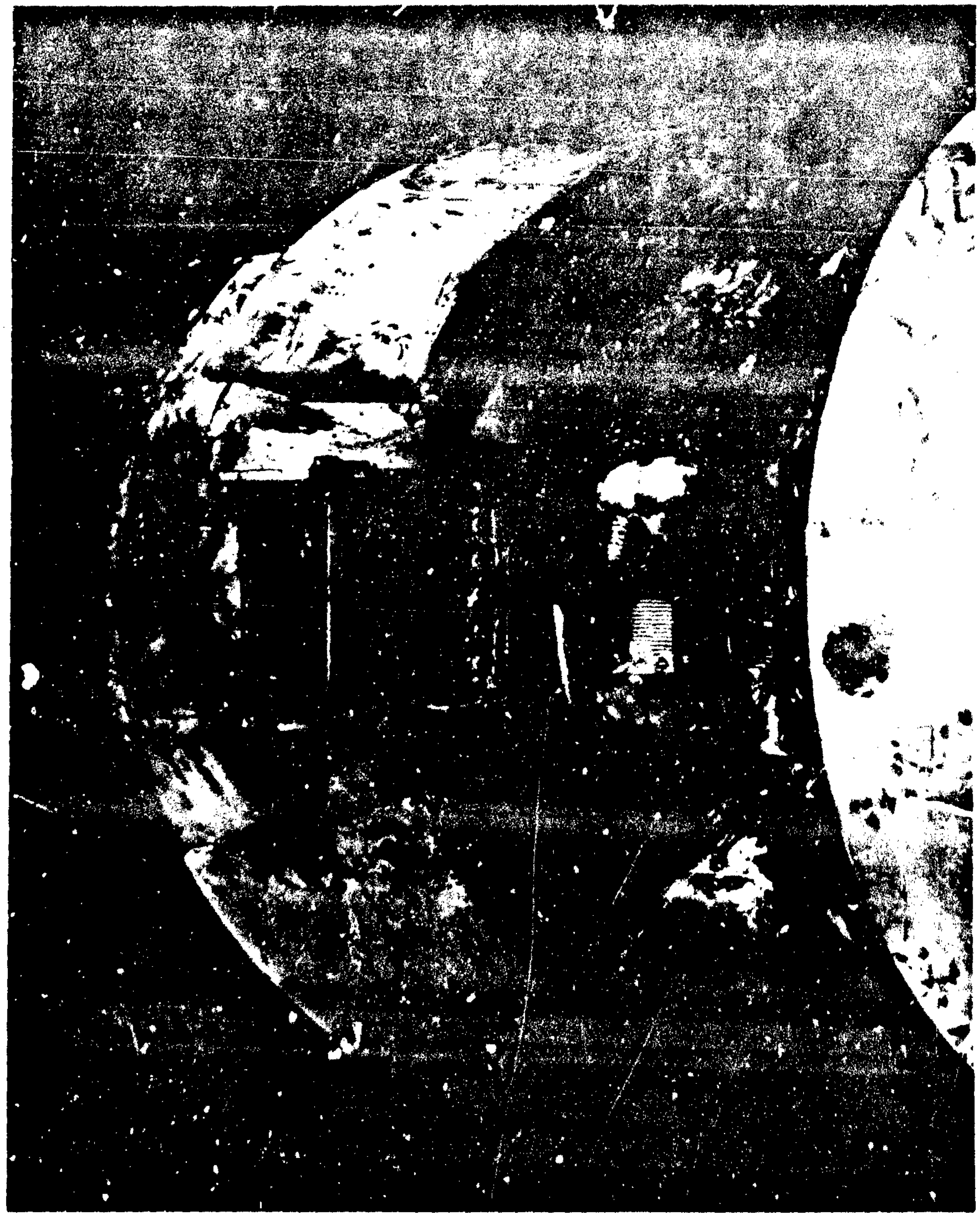
NP(3)-256082(L)-6-48

TBM-3E TARGET AIRPLANE - ENGINE AND ACCESSORIES
RIGHT SIDE VIEW

PLATE



NP(3)-256083(L)-6-48

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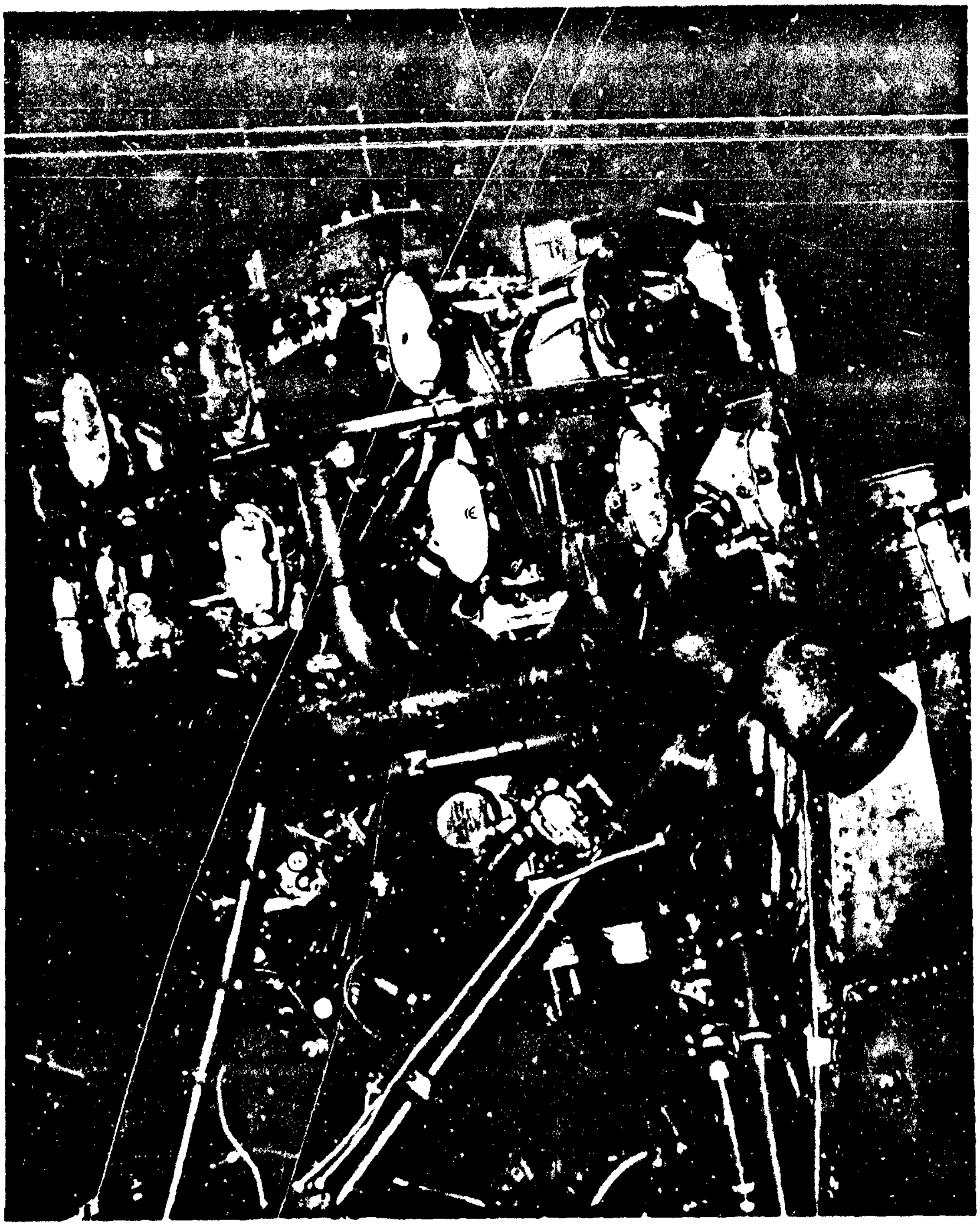
TBM-3E TARGET AIRPLANE - ENGINE INSTALLATION
TOP VIEW LOOKING AFT

PLATE

NP(3)-256084(L)-6-48
TBM-3E TARGET AIRPLANE - ENGINE INSTALLATION
BOTTOM VIEW

PLATE



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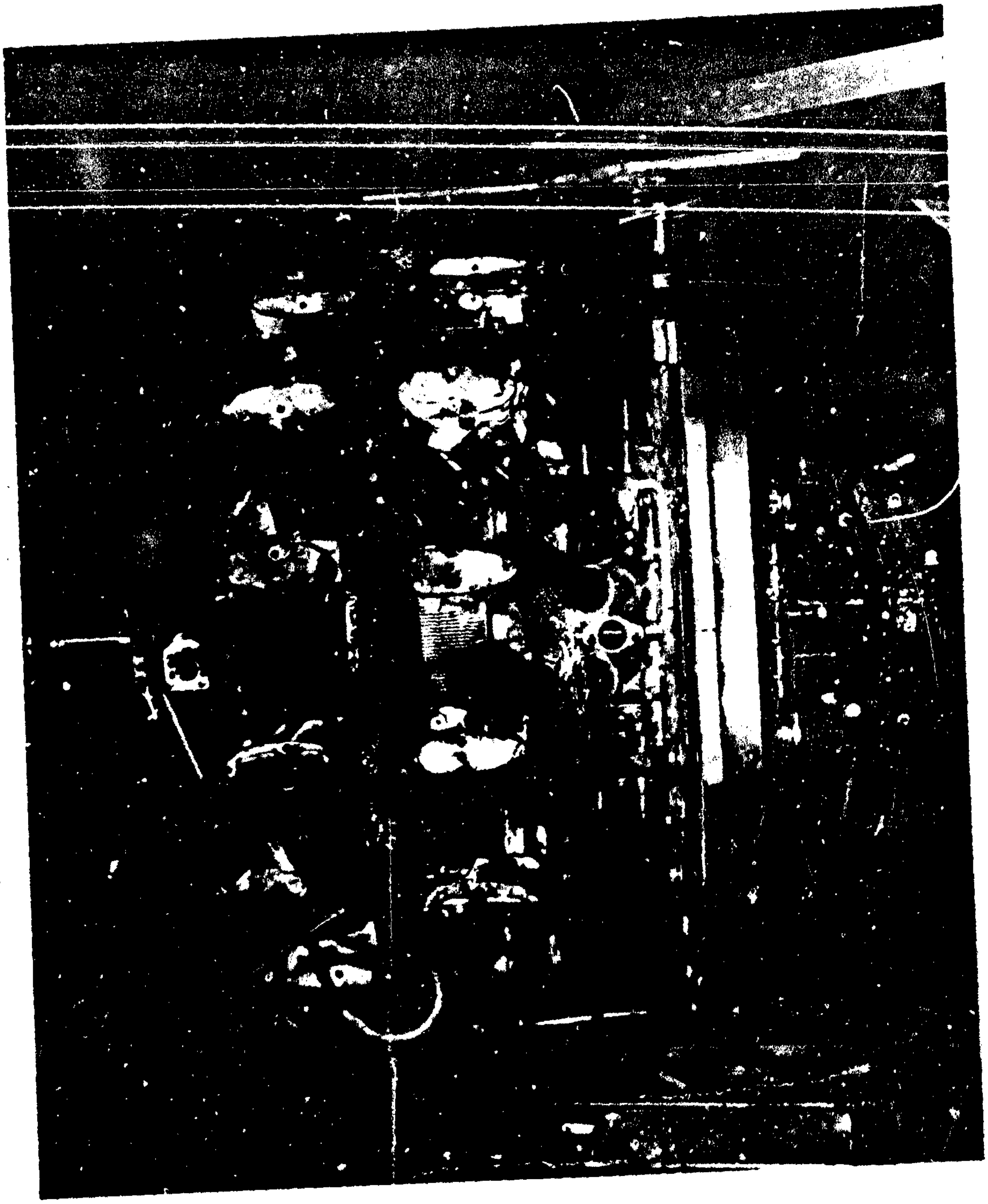
C NP(3)-256085(L)-6-48
R-2600-20 ENGINE INSTALLATION - TBM-3E TARGET AIRPLANE
RIGHT SIDE VIEW

PLATE 4



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NP(3)-256086(L)-6-48

R-2600-20 ENGINE FROM TARGET AIRPLANE
TOP VIEW

PLATE

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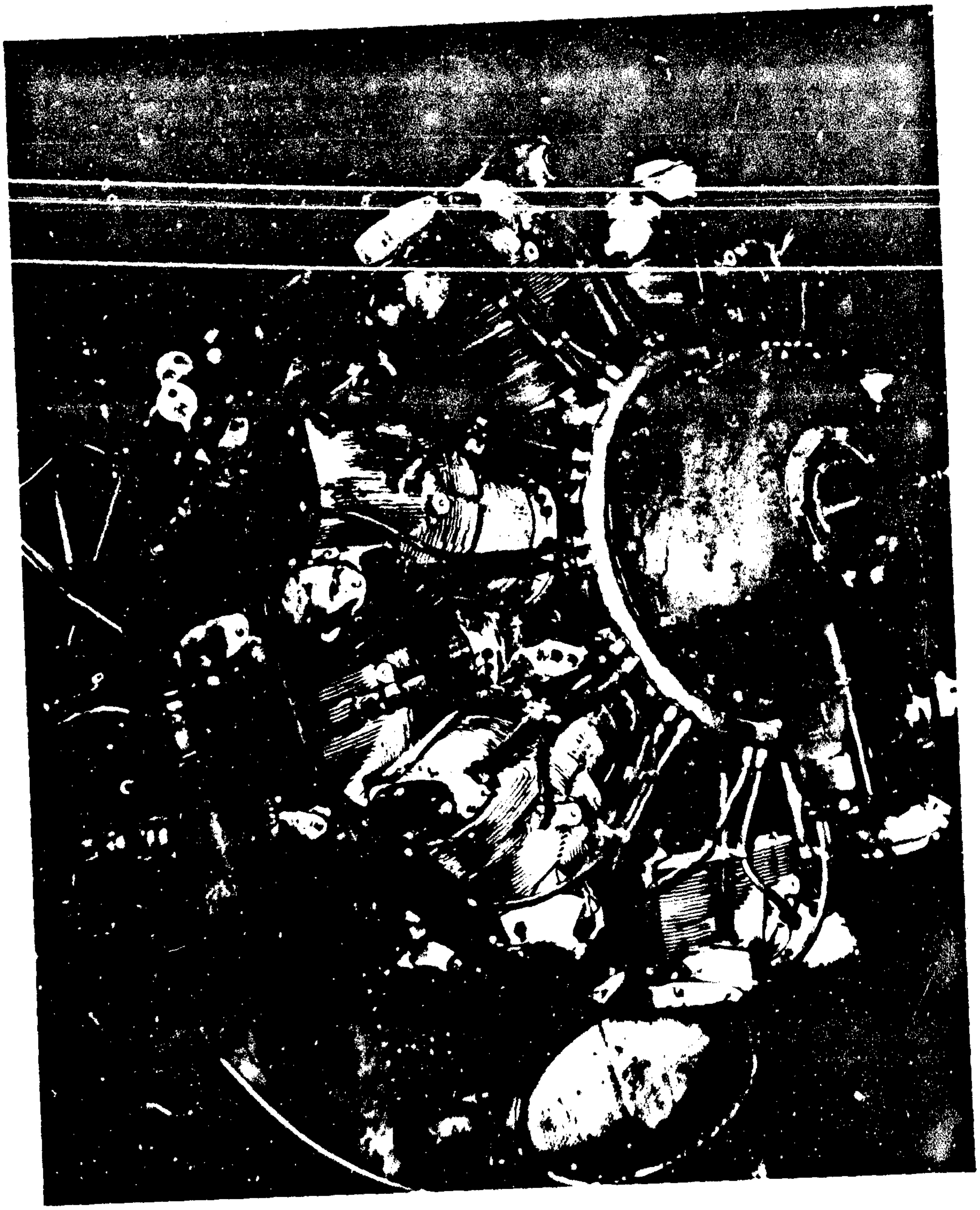

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NP(3)-256087(L)-6-48
R-2600-20 ENGINE INSTALLATION - TBM-3E TARGET AIRPLANE
FRONT THREE-QUARTER VIEW

PLATE

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C NP(3)-256088(L)-6-48

R-2600-20 ENGINE INSTALLATION - TBM-3E TARGET AIRPLANE
FRONT THREE-QUARTER VIEW

PLATE

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NP(3)-256089(L)-6-48
R-2600-20 ENGINE INSTALLATION - TBM-3E TARGET AIRPLANE
SHOWING REMOVAL OF CARBURETOR

PLATE

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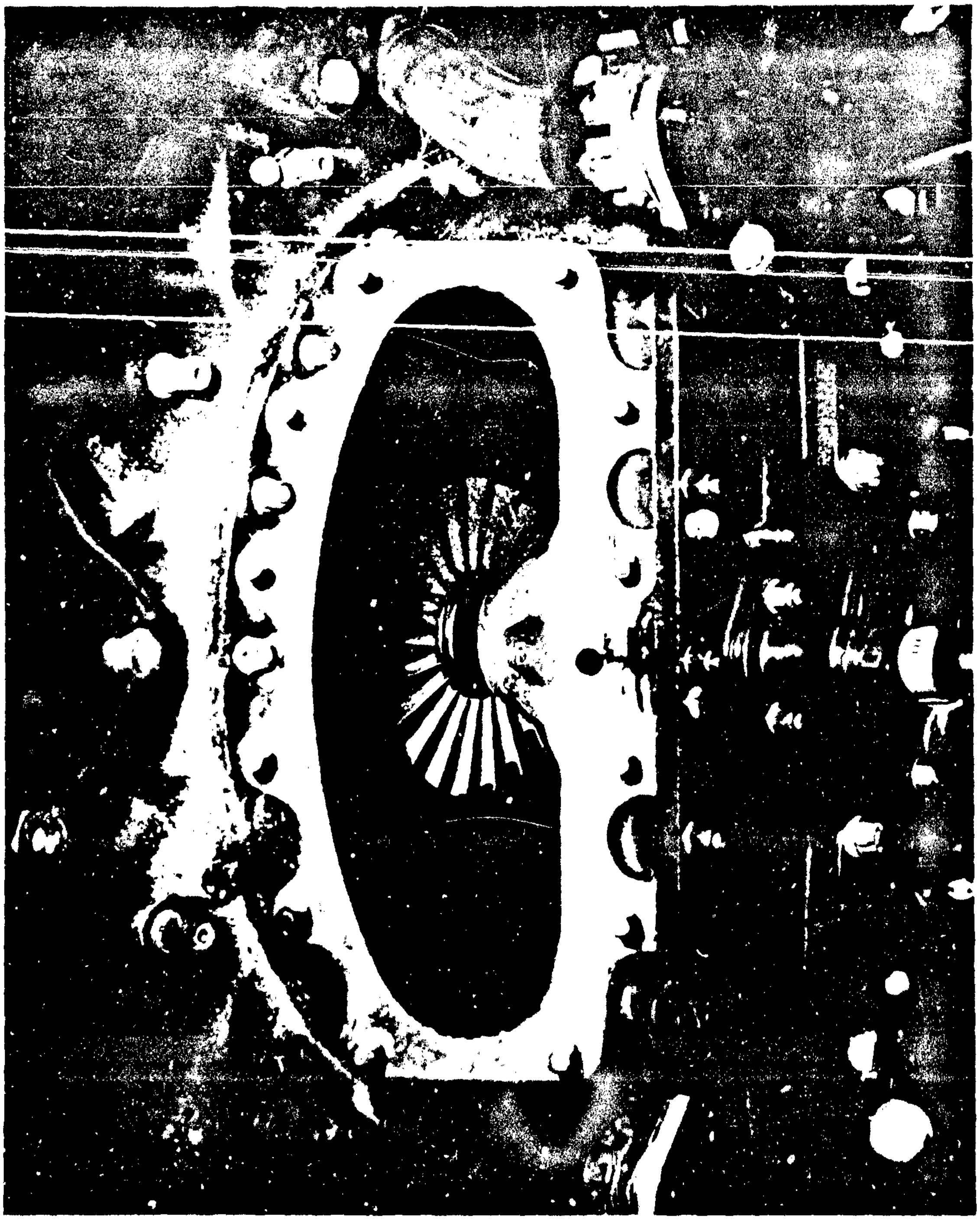
NP(3)-256090(L)-6-48

VIEW SHOWING CONDITION OF CYLINDER FINS
R-2600-20 ENGINE

PLATE



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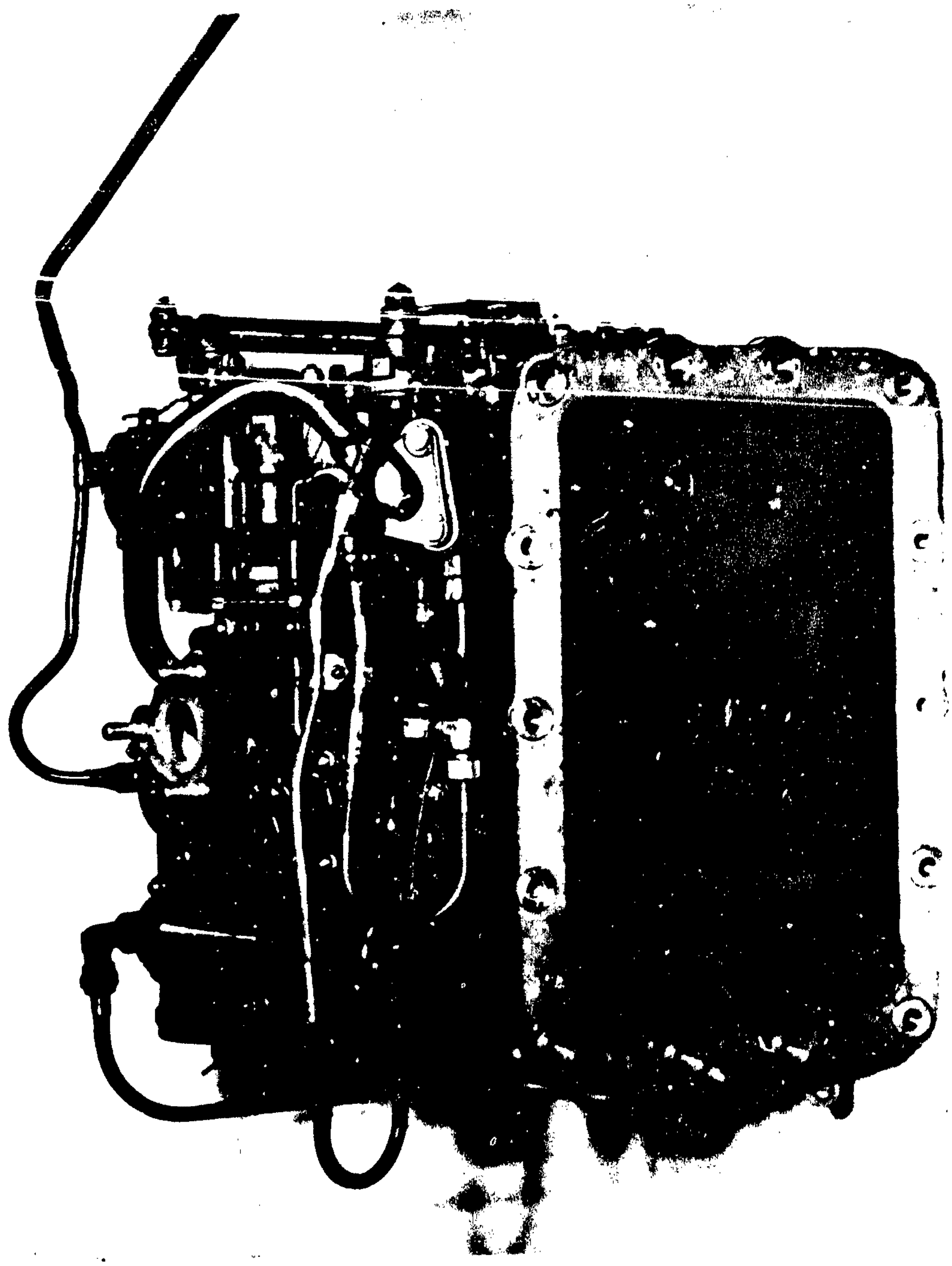
NP(3)-256091(L)-6-48

VIEW SHOWING CONDITION OF IMPELLER
R-2600-20 ENGINE

PLATE



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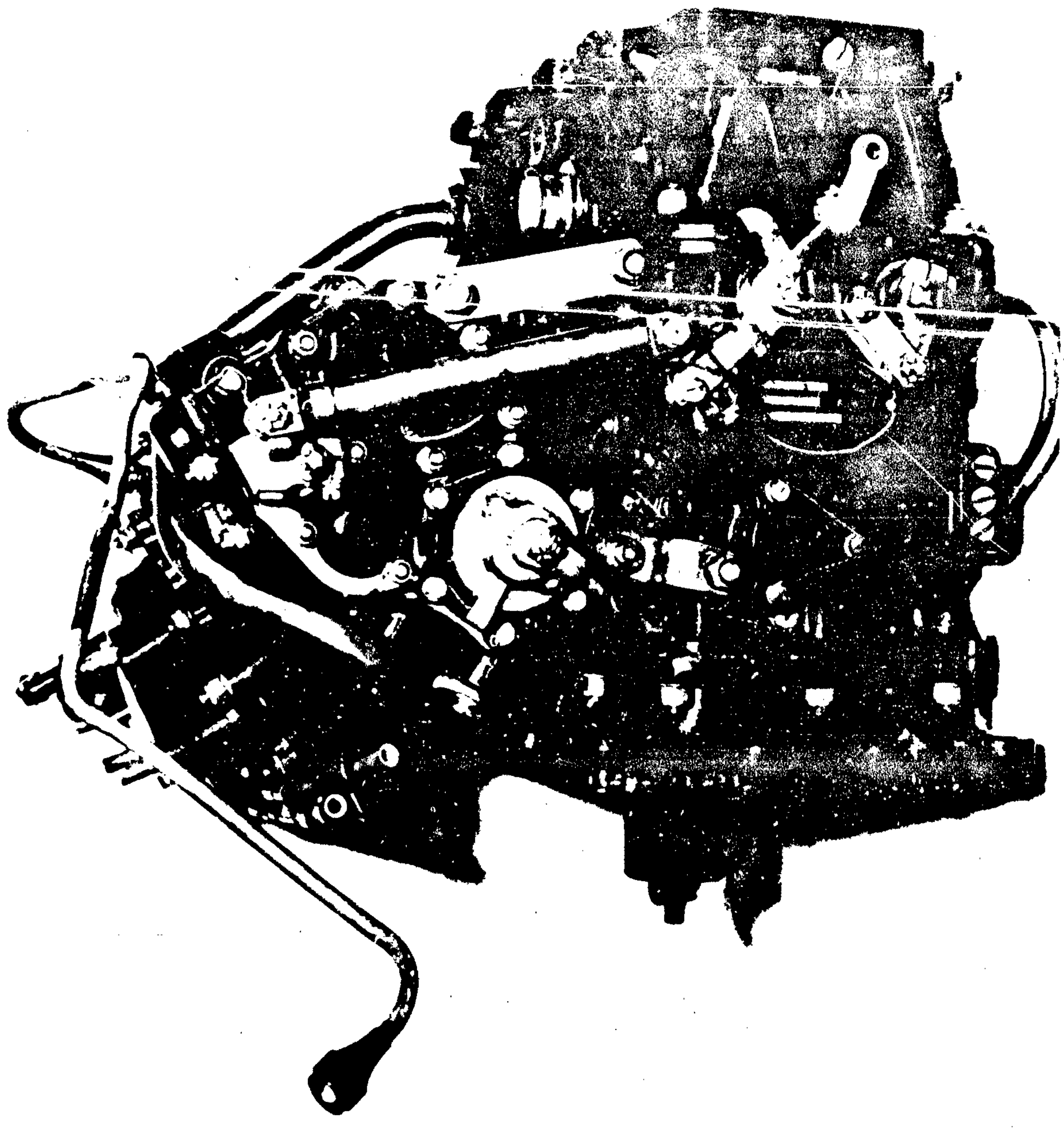
C NP(3)-259206(L)-4-49

CARBURETOR FROM TBM-3E TARGET AIRPLANE
SHOWING GENERAL CORRODED CONDITION

PLAT



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NP(3)-259207(L)-4-49

CARBURETOR FROM TBM-3E TARGET AIRPLANE
SHOWING GENERAL CORRODED CONDITION

PLATI

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REPORT NO. AML NAM AE 540001
SECTION C

NAVY DEPARTMENT
BUREAU OF AERONAUTICS

REPORT ON

TESTS OF AIRCRAFT INSTRUMENTS FROM OPERATION CROSSROADS, TARGET AIRPLANE, TBM-3E, BUNO 69169

BY

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Authorization . . . . BuAer Confidential ltr Aer-AE-45 C08267 of 29 Nov 46.

Dates of Test . . . . From 7 Mar 49 to 18 May 49.

Reviewed by . . . . M. G. Greenland — Supervisor, Instruments Division

Approved by . . . . H. M. Schroder, LCDR, USN — Superintendent, Aero. Instr. Lab.

DATE ISSUED 1 Apr 1950

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REFERENCES

(a) ILWR #652-47 of 26 Jun 47.

TABLES

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Description of Engine Instruments Tested.	II
Results of External Examination of Pointer and Dial Markings.	III
Manifold Pressure Gage, Scale Error at Room Temperature.	IV
Oil Pressure Gage, Scale Error at Room Temperature.	V
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Tachometer Indicator, Oscillation Error at Room Temperature.	IX
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[redacted]

ABSTRACT

(a) This is a report of investigations and tests conducted on sixteen aircraft instruments of various types, manufacturers and ages removed from an Operation CROSSROADS target airplane. The instruments were originally designed to withstand normal service usage. This usage does not include either exposure to extreme blast pressure, weathering, or atomic radiation. The instruments tested were exposed to all three of these phenomena, in addition to previous service usage. No unique tests were devised; standard performance tests against specifications were employed.

(b) The report describes the various errors found in the performance of the instruments and discloses that the errors found are attributable to effects of phenomene other than atomic radiation.

[redacted]

1. AUTHORIZATION

This investigation was authorized by ref (a).

2. OBJECT

These tests were conducted to determine the effects, if any, of atomic radiation on instruments removed from an aircraft which had been exposed to atomic radiation during Operation CROSSROADS.

3. DESCRIPTION

The instruments were removed from the TBM-3E BuNo 69169 at NAMC. They were then subjected to a process of decontamination following which they were brought to the Aeronautical Instruments Laboratory for testing. The tests were conducted during the period from 7 Mar 49 to 18 May 49. Each instrument was given operational and functional tests which included all or most of the individual tests of the applicable specifications. The tests were performed in accordance with the applicable specifications and the tolerances listed are taken from these specifications.

4. CATEGORY I - ENGINE INSTRUMENTS
METHOD AND RESULTS

(a) A list of engine instruments tested, giving manufacturer's data, is shown in Table I. The instruments' range, type mechanism, and applicable AN specification are shown in Table II.

(b) Examination - Each instrument was examined externally and nothing of any significance was observed. The dial markings of each indicator and the marking of each pointer were observed in the daylight, under ultraviolet light and for ten minutes after extinguishing the light in a darkroom. There is not sufficient information available to warrant any precise interpretation of the results. The exact composition of the paint or the date of application is not known. There are no changes in appearance that are marked enough or consistent enough to definitely indicate any effects that might not have occurred in normal service. The results of the examination of the markings are shown in Table III.

(c) Tests - Manifold Pressure Gage

(1) Scale Error at Room Temperature - Acceptable. (See note in Table IV.)

A. The gage was connected to a mercury manometer, the pressure adjusted and the indicator reading noted. The errors obtained are shown in Table IV.

(2) Friction - Unsatisfactory.

A. This test was run in conjunction with the scale error test. The indicator reading at several of the test points was noted before and after tapping. The difference in the two readings or friction error was between 0.5 and 0.7 inch of mercury. The tolerance is 0.5 inch of mercury.

(d) Oil Pressure Gage

(1) Scale Error at Room Temperature - Satisfactory.

A. The gage was connected to a dead weight tester and weights added to give the desired pressure and the indicator reading noted. The errors obtained are shown in Table V.

(2) Friction - Satisfactory.

A. This test was run in conjunction with the scale error test. There was no change in indication observed after tapping at each of the test points. The tolerance is 5.0 pounds per square inch.

(e) Hydraulic Pressure Gage

(1) Scale Error at Room Temperature - Acceptable.

A. The gage was connected to a dead weight tester and weights added until the desired pressure was obtained. Additional weights were added and then weight was slowly removed until the pressure had decreased to the desired test point. Readings were taken at the test points under conditions of increasing and decreasing pressure. The errors obtained are shown in Table VI.

(2) Friction - Satisfactory.

A. This test was run in conjunction with the scale error test. There was no change in indication observed after tapping at each of the test points. The tolerance is 50 pounds per square inch.

(f) Tachometer Indicator

(1) Scale Error at Room Temperature - Satisfactory.

A. The tachometer indicator was connected to a test generator and the generator operated at shaft speeds adjusted so that the speed was increased to each of the desired test points and then in turn decreased to each of the points. The errors obtained are shown in Table VII.

(2) Friction - Satisfactory.

A. The indicator readings were noted before and after tapping. Errors obtained are shown in Table VIII.

B. At each of the test points of the scale error at room temperature test, the indicator pointer was observed for oscillation. Results obtained are shown in Table IX.

(g) Tachometer Generator

(1) Continuity - Satisfactory.

A. The stator windings were checked for continuity between the A, B and C electrical connector pins and between each of the pins and the generator frame. There were no signs of discontinuity. The resistance in each of the three windings was measured and agreed within 0.1 ohm. The allowable tolerance is 1.0 ohm.

(2) Phase Rotation - Satisfactory.

A. The generator was connected to a test indicator. The test indicator gave a positive reading when the generator shaft was rotated in a counterclockwise direction.

(3) Voltage - Satisfactory.

A. The generator was operated at a drive shaft speed of 1250 revolutions per minute with a load across the output terminals of three 40 ohm resistances connected in a Y. The voltage measured across the generator terminals was 18 volts in all three cases. The tolerance is not to exceed 21 volts. With a drive shaft speed of 300 RPM the voltage measured was between 3.5 and 3.7 volts. The tolerances at 300 RPM is not less than 3.5 volts.

(h) Fuel Quantity Indicator

(1) Scale Error at Room Temperature - Unsatisfactory.

A. The fuel quantity indicator was connected to the Liquidometer master test unit EA310; a transparent master dial was placed over the indicator cover glass,and each of the four units tested in turn. The errors obtained are listed in Table X.

(2) Friction - Unsatisfactory.

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A. The indicator readings were noted before and after tapping. The errors obtained are listed in Table XI.

(3) Note - Difficulty was encountered in removing the fuel quantity indicator from the airplane. The AN connector plug was frozen to the receptacle and later had to be cut off. The indicator case was broken open above and below the AN connector receptacle during removal from the airplane. It will be noted from the room temperature scale errors that the center tank unit, which was indicating correctly at the full indication was within tolerance at all of the other test points. Furthermore, if allowance were made for a full point adjustment for each of the other three elements, only one point might be in excess of tolerance.

(i) Fuel Quantity Transmitters

(1) Scale Error at Room Temperature - Unsatisfactory.

A. Each of the three fuel quantity transmitters was connected to the indicator from the airplane and tested for operation. (There were only three, since there was no droppable tank on the airplane. They were tested with the indicator from the airplane because the master indicator of test unit EA310 was not operating properly.) All three gave an indication which varied uniformly from empty to full as the float arm was moved through its approximate normal range. A scale error calibration was made with only one unit because the float was missing from one of the other two units, and the float arm sheared off of the third unit. The two units were apparently damaged during removal from the airplane. The float positions corresponding to empty and full were obtained from the Handbook of Overhaul Instructions for Liquidometer Fuel Gage Systems AN-05-65A-G. The intermediate points were obtained as a fraction of this total travel. The transparent master dial was placed over the indicator cover glass for the test. The errors obtained are listed in Table XII.

(j) Engine Gage Unit

(1) Scale Error at Room Temperature - Satisfactory.

A. Oil Pressure - The oil pressure gage was connected to a dead weight tester and weights added to give the desired pressure and the indicator reading noted. The errors obtained are shown in Table XIII.

B. Fuel Pressure - The fuel pressure element was also tested with a dead weight tester. The errors obtained are shown in Table XIV.

C. Oil Temperature Thermometer - A decade resistance box was connected across the resistance bulb terminals of the indicator, and with 28.5 volts applied to the terminals the resistance was adjusted to the desired value for the corresponding test indication and the indicator reading noted. The test was then repeated with 14.25 volts applied to the terminals. The errors obtained are shown in Table XV.

(2) <u>Friction</u> - Satisfactory.

A. In conjunction with the scale error at room temperature tests, the indicator readings were noted before and after tapping. The maximum change in indication was 1.0 psi for the oil pressure gage, 0.2 psi for the fuel pressure gage, and 3.0°C. for the thermometer. The allowable tolerances are 3.0 psi, 0.4 psi and 4.0°C., respectively.

(3) <u>Position Error</u> - Satisfactory.

A. With an indication of approximately mid-scale on each of the three units in turn, the change in indication was noted as the indicator was rotated 90° to the right and then 90° to the left. The maximum change in indication was 1.0 psi for the oil pressure gage, 0.3 psi for the fuel pressure, and 1.0°C. for the thermometer. The allowable tolerances are 3.0 psi, 0.3 psi and 4.0°C., respectively. On a further check of the thermometer with the voltage off, the indicator pointer was off scale in the vertical position and remained off scale with no change in pointer position when rotated 90° to the left and 90° to the right.

(k) <u>Temperature Indicators</u>

(1) <u>Scale Error at Room Temperature</u> - Satisfactory.

A. The two temperature indicators were tested in the same manner as the thermometer of the Engine Gage Unit. Results obtained are shown in Table XVI.

(2) <u>Friction</u> - Satisfactory.

A. In conjunction with the scale error test, the indicator reading was noted at each test point before and after tapping. The maximum change in indication was 2° at each of the four tests. The allowable tolerance is 4°.

(3) <u>Position Error</u> - Satisfactory.

A. With no voltage applied each of the indicators was rotated first 90° to the left and then 90° to the right from its normal vertical position. In each case the pointer remained slightly off scale at the low temperature end.

B. The test was repeated with 28.5 volts applied and an indication setting corresponding to the 30° test point. Results obtained are shown in Table XVII.

(l) Temperature Bulbs - Both of the Weston bulbs were heavily corroded and one of these bulbs was bent at the connector shoulder and found to have an open circuit. It could not be tested. The test results for the operative Weston bulb and for the Edison Splitdorf bulb are as follows:

(1) Bulb Resistance - Satisfactory.

A. The resistance of each bulb was measured with a Wheatstone Bridge with 1.5 volts across the bulb at temperatures of -50°C., 0°C., +120°C. and +170°C. The bulbs were immersed to the top of the attaching thread in an agitated liquid bath. A bath of dry ice and alcohol was used at -50°C., ice and water at 0°C., and an oil bath at 120°C. and 170°C. Results obtained are shown in Table XVIII.

(m) Cylinder Temperature Indicator

(1) Scale Error at Room Temperature - Acceptable.

A. Wheeler Tester, AN Model 88-T-880-100 was connected across the indicator. The tester is essentially a potentiometer with a source of voltage. When the tester is set to a desired test point it establishes an EMF across the indicator equivalent to the EMF that would be obtained from a thermocouple at a temperature corresponding to that of the test point. Results obtained are shown in Table XIX.

(2) Friction - Satisfactory.

A. In conjunction with the scale error at room temperature, the indicator readings were noted at each test point before and after tapping. The maximum change in indication was 6°C. The allowable tolerance is 15°C.

(3) Position Error - Unsatisfactory.

A. With the indicator on open circuit, it was turned from the vertical 90° to the left and 90° to the right and the change in indication noted. Results obtained are shown in Table XX.

Note: The engine cylinder thermocouple was not available for testing.

5. CONCLUSIONS

The examination and test results do not indicate any damage or effects of any particular significance. Of the eleven types of instruments tested, six were operating satisfactorily, two were satisfactory with allowance for end point adjustments, one gave small errors in excess of the allowable tolerance, and two gave excessive errors. The latter two were the fuel quantity gage indicator and transmitter.

6. **CATEGORY II - FLIGHT INSTRUMENTS**

METHOD

(a) A list and description of flight instruments tested is shown in Table XXI.

(1) Tests

A. The instruments were tested in accordance with the following specifications:

Altimeters: AN-A-30 Amend -2 - dated 4 Jan 46.
Airspeed Indicator = Sq - 80 with specification Notice #3 dated 18 Mar 43.
Rate-of-Climb Indicator: AN-I-33 dated 23 Feb 45.

B. In each case the individual tests, generally comprising the following tests, were performed:

I. Examination of Instrument
II. Leakage
III. Room Temperature Scale Error Test
IV. Friction Test (where applicable)

7. **RESULTS**

(a) Examination

(1) The external appearance of the four flight instruments was in no way different from that of any which might have been in use for a long period of time. A discoloration of the paint and the dial-face markings had no visible effect on the properties of the luminescent paint when compared, in a darkroom and under ultraviolet light, with an instrument of the same stock number and manufacturer.

(2) The Eclipse altimeter had a range of 0 - 35,000 feet. The Kollsman altimeter had a range of 0 - 50,000 feet. The Kollsman altimeter had a plastic plug which had been broken off in its static opening. This had to be drilled out before tests could be conducted on this instrument.

(3) The range of the airspeed indicator was 30 - 430 knots and that of the rate-of-climb indicator, 0 - 6,000 feet per minute.

(b) Tests

(1) Eclipse Altimeter - AN Part No. 5761-1

[redacted]

A. Case Leakage Test - Satisfactory.

I. Data obtained is shown in Table XXII.

B. Scale Error Test, Room Temperature - Unsatisfactory.

I. Data obtained is shown in Table XXIII.

C. Hysterisis Test - Satisfactory.

I. Data obtained is shown in Table XXIV.

(2) Kollsman Altimeter - AN Part No. 5760-2

A. Case Leakage Test - Unsatisfactory.

I. Data obtained is shown in Table XXV.

B. Scale Error Test, Room Temperature - Unsatisfactory.

I. Data obtained is shown in Table XXVI.

C. Hysterisis Test - Satisfactory.

I. Data obtained is shown in Table XXVII.

(3) Airspeed Indicator

A. Case Leakage Test - Satisfactory.

I. Data obtained is shown in Table XXVIII.

B. Diaphragm Capsule Leakage Test - Satisfactory.

I. Data obtained is shown in Table XXIX.

C. Scale Error Test, Room Temperature - Unsatisfactory.

I. Data obtained is shown in Table XXX.

D. Friction Test - Satisfactory.

I. Data obtained is shown in Table XXXI.

(4) Rate-of-Climb Indicator

A. Case Leakage Test - Satisfactory.

I. Data obtained is shown in Table XXXII.

B. Scale Error Test, Room Temperature - Satisfactory.

I. Data obtained is shown in Table XXXIII.

[redacted]

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8. CONCLUSIONS

(a) Generally, all four instruments operated satisfactorily.

(b) The excessive scale errors in the two altimeters and the airspeed indicator might be encountered in similar instruments which had been in service use for some time and had not been exposed to atomic radiation and other phenomena coincidental with Operation CROSSROADS.

(c) Although the discoloration of the paint on the dial faces was readily visible in daylight, it had no visible effect on the properties of the paint when viewed in darkness or under ultraviolet light. Similar discoloration has been noted in old instruments which had been kept in the laboratory.

(d) It is concluded that exposure to atomic radiation had no effect on this group of instruments.

9. CATEGORY III - MAGNESYN REMOTE INDICATING COMPASS EXAMINATION

This instrument consists of two components: a transmitter, AN Part No. 5730-3, Serial No. 214277 and an indicator, AN Part No. 5730-2, Serial No. 221614. Both components were manufactured by the Eclipse-Pioneer Division, Bendix Aviation Corporation, Teterboro, New Jersey. When removed from the aircraft, the instrument had the appearance of one which had been in service use for a long period of time, but, except for a cracked cover glass on the indicator, there was no visible evidence of damage. Both components were fully operative.

10. METHOD

(a) The compass was tested in accordance with Specification AN-C-138. Only the most important performance tests were conducted, since these tests revealed the compass to be in good condition, and nothing more was to be learned by further tests. The following tests were performed:

(1) Scale Error

  A. Transmitter
  B. Indicator

(2) Time of Swing - Room Temperature
(3) Compass Error with Compensator Removed
(4) Compensator Range
(5) Compensator Error
(6) Tilt Error
(7) Damping

(8) Swirl
(9) Vibration Error

All tests were conducted exactly as described in Specification AN-C-138.

11. RESULTS

(a) Transmitter Scale Errors - The transmitter scale errors were determined at intervals of 30° using a master test indicator. The average error without regard to sign was 0.4° with a spread of 1.9°, and the maximum error of +1.3° occurred at a heading of 090. The maximum permissible error is 3° with a spread of 3°.

(b) Indicator Scale Errors - The indicator scale errors were determined at intervals of 30° using a master test transmitter. The average error without regard to sign was 0.4° with a spread of 1.8°, and the maximum error of +1.25° occurred at a heading of 030. The maximum permissible error is 3° with a spread of 4°.

(c) Time of Swing - Room Temperature - The compass was set to north and the magnetic element then displaced 30° first in one direction and then in the other direction by means of an external magnet. The time required for the indication to return to within 5° of north after the magnet was suddenly removed was noted. The average time for six tries, three in each direction was 2.9 seconds. The maximum permissible time is 5 seconds.

(d) Compass Error with Compensator Removed

(1) The transmitter and indicator were connected and scale errors determined at intervals of 30° for both clockwise and counterclockwise rotation of the transmitter. The average error without regard to sign was 0.7° with a spread of 2.25°, and the maximum error of 1.8° occurred on a heading of 180. The maximum permissible error is 3° with a spread of 4°.

(2) This test was repeated with a second indicator connected in parallel. Readings were taken only of the indicator under test. The average error was 1.3° with a spread of 5°. The maximum error was 2.25° and occurred on four headings. The maximum permissible error is 3° with a spread of 6°.

(e) Compensator Range and Compensator Error - The maximum range of compensation for the N-S compensator was 15.75° on each side of north, and for the E-W compensator the maximum range was 16.5° on each side of west. These fall within the allowed values of 15 to 20°. The error introduced by the N-S compensator was 1.25° and the error introduced by the E-W compensator was 2.25°. The last value is slightly greater than the tolerance of 2°.

(f) Tilt Error - The errors caused by tilting the transmitter 10° in any direction on a number of headings was noted on a master test indicator. The maximum tilt error was 4.25° exceeding slightly the tolerance of 4°.

(g) Damping and Swirl - The maximum overswing of the pointer of the master test indicator was 11.5° which is less than the 13° allowed. The swirl was found to be too small to measure.

(h) Vibration Error - Both the transmitter and indicator were mounted on a vibration stand. The double amplitude of the vibration was .009 inch and the frequency was varied from 500 CPM to 3000 CPM. The maximum pointer oscillation was 1°, occurring at a frequency of 1800 CPM. The maximum change of heading was 2° and occurred at a frequency of 2800 CPM.

12. CONCLUSIONS

No damage to the compass system was evident that could be attributed to its exposure to atomic radiation.

13. RECOMMENDATIONS

No recommendations are necessary.

LIST OF ENGINE INSTRUMENTS TESTED

ITEM NO.	TITLE	AN STOCK NO. R88-	MANUFACTURER	MANUFACTURER'S PART NO.	MANUFACTURER'S SERIAL NO.
1	Manifold Pressure Gage	G-773-100	Manning-Maxwell-Moore	6748-267	A-13203
2	Oil Pressure Gage	G-885	Northern Engraving	D-103	52534
3	Hydraulic Pressure Gage	G-620	Northern Engraving	D-118	*
4	Tachometer Indicator	I-2385	General Electric	8DJ13ACX-27	1136852
5	Tachometer Generator	G-1335	General Electric	2CM-5ABW-21	2170566
6	Fuel Quantity Indicator	I-2121	Liquidometer	EA140-4	N288S-15965**
7	(3) Fuel Quantity Transmitters	T-2770	Liquidometer	EA65-141	NOA(S)-2616** N288S-15965** N288S-15966**
8	Engine Gage Unit	G-1020-10	Thomas A. Edison	33351	NOS-93065 **
9	Temperature Indicator Temperature Indicator	I-2720 I-2720-10	Electric Auto-Lite Motometer	10283A 10498A	6074 10435
10	(2) Temperature Bulbs Temperature Bulb	B-890 B-890	Weston Edison Splitdorf	106346 B2201	* *
11	Cylinder Temperature Indicator	I-2650	Lewis Engineering	17AT4P	1711

* No serial number or contract number on instrument.
** Contract number on instrument; no serial number on instrument.

TABLE I

DESCRIPTION OF ENGINE INSTRUMENTS TESTED

ITEM NO.	TITLE	RANGE	TYPE MECHANISM	APPLICABLE AN SPEC.
1	Manifold Pressure Gage	10-75 Inches Hg.	Non-Electric Diaphragm and Leverage	AN-G-9a
2	Oil Pressure Gage	0-200 Lbs./In.^{2}	" " Bourdon Tube and "	AN-G-2c
3	Hydraulic Pressure Gage	0-2000 Lbs./In.^{2}	" " " " " "	" " "
4	Tachometer Indicator	0-4500 RPM	Synchronous Motor with Magnetic Drag Coupling to Indicating Element	AN-I-3b
5	Tachometer Generator		Three Phase Generator	AN-G-34
6	Fuel Quantity Indicator	4 Unit - Left and Right 0-100 gals. Center 0-150 gals. Droppable 0-275 gals.	28 Volt DC Ratiometer - 3 Coils acting on a Magnetic Rotor (Liquidometer 300 Degree System)	AN-G-19a
7	Fuel Quantity Transmitter		Resistance Strip and Moveble Arm (Potentiometer)	AN-G-19
8	Engine Gage Unit -	3 Mechanisms		AN-G-18a
	Oil Pressure	0-200 Lbs./In.^{2}	Non-Electric Bourdon Tube and Leverage	
	Fuel Pressure	0-25 Lbs./In.^{2}	Non-Electric Differential of Two Bourdon Tubes	
	Temperature Indicator	-70°C. to +150°C.	See Temperature Indicators below	
9	Temperature Indicators	-70°C. to +150°C.	28 Volt DC Modified Wheatstone Bridge. Indicator contains 3 fixed resistance arms and D'Arsonval type movement.	AN-I-34
10	Temperature Bulbs		Bulb contains resistance which varies with temperature and is fourth arm of bridge.	AN-B-19
11	Cylinder Temperature Indicator	0° - 350°C.	D'Arsonval type mechanism activated by EMF from copper-constantan thermocouple.	AN-I-6a

TABLE II

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[redacted]

RESULTS OF EXTERNAL EXAMINATION OF POINTER AND DIAL MARKINGS

ITEM NO.	INDICATOR	TYPE* PAINT	APPEARANCE UNDER DAYLIGHT	APPEARANCE UNDER ULTRAVIOLET	APPEARANCE AFTER EXTINGUISHING LIGHT IN DARK ROOM
1	Manifold Pressure	1	Slightly Faded	Bright	Fades out immediately
2	Engine Gage Unit	1	Good	Bright	Fades out immediately
3	Temperature (I-2720-10)	1	Slightly Faded	Slightly Faded	Fades out immediately
4	Oil Pressure	2	Some Discoloration	Slightly Faded	After 10 minutes pointer still glows; numerals very faint.
5	Hydraulic Pressure	2	Good	Bright	After 10 minutes pointer and numerals still glow.
6	Tachometer	2	Slightly Faded	Slightly Faded	After 10 minutes pointer bright; numerals faint.
7	Temperature (I-2720)	2	Good	Bright	After 10 minutes pointer bright; numerals faint.
8	Cylinder Temperature	2	Slightly Faded	Slightly Faded	After 10 minutes pointer fair; numerals very faint.
9	Fuel Quantity	3	Good	Bright	After 10 minutes pointer faint; numerals bright.

* The type of paint is listed along with the ASO stock number in the Class 88 stock catalogue first edition of Jan 45 and the second edition of Nov 46 as follows:

1. In each case in both editions this is listed as yellow fluorescent paint for major markings with minor markings in non-luminescent paint, color Munsell green (G) 6/6.
2. With the exception of the tachometer (which is not listed in the first edition) all of the remaining indicators (type 2 paint) are listed as having green fluorescent paint for the major dial markings. The second edition lists each of these as having green phosphorescent paint for the major dial markings. Some of these markings may be of faintly radioactive material.
3. In both editions this is listed as green radioactive paint for the major dial markings with fluorescent paint for the minor markings. The paint on the pointer of this instrument, if radioactive at all, is only very faintly so, and is almost invisible, while the dial markings remain bright.

TABLE III

[redacted]

[redacted]

MANIFOLD PRESSURE GAGE, SCALE ERROR AT ROOM TEMPERATURE

PRESSURE INCHES Hg.	ERROR * INCHES Hg.	TOLERANCE INCHES Hg.
30	-1.9	0.3
25	-1.8	0.4
20	-1.6	0.4
15	-1.8	0.5
10	-2.2	0.6
20	-1.8	0.4
30	-1.8	0.3
35	-1.9	0.3
40	-1.9	0.3
45	-2.2	0.3
50	-1.5	0.4
55	-1.9	0.4
60	-2.0	0.5
65	-2.0	0.5
70	-2.0	0.6
75	-2.2	0.6
70	-2.2	0.6
60	-1.8	0.5
50	-1.6	0.4
40	-1.8	0.3
30	-1.8	0.3

NOTE: There would appear to be a shift in calibration, and if zero adjustment were made all points should be within tolerance.

* Errors underlined are in excess of tolerance.

[redacted]

TABLE IV

[redacted]

OIL PRESSURE GAGE, SCALE ERROR AT ROOM TEMPERATURE

PRESSURE PSI	ERROR PSI	TOLERANCE PSI
0	0	3
10	0	3
20	+1	3
40	+1	3
60	+1	3
80	0	3
100	0	5
120	-1	5
140	-1	5
160	-1	5
180	-2	5
200	-2	5

TABLE V

HYDRAULIC PRESSURE GAGE, SCALE ERROR AT ROOM TEMPERATURE

TEST PRESSURE PSI	INCREASING ERROR * PSI	DECREASING ERROR * PSI	TOLERANCE PSI
0	+100	+100	30
200	+100	+100	30
400	+100	+120	50
600	+100	+120	50
800	+100	+120	50
1000	+100	+110	50
1200	+ 80	+100	50
1400	+ 80	+ 90	50
1600	+ 60	+ 70	50
1800	+ 55	+ 55	50
2000	+ 50	+ 50	50

NOTE: If a zero adjustment were made all points should be within tolerance.

* Errors underlined are in excess of tolerance.

[redacted]

TABLE VI

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[redacted]

TACHOMETER INDICATOR, SCALE ERROR AT ROOM TEMPERATURE

TEST POINT RPM	INCREASING ERROR PSI	DECREASING ERROR PSI	TOLERANCE PSI
0	- 5	-10	15
600	-20	-20	25
1000	-10	-10	25
1400	-10	-10	25
1800	-15	-10	25
2000	-15	-10	25
2200	-20	-15	25
2400	-15	-15	25
2600	-20	-15	25
2800	-20	-15	25
3000	-15	-10	25
3200	-20	-20	30
3600	-20	-15	30
4000	-15	-10	40
4400	-25	+20	40

TABLE VII

TACHOMETER INDICATOR, FRICTION ERROR AT ROOM TEMPERATURE

TEST POINT RPM	ERROR RPM	TOLERANCE RPM
0	0	25
1000	0	15
2600	0	15
3600	-5	15

TABLE VIII

TACHOMETER INDICATOR, OSCILLATION AT ROOM TEMPERATURE

TEST POINTS RPM	MAXIMUM OSCILLATION RANGE RPM	TOLERANCE RPM
0 to 800	10	20
800 to 4500	5	10

TABLE IX

[redacted]

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[redacted]

FUEL QUANTITY INDICATOR, SCALE ERROR AT ROOM TEMPERATURE

TEST POINT	ERROR IN PERCENT OF FULL SCALE *				TOLERANCE PERCENT OF FULL SCALE
	LEFT	RIGHT	CENTER	DROPPABLE	
Empty	0	0	0	0	0
1/8 Full	+1.3	+0.7	0	+0.7	1-1/2
1/4 Full	+2.0	0	0	0	1-1/2
1/2 Full	0	-2.0	+0.7	-0.7	1-1/2
3/4 Full	-2.0	-4.7	-1.3	-2.7	1-1/2
Full	-0.7	-2.7	0	-2.0	0

* Errors underlined are in excess of tolerance.

TABLE X

FUEL QUANTITY INDICATOR, FRICTION ERROR AT ROOM TEMPERATURE

TEST POINT	ERROR IN PERCENT OF FULL SCALE *				TOLERANCE PERCENT OF FULL SCALE
	LEFT	RIGHT	CENTER	DROPPABLE	
Empty	1.3	1.3	**	1.3	1.0
1/8 Full	1.3	3.3	1.3	0.7	1.0
1/4 Full	1.3	2	2	1.3	1.0
1/2 Full	1.3	2	1.3	1.3	1.0
3/4 Full	2	2.7	1.3	1.3	1.0
Full	0.7	1.3	1.3	0.7	1.0

** Sticks off scale.

* Errors underlined are in excess of tolerance.

TABLE XI

[redacted]

[redacted]

FUEL QUANTITY TRANSMITTER,
SCALE ERROR AT ROOM TEMPERATURE

TEST POINT	ERROR IN PERCENT OF FULL SCALE *	TOLERANCE IN PERCENT OF FULL SCALE
Empty	+ 6.7	0
1/8 Full	+10.7	1-1/2
1/4 Full	+ 3.3	1-1/2
1/2 Full	+ 5.0	1-1/2
3/4 Full	+ 2.0	1-1/2
Full	- 1.7	0

NOTE: No adjustments were made for the empty and full indicators.

* Errors underlined are in excess of tolerance.

TABLE XII

ENGINE GAGE UNIT, OIL PRESSURE INDICATOR,
SCALE ERROR AT ROOM TEMPERATURE

PRESSURE PSI	ERROR PSI	TOLERANCE PSI
0	-2	3
50	-3	3
100	-1	5
150	-1	5
200	-1	5

TABLE XIII

ENGINE GAGE UNIT, FUEL PRESSURE INDICATOR,
SCALE ERROR AT ROOM TEMPERATURE

PRESSURE PSI	ERROR PSI	TOLERANCE PSI
0	+0.1	0.2
5	+0.3	0.3
10	+0.4	0.4
15	+0.3	0.5
20	+0.3	0.5
25	+0.1	0.5

[redacted]

0 1711 TABLE XIV

[redacted]

ENGINE GAGE UNIT, OIL TEMPERATURE THERMOMETER INDICATOR, SCALE ERROR AT ROOM TEMPERATURE

TEST POINT DEGREES C.	ERROR IN DEGREES C. 28.5 VOLTS	ERROR IN DEGREES C. 14.25 VOLTS	TOLERANCE DEGREES C.
-70	-1	-1	4
-50	-3	-1	4
-30	-1	0	4
-10	-1	0	4
0	-1	0	4
10	-2	0	4
30	+1	+2	4
50	-1	-1	4
80	-1	0	4
100	+1	+2	4
120	0	+1	4
150	0	+1	5

TABLE XV

TEMPERATURE INDICATORS, SCALE ERROR AT ROOM TEMPERATURE

TEST POINT DEGREES C.	ERROR DEGREES C. AT 28 VOLTS		ERROR DEGREES C. AT 14.25 VOLTS		TOLERANCE DEGREES C.
	IND. #1	IND. #2	IND. #1	IND. #2	
-70	-1	0	0	-1	3.0
-50	0	-1	0	-2	3.0
-30	0	-2	0	-1	3.0
-10	0	-2	0	0	3.0
0	0	-2	+1	0	3.0
10	0	-2	0	0	3.0
30	0	-2	0	-1	3.0
50	-1	-2	-1	-2	3.0
80	-1	-3	0	-2	3.0
100	+1	-2	+1	-2	3.0
120	+1	-3	+1	-2	3.0
150	+2	-2	+2	-1	3.0

TABLE XVI

[redacted]

TEMPERATURE INDICATORS, POSITION ERROR AT ROOM TEMPERATURE

	ERROR DEGREES C. 90° L.	ERROR DEGREES C. 90° R.	TOLERANCE DEGREES C.
Indicator #1	-1	-1	4.0
Indicator #2	+2	0	4.0

TABLE XVII

TEMPERATURE BULBS, BULB RESISTANCE

TEMPERATURE DEGREES C.	ERROR DEGREES C. WESTON	ERROR DEGREES C. EDISON	TOLERANCE DEGREES C.
-50	-0.4	+0.14	0.4
0	+0.27	+0.36	0.4
+120	-0.05	-0.2	0.6
+170	-0.36	-0.45	0.8

TABLE XVIII

CYLINDER TEMPERATURE INDICATOR, SCALE ERROR AT ROOM TEMPERATURE

TEST POINT DEGREES C.	ERROR * DEGREES C.	TOLERANCE DEGREES C.
25	0	8
50	0	8
100	0	8
150	- 3	8
200	- 6	8
250	- 8	8
300	-10	8
350	-12	8

NOTE: *Errors underlined are in excess of tolerance.

TABLE XIX

CYLINDER TEMPERATURE INDICATOR, POSITION ERROR AT ROOM TEMPERATURE

INDICATOR READING VERTICAL	ERROR DEGREES C. *		TOLERANCE DEGREES C.
	90° L.	90° R.	
26°C.	-4	+13	10

NOTE: *Error underlined is in excess of tolerance.

TABLE XX

LIST AND DESCRIPTION OF FLIGHT INSTRUMENTS TESTED

(a) Instrument: Altimeter
Manufacturer: Eclipse-Pioneer Division of Bendix Aviation Corp.
Contract: 93190
Manufacturer's Part No.: 1583-24-A
Manufacturer's Serial No.: 4601
AN Part No.: 5761-1

(b) Instrument: Altimeter
Manufacturer: Kollsman Instrument Division of Square D Co.
Contract: 93189
Federal Standards Stock Catalogue No.: 88-A-350
AN Part No.: 5760-2

(c) Instrument: Airspeed Indicator
Manufacturer: U. S. Gauge Co.
Contract: NOs-94174
Manufacturer's Part No.: AW-2-3/4-20-B
Federal Standards Stock Catalogue No.: 88-I-350

(d) Instrument: Rate of Climb Indicator
Manufacturer: Kollsman Instrument Division of Square D Co.
Contract: Noa(s) 553
Manufacturer's Part No.: 731-KN-08
Federal Standards Stock Catalogue No.: 88-I-751

TABLE XXI

[redacted]

ECLIPSE ALTIMETER, CASE LEAKAGE TEST RESULTS

ALTIMETER READING FEET	CHANGE IN READING DUE TO LEAK	TOLERANCE
18,000	15 ft. in 10 sec.	100 ft. in 10 sec.

TABLE XXII

ECLIPSE ALTIMETER, SCALE ERROR AT ROOM TEMPERATURE

STANDARD ALTITUDE FEET	SCALE ERROR * FEET	TOLERANCE FEET
0	-175	50
500	-170	50
1,000	-160	75
1,500	-190	75
2,000	-190	100
3,000	-170	100
4,000	-170	100
6,000	-145	100
8,000	-140	150
10,000	-120	150
12,000	-110	200
14,000	-130	200
16,000	-100	200
18,000	- 80	200
20,000	- 20	200
22,000	- 10	300
25,000	+ 10	300
30,000	+ 80	300
35,000	- 60	300

NOTE: *Errors underlined are in excess of tolerance.

TABLE XXIII

[redacted]

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ECLIPSE ALTIMETER, HYSTERESIS TEST RESULTS

TEST POINT STANDARD ALTITUDE FEET	HYSTERESIS ERROR FEET	TOLERANCE FEET
18,000	30	70
16,000	40	70
0	35	50

TABLE XXIV

KOLLSMAN ALTIMETER, CASE LEAKAGE TEST RESULTS

ALTIMETER READING FEET	CHANGE IN READING DUE TO LEAK *	TOLERANCE
18,000	300 ft. in 10 sec.	100 ft. in 10 sec.

NOTE: *Errors underlined are in excess of tolerance.

TABLE XXV

KOLLSMAN ALTIMETER, SCALE ERROR AT ROOM TEMPERATURE

STANDARD ALTITUDE FEET	SCALE ERROR * FEET	TOLERANCE FEET
0	-115	50
500	-120	50
1,000	-100	75
1,500	-140	75
2,000	-130	100
3,000	-120	100
4,000	-130	150
6,000	-155	150
8,000	-130	175
10,000	-190	175
12,000	-200	200
14,000	-250	225
16,000	-250	240
18,000	-320	275
20,000	-300	300
22,000	-300	340
25,000	-295	375
30,000	-160	450
35,000	+ 40	525
40,000	- 40	600
45,000	+ 70	675
50,000	-150	750

NOTE: *Errors underlined are in excess of tolerance.

TABLE XXVI

KOLLSMAN ALTIMETER, HYSTERISIS TEST RESULTS

TEST POINT STANDARD ALTITUDE FEET	HYSTERESIS ERROR FEET	TOLERANCE FEET
25,000	70	150
20,000	40	150
0	45	60

TABLE XXVII

[redacted]

AIRSPEED INDICATOR, CASE LEAKAGE TEST RESULTS

APPLIED PRESSURE	LEAKAGE INCHES OF MERCURY IN 10 SEC.	TOLERANCE INCHES OF MERCURY IN 10 SEC.
15" Hg. Vacuum	.1	0.2
10" Hg. Pressure	.05	0.2

TABLE XXVIII

AIRSPEED INDICATOR, DIAPHRAGM CAPSULE LEAKAGE TEST RESULTS

APPLIED PRESSURE	CHANGE IN POSITION OF POINTER DUE TO LEAK IN ONE MINUTE	TOLERANCE CHANGE IN ONE MINUTE
To cause full scale (430 kts.) deflection of pointer	No change	1 knot

TABLE XXIX

AIRSPEED INDICATOR, SCALE ERROR AT ROOM TEMPERATURE

AIR SPEED KNOTS	SCALE ERROR* - KNOTS UP	SCALE ERROR* - KNOTS DOWN	TOLERANCE KNOTS
40	7.0	9.0	1.5
60	4.5	6.0	1.5
80	4.0	5.5	1.5
100	3.5	4.5	1.5
120	3.0	4.0	1.5
140	3.0	4.0	1.5
160	3.0	3.5	1.5
180	3.0	3.5	1.5
200	3.0	3.0	1.5
220	4.0	5.0	2.0
260	4.0	4.0	2.0
300	4.0	5.0	2.0
340	3.0	3.0	2.0
380	2.0	2.5	2.0
400	1.0	3.0	2.0
430	1.0	1.5	3.0

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NOTE: The zero reading was approximately 15 knots, which is an extremely large zero shift.

[redacted] *Errors underlined are in excess of tolerance.

TABLE XXX

AIRSPEED INDICATOR,
FRICTION TEST RESULTS

TEST POINT KNOTS	FRICTION KNOTS	TOLERANCE KNOTS
40	1.0	2.0
60	1.0	2.0
80	0.5	2.0
100	0.5	2.0
120	0.5	2.0
140	0.5	2.0
160	0.5	2.0
180	0.5	2.0
200	0.5	2.0
220	0.5	2.0
260	0.5	2.0
300	0.5	2.0
340	0.5	2.0
380	0	2.0
400	0	2.0
430	0	2.0

TABLE XXXI

RATE OF CLIMB INDICATOR,
CASE LEAKAGE TEST RESULTS

APPLIED PRESSURE	LEAKAGE INCHES OF MERCURY IN 10 SEC.	TOLERANCE INCHES OF MERCURY IN 10 SEC.
15" Mercury Vacuum	0	0.1
10" Mercury Pressure	0	0.1

TABLE XXXII

RATE OF CLIMB INDICATOR,
SCALE ERROR AT ROOM TEMPERATURE

STANDARD ALTITUDE INTERVAL FEET	TEST RATE FT. PER MIN.	SCALE ERROR * FT. PER MIN. CLIMB	DIVE	SCALE ERROR TOLERANCE FT. PER MIN.
2,000 to 4,000	500	- .8	+ 3	100
	1,000	+ 12	- 19	200
	2,000	+ 26	- 31	300
	3,000	-225	-141	300
	4,000	-350	-161	400
	5,000	-405	-170	500
15,000 to 17,000	2,000	+ 17	- 41	300
	4,000	-379	-240	400
28,000 to 30,000	2,000	+ 42	- 41	300
	4,000	-412	-138	400

NOTE: *Error underlined is in excess of tolerance.

[redacted]

REPORT NO. AML NAM AE 540001
SECTION D

NAVY DEPARTMENT
BUREAU OF AERONAUTICS

REPORT ON

TESTS OF MATERIALS FROM OPERATION CROSSROADS, TARGET AIRPLANE, TBM-3E, BUNO 69169

BY

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NAVAL AIR MATERIAL CENTER PHILADELPHIA

Authorization . . . . BuAer Confidential ltr Aer-AE-45 C08267 of 29 Nov 46.

Dates of Test . . . . From Oct 47 to May 49.

Approved by . . . . J. H. Bowen, Jr. — Head, Chemical Engineering Div.

Approved by . . . . J. F. Hardecker — Head Engineer, Aero. Matls. Lab.

Approved by . . . . R. E. Clements, LCDR, USN — Superintendent, Aero. Matls. Lab.

DATE ISSUED 1 Apr 1950

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REFERENCES

(a) BuAer Confidential ltr Aer-AE-45 C08267 of 29 Nov 1946.

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[redacted]

REPORT NO. AML NAM AE 540001
SECTION D

ABSTRACT

(a) This is a report of tests conducted on the basic materials contained in an Operation CROSSROADS target airplane. These materials, fabrication of which formed the structure and component parts of the test airplane and accessories, were originally formulated and manufactured to withstand service usage. This usage does not include either exposure to extreme blast pressure, unshielded tropical weathering or atomic radiation. The test airplane was exposed to all three of these phenomena, in addition to previous service usage. In the main, standard specification tests were employed. Tests specific to certain materials were forgone in some instances, however, being supplanted by visual examination and on-the-spot qualitative tests conducted by experienced engineers, results being compared to similar tests previously run on non-radioactive materials.

(b) The report describes the damage suffered by certain materials, and the points of failure and the non-specification qualities of others. It discloses that, in so far as could be determined, the results are attributable to effects of phenomena other than atomic radiation.

[redacted]

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1. AUTHORIZATION

These investigations were authorized by ref (a).

2. OBJECT

These tests were conducted to determine the effects, if any, of atomic radiation on the materials contained in the structure and component parts of an aircraft which had been exposed to atomic radiation during Operation CROSSROADS.

3. DESCRIPTION

(a) These tests were conducted on the hydraulic and lubrication oil, hydraulic and mechanical components, metals, paint, plastic, rubber and textile products of Model TBM-3E airplane BuNo 69169.

(b) Samples of hydraulic oil and lubrication oil were removed from various points of the hydraulic system and engine of the test airplane. Since decontamination was impossible, readings were taken of each sample's radioactivity and the samples were shipped to the Chemistry Laboratory for tests against specifications. No data was available from the airplane's log regarding the exact specification of the hydraulic oil found in the airplane, so tests were run against hydraulic specifications found in the Erection and Maintenance manual for this model aircraft.

(c) The hydraulic and mechanical components of the aircraft were, in most cases, so badly damaged that removal from the aircraft would serve no useful purpose. They were, therefore, inspected and tested in place.

(d) Metal samples were taken exclusively from the outside skin of the fuselage. Duplicate samples were taken from the port and starboard sides. Since the port side of the airplane was exposed to the maximum amount of initial radiation flux and the starboard side was shielded by the rest of the plane, it was concluded that these samples would yield the best comparative information as to radiation effects on metallic components, or at least would be the best indicators for either the continuation or discontinuation of further investigations on these components. Comparative data was gathered both from similar tests run on similar virgin metal and from data gathered from previous metallurgical reports on similar non-radioactive metal.

(e) The paint on the airplane was examined at various points on the surface of the ship. As often as possible paints that had been facing zero point at Baker were compared with their opposites that had not been exposed to the direct flash. Also those which showed more residual radiation from fission product contamination were compared with areas showing less or no fission product contamination. Although some decontamination had been effected by Kwajalein weathering, these methods were considered the most valid to compare areas of maximum and minimum radiation exposure.

(f) Various articles of clear acrylic plastic were removed from the windows and cockpit enclosure. In this case, too, as nearly opposites as possible were obtained in order to gather comparative data. Further comparative data was gathered by obtaining duplicate samples from a stricken TBM-3E, BuNo 23602, and subjecting these to duplicate tests against specifications.

(g) Rubber samples were obtained from tires, inner tubes and self-sealing fuel cells of the airplane. Tests were run against standard specifications on these samples. Gasketing, tubing and shock mountings were inspected visually.

(h) All textile products in the airplane were so extensively damaged that their removal would serve no useful purpose. They were, therefore, examined in place.

4. METHOD

(a) Hydraulic and Lubrication Oil

(1) The hydraulic oil samples were tested against AN Specification AN-O-366.

(2) The lubrication oil was tested against AN Specification AN-VV-O-446.

(3) In both cases, the oil was checked for radioactivity before tests were begun. Then the oil was centrifuged, the residue washed and checked for radioactivity along with the supernatant oil.

(b) Hydraulic and Mechanical Components - Inasmuch as no laboratory tests were conducted on these components, the method is included under Results, Section (b).

(c) Metallurgical Specimens

(1) Tensile and Endurance Tests

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A. Specimens obtained from nearly identical locations on the port and starboard side were subjected to both tensile and endurance tests.

B. Virgin specimens of 24ST aluminum alloy were subjected only to tensile tests for comparative data.

(2) Corrosion Tests

A. Both unstressed specimens and specimens stressed to 75% of yield strength from both sides of the test airplane were subjected to a standard NaCl - H_2O_2 solution for a period of 7 days.

B. Similar tests were run on virgin 24ST aluminum alloy.

(3) Intergranular Corrosion Study - Samples of Alcoa and Reynolds Company 24ST sheet from both sides of the plane were subjected to tests to determine susceptibility to intergranular corrosion.

(d) Organic Protective Coatings

(1) The aircraft exterior surface was coated in accordance with specification requirements: i.e., Specification AN-P-656 primer and Specification AN-L-29 cellulose nitrate lacquer. The fabric surfaces were coated with cellulose acetate butyrate dope, Specifications AN-D-1 and AN-D-2.

(2) Standard visual examinations and tests were conducted along with chemical and spectrographic analyses to determine the composition of the dust or chalk found to be coating a portion of the finish.

(e) Plastics

(1) Various tests were performed in accordance with ANA Specifications AN-P-44a and AN-L-P-406a on various acrylic parts taken from both the test aircraft and a control aircraft, TBM-3E BuNo 23602, with, as nearly as could be determined, similar service history except exposure to atomic radiation.

(2) In this report, acrylic material taken from the test aircraft will be designated as Material A and acrylic material taken from the control aircraft, BuNo 23602, will be designated as Material B.

(3) Table I includes the sample number and describes the location in the aircraft from which each sample was obtained.

(4) Ultimate Tensile Strength - Tests were conducted on Materials A and B in accordance with Method 1011 of ANA Specification L-P-406a.

(5) Percent Elongation - Tests were conducted on Materials A and B in accordance with Method 1011 of ANA Specification L-P-406a.

(6) Index of Refraction - Tests were conducted on Materials A and B in accordance with Method F-50 of ANA Specification AN-P-44a.

(7) Angular Deviation - Tests were conducted on Materials A and B in accordance with Method 3041 of Specification L-P-406a.

(8) Percentage Light Transmission - Tests were conducted on Materials A and B in accordance with Method 3021 of Specification L-P-406a.

(9) Percentage haze - Tests were conducted on Materials A and B in accordance with Method 3021 of Specification L-P-406a.

(10) Rate of Burning - Tests were conducted on Materials A and B in accordance with Method 2021 of Specification L-P-406a. Due, however, to the possibility of air pollution and subsequent human ingestion of possible residual radiological contamination (the test samples had been decontaminated, monitored and declared "SAFE") during burning, Material A was burned in a ventilated hood.

(11) Flexural Deformation - Tests were conducted on Materials A and B in accordance with Method 2011 of Specification L-P-406a.

(12) Stress Craze - Tests were conducted on Materials A and B in accordance with Method 3053 of Specification L-P-406a, with the exception that no solvent was used. During part of this test the air conditioning system in the laboratory was shut down, thereby making the results of this test less valid than otherwise.

(13) Percentage Water Absorption - Tests were conducted on Materials A and B in accordance with Method 7031 of Specification L-P-406a.

(14) Specific Gravity - Tests were conducted on Materials A and B in accordance with Method F-5b of Specification AN-P-44a.

(f) Rubber

(1) Tire - Destructive tests to determine tensile strength and ultimate percent elongation was conducted on the port tire of the test aircraft. Tests were conducted in accordance with Federal Specification ZZ-R-601a.

(2) Inner Tube - Destructive tests to determine tensile strength and ultimate percent elongation were conducted on the port tire inner tube of the test aircraft. Tests were conducted in accordance with Federal Specification ZZ-R-601a.

(3) Self-Sealing Fuel Cell - Tests to determine the self-sealing properties of the main fuel cell were conducted as described in Report No. AML NAM AE 424714, Part I, Aromatic Fuel Resistant Rubber, Shrinkage in Grade 115/145 Fuel.

(4) Gasketing, Tubing and Shock Mounts - These components, in general, were so severely attacked by weather that detailed tests would have been inconclusive. They were inspected in place visually.

(g) Textiles

(1) Inspection of the aircraft assembly revealed various textile materials to be present showing varying amounts of deterioration.

(2) A canvas hatch cover, an instrument carrying case and two safety belts and shoulder harnesses were present in the radioman's compartment but all showed evidence of repeated water soaking. Also present were a safety belt and shoulder harness in the pilot's cockpit and the bombardier's compartment. These also showed evidence of extreme weathering, all fittings being severely corroded. A size 7 ensign of unknown history was found in the life raft compartment. It showed evidence of severe weathering, viz.: the fly was missing and the remaining fabric was tattered, frayed and discolored.

(3) Control surfaces of the tail assembly were fabric covered. However, since these surfaces had been exposed to severe uncontrolled and unknown tropical conditions for at least 15 months following Test Baker of CROSSROADS, it was decided that deterioration due to this weathering would mask any effects due to atomic radiation.

(4) Because of the well-known deterioration of textile products due to weathering and since no control samples with equivalent weather exposure were available, no tests were performed on any textiles contained in the aircraft.

(5) Project No. AML NAM AE 525036, reported on 3 Jun 47, revealed that no effect either in structural properties or operating characteristics could be noted in a Mark 2 life raft that had been subjected to atomic radiation during Test Able. When it is realized that accurate controls were available for this specimen whose history was known at least partially and no indication of radiation damage could be found, it is readily seen that tests on specimens such as those found in this test aircraft would have been meaningless.

5. RESULTS

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(a) Hydraulic and Lubrication Oil

(1) Results of radioactivity determinations on hydraulic oil samples are shown on Table II.

(2) Results of tests of hydraulic oil against Specification AN-O-366 are shown on Table III.

(3) Results of radioactivity determinations on lubricating oil samples are shown on Table IV.

(4) Results of tests of lubrication oil against Specification AN-VV-O-366 are shown on Table V.

(b) Hydraulic and Mechanical Components

(1) Due to the weathered and structurally-damaged condition of the airplane, in general, it was possible to actuate only a few of the hydraulic components.

(2) The starboard wing hydraulic system was found in fair condition, but the port wing was in bad shape and its hydraulic system was not operable. (The port wing had to be shored up to prevent its falling off when opened.) Several leaking joints were observed which appeared to be a result of distortion of structural members due to blast. Piston rods were moderately corroded on their exposed surfaces.

(3) The bomb-bay doors were actuated with the hand pump, and were observed to function normally.

(4) The starboard wing flap was actuated part way by the hand pump, but complete actuation was not obtained due to the bent condition of the flap and wing stub and corrosion on the exposed surface of the piston rod. The port wing flap was held shut by bracing, and fluid was leaking from joints when pressure was applied.

(5) Landing gear retracting cylinder rods were corroded on their exposed surfaces so that their actuation was not feasible.

(6) The selector valve, hand pump, and, in general, all parts not subjected to corrosion and physical damage inside the cabin were in operable condition.

(7) As it was observed (1) that the poor condition of the hydraulic system, in general, was due to corrosion and physical damage (probably from the blast, as noted), and (2) it could not be seen how effects of possible radiation damage could be separated from these other gross effects, further tests were discontinued.

(c) Metallurgical Specimens

(1) Tensile and Endurance Tests

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A. A summary tabulation of results of tensile and endurance tests is shown in Table VI.

B. Detailed tabulation of results of endurance tests is shown on Tables VII and VIII.

C. Plots of endurance strength are shown on Plates 1 and 2.

(2) Corrosion Tests

A. A summary tabulation of results of corrosion tests is shown on Table VI.

(3) Intergranular Corrosion Study

A. Photomicrographs of specimens subjected to intergranular corrosion tests are shown on Plates 3, 4, 5 and 6. The photomicrographs showed the material to be moderately susceptible to intergranular corrosion.

(d) Organic Protective Coatings

(1) The finish system on the aircraft was in good condition. Adhesion of the paint was very good; there was no evidence of checking; no blistering of the surface was noted on close inspection; no cracking or alligatoring of the finish could be found. The paint showed sign of considerable chalking, but determination of degree and reason for chalking was complicated by the presence, over a large part of the surface, of a rust-colored dust. This dust was presumably the residue of foamite which is known to have been sprayed on the Independence and also the airplane. Chemical and spectrographic analysis of this reddish dust revealed the strong presence of Aluminum Sulfate, one of the components of foamite.

(e) Plastics

(1) A comparison of the average values of results of tests on Material A and, similarly, on Material B, together with the requirements of the pertinent specification and whether or not the specification requirements are met or not met by the test materials is shown on Table IX. Also indicated is that material considered superior in each given test.

(2) Ultimate Tensile Strength - Results are shown on Table X.

(3) Percentage Elongation - Results are shown on Table XI.

(4) Index of Refraction - Results are shown on Table XII.

(5) Angular Deviation - Results are shown on Table XIII.

(6) Percentage Light Transmission - Results are shown on Table XIV.

(7) Percentage Haze - Results are shown on Table XV.

(8) Rate of Burning - Results are shown on Table XVI.

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(9) Flexural Deformation - Results are shown on Table XVII.

(10) Stress Craze - Results are shown on Table XVIII.

(11) Percentage Water Absorption - Results are shown on Table XIX.

(12) Specific Gravity - Results are shown on Table XX.

(f) Rubber

(1) Tire

A. The inboard side wall rubber showed a higher tensile strength and ultimate elongation than the outboard side wall (both from port tire). This, however, could not be attributed solely to atomic radiation. Both side walls had, no doubt, decreased considerably in tensile strength and ultimate elongation from their values at the time of manufacture. They were then probably about 2500 psi and 500%, respectively. The outboard side wall had been aged more rapidly because of more exposure to sunlight than the inboard side wall. This was apparent on examination of the surface of both tires. The outboard side walls of both tires showed more extensive sunlight cracking than the inboard side walls. This fact was reflected in the tensile strength values obtained.

B. Results of tests conducted on the port tire are shown on Table XXI.

(2) Inner Tube

A. The inner tube tested demonstrated normal tensile properties considering its age and service conditions encountered.

B. Results of tests conducted on the inner tube are shown on Table XXII.

(3) Self-Sealing Fuel Cell

A. The self-sealing properties of the fuel cell tested, when in contact with fuel at -20°F. was equal to the cells in current use in naval aircraft.

B. Results of tests conducted on the self-sealing fuel cell are shown on Table XXIII.

(4) Gasketing, Tubing and Shock Mounts Q 1711

A. Visual inspection of gasketing showed no deterioration that could be considered abnormal after the time of weather exposure of the airplane.

B. Tubing not exposed to direct sunlight was in normal condition. Weathered tubing was badly deteriorated, but this was considered normal.

C. Shock mounts, in most cases, maintained good tensile properties. Those exposed to weather showed considerable aging but this, also, was considered normal after a prolonged period of tropical weather exposure.

(d) Textiles

(1) Inasmuch as no tests were conducted on these components, the results are included under Method, Section (4).

6. CONCLUSIONS

(a) Hydraulic and Lubrication Oil

(1) Tests conducted on the hydraulic oil samples indicated that:

A. Very small amounts of contamination had entered the hydraulic system. No measurable alpha contamination was present.

B. After centrifuging, the samples tested contained little or no residual radioactivity. It is believed that further, or perhaps ultra, centrifuging would have removed this remainder.

C. Specification requirements were not met, assuming that the hydraulic oil in the airplane was AN-O-366. This, however, cannot be attributed to radiation effects. Hydraulic oil, upon long standing and, through leak and breaks in the system, oxidation and contamination (not necessarily radiological) will, in many cases, not meet specification requirements. It is believed that these factors played a major part in the non-specification qualities of the oil.

(2) Tests conducted on the lubricating oil showed that:

A. Considerable radiological contamination was present. After centrifuging, a negligible amount remained, its presence explainable in the same manner as that remaining in the hydraulic oil. (Section 6(a)(1)).

B. The lubricating oil did not meet specification requirements, assuming that it was AN-VV-O-366. This is presumably attributable to the same factors that caused the hydraulic oil samples to fail specification tests, and not due to effects of atomic radiation.

(b) Hydraulic and Mechanical Components - Considerable damage was suffered by the hydraulic and mechanical components of the test airplane. It is considered that this damage was caused by effects other than atomic radiation and no effects attributable to damage by atomic radiation were found.

(c) Metallurgical Specimens - An analysis of test results obtained indicated that there was no difference that could be considered conclusive between the results obtained from tests on samples from the starboard skin of the test aircraft as compared with results of samples from the port skin; nor was there any conclusive difference between the results obtained from tests on material from the test aircraft as compared with virgin material that might be attributed to effects of atomic radiation.

(d) Organic Protective Coatings - It is considered that degradation of the film had not occurred due to its exposure to atomic radiation.

(e) Plastics - There is no conclusive evidence to show that non-specification properties of the plastic samples tested were caused by exposure to atomic radiation.

(f) Rubber - There is no conclusive evidence to show that non-specification properties of the rubber samples tested were caused by exposure to atomic radiation.

(g) Textiles - No conclusion can be made regarding the textiles obtained from the aircraft. All textile materials were so severely damaged by weather that tests were not conducted. (See Method, Section (g).)

7. RECOMMENDATIONS

(a) It is recommended that if BuAer intends to continue investigations of this type, a much stricter control of sampling methods, exposure method and control samples be observed. As is readily seen in this report, possible effects of atomic radiation were masked completely by many indeterminates.

(b) It is, however, believed that definite constructive information might be obtained if this laboratory were given the project of determining the effects of atomic radiation on materials presently used in naval aircraft. In cooperation with, for instance, Oak Ridge facilities, definite control standards could be maintained, thereby rendering test results valid and conclusive.

(c) Leading from this, it is conceivable that materials of higher quality might be developed, thereby rendering naval aircraft less vulnerable to the effects of atomic radiation.

(d) It is, therefore, recommended that a project be established at NAES so that precisely controlled samples may be prepared and exposed in the pile at Oak Ridge, or, better still, Brookhaven National Laboratories (because of its proximity to Philadelphia). These samples then might be evaluated at NAES and compared with unexposed materials. Since the Aeronautical Materials Laboratory at NAES is the only laboratory of its kind in the service of BuAer with complete facilities to prosecute such an investigation, this project could be handled capably and expeditiously.

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PLASTIC SAMPLES FROM TEST AIRPLANE

SAMPLE NO.	DESCRIPTION	LOCATION IN AIRPLANE
A-1	Single curve, 1/8" acrylic	Cabin enclosure, top cover, starboard side, Station 81-107.
A-2	Flat, 3/16" acrylic	Gun turret, top half, port side, gunner facing aft, Station 134-146.
A-3	Flat, 1/8" acrylic	Gun turret, bottom half, port side, gunner facing aft, Station 134-146.
A-4	Single curve, 1/8" acrylic	Bombardier's compartment window, port side, Station 170-146.
A-5	Flat, .100" acrylic	Bombardier's compartment window, starboard side, Station 216-232.

PLASTIC SAMPLES FROM CONTROL AIRPLANE

SAMPLE NO.	DESCRIPTION	LOCATION IN AIRPLANE
B-1	See A-1	See A-1
B-2	See A-2	See A-2
B-3	See A-3	See A-3
B-4	See A-4	See A-4
B-5	See A-5	See A-5

[redacted]

TABLE I

READINGS TAKEN ON HYDRAULIC OIL SAMPLES

	SAMPLE 1 C/MIN. (NET)		SAMPLE 2 C/MIN. (NET)		SAMPLE 3 C/MIN. (NET)	
	BETA PLUS GAMMA	ALPHA	BETA PLUS GAMMA	ALPHA	BETA PLUS GAMMA	ALPHA
Oil before Centrifuging	23	Neg.	18	Neg.	33	Neg.
Residue after Centrifuging	37	Neg.	30	Neg.	50	Neg.
Centrifuged Oil	10	Neg.	Neg.	Neg.	17	Neg.

Equipment Used: 2.7 mg./cm^2 end-window type argon-ether filled self-quenching.
General Electric Proportional Counter with rubber hydrochloride window, air-filled chamber probe.

TABLE II

RESULTS OF TEST OF HYDRAULIC OIL - THREE SAMPLES TESTED AGAINST SPECIFICATION AN-0-366

	SAMPLE 1	SAMPLE 2	SAMPLE 3	MEETS SPECIFICATION	DOES NOT MEET SPECIFICATION
Pour Point	-75.0°F.	-75.0°F.	-75.0°F.	X	
Flash Point	90.0°F.	92.0°F.	90.0°F.		X
Turbidity at -65.0°F. to -70.0°F.	Passed 72 hr. test	Passed 72 hr. test	Passed 72 hr. test	X	
Viscosity Centistokes					
130°F.	10.99	10.86	11.37	X	
-40°F.(a)	530.3	552.1	585.7		X
-40°F.(b) (1 hr. later than (a))	525.0	547.0	580.4		X

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[redacted]

TABLE II

READINGS TAKEN ON LUBRICATING OIL SAMPLES

	SAMPLE 1 - C/MIN. (NET)		SAMPLE 2 - C/MIN. (NET)	
	BETA PLUS GAMMA	ALPHA	BETA PLUS GAMMA	ALPHA
Oil before Centrifuging	18	Neg.	125	Neg.
Residue after Centrifuging	36	Neg.	108	2
Centrifuged Oil	12.0	Neg.	9.6	Neg.

TABLE IV

RESULTS OF TEST OF LUBRICATING OIL
TWO SAMPLES TESTED AGAINST SPECIFICATION AN-VV-0-446

	SAMPLE 1	SAMPLE 2	SPECIFICATION REQUIREMENTS
Pour Point	-10°C. +14°F.	-10°C. +14°F.	Max. +20°F.
Flash Point	Above 255°C. 491°F.	Above 255°C. 491°F.	Min. 490°F.
Viscosity at 99°C. (210°F.) (Saybolt Universal)	119	117.5	115 - 125

TABLE V

SUMMARY OF RESULTS FROM TENSILE (a), CORROSION (a), AND ENDURANCE (d) TESTS

PROPERTY	LOCATION OF SAMPLES (b)	SPECIMENS UNCORRODED	SPECIMENS UNSTRESSED AND CORRODED (7 DAYS)	% LOSS	SPECIMENS STRESSED TO 75% OF Y. S. AND CORRODED (7 DAYS)	% LOSS
Ultimate Tensile Strength, psi	*	(e)				
	1 **	68,500	47,500	30.6	29,100	57.5
	*	70,600				
	2 **	68,800				
	*	(e)				
	3 **	69,900	54,400	22.1	51,500	26.3
	*	71,450				
	4 **	67,500				
	Virgin 24ST **	69,200	53,300	29.8	50,200	27.4
Tensile Yield Strength, psi (c)	*	(e)				
	1 **	45,400	34,800	23.3	24,800	45.3
	*	53,800				
	2 **	46,200				
	*	(e)				
	3 **	46,200	38,400	16.8	40,100	13.2
	*	53,950				
	4 **	46,600				
	Virgin 24ST **	44,500	41,300	7.1	38,300	13.9
Percent Elongation in 2 Inches	*	(e)				
	1 **	17.25	3.3	80.8	.83	95.0
	*	16.0				
	2 **	19.0				
	*	(e)				
	3 **	19.75	4.0	79.7	2.8	85.8
	*	16.5				
	4 **	14.75				
	Virgin 24ST **	17.5				

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TABLE

SUMMARY OF RESULTS FROM TENSILE (a), CORROSION (a), AND ENDURANCE (d) TESTS

PROPERTY	LOCATION OF SAMPLES (b)	SPECIMENS UNCORRODED	SPECIMENS UNSTRESSED AND CORRODED (7 DAYS)	% LOSS	SPECIMENS STRESSED TO 75% OF Y. S. AND CORRODED (7 DAYS)	% LOSS
Endurance Strength, psi (d)	*	20,500				
	2 **	19,400				
	*	19,200				
	4 **	17,600				
	*	(f) ≥18,000				
	Virgin 24 ST **	(f) ≥18,000				

* Parallel with grain.
** Transverse to grain.
(a) Averages of three tests.
(b) Sample 1: Starboard skin, 24ST, .040", Station 54 to Station 90-1/2.
Sample 2: Starboard skin, 24ST, .032", Station 90-1/2 to Station 122.
Sample 3: Port skin, 24ST, .040", Station 54 to Station 90-1/2.
Sample 4: Port skin, 24ST, .032", Station 90-1/2 to Station 122.
(c) 0.2% offset.
(d) 50,000,000 reversals of stress.
(e) Values were not determined.
(f) Value obtained from Alcoa handbook "Aluminum Company of America Aluminum and Its Alloys - 1947". Endurance strength of virgin 24ST aluminum shown as 18,000 psi at 500,000,000 reversals of stress. The stress curve becomes practically asymptotic on a single log plot graph from 50,000,000 stress reversals.

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TABLE V:

[redacted]

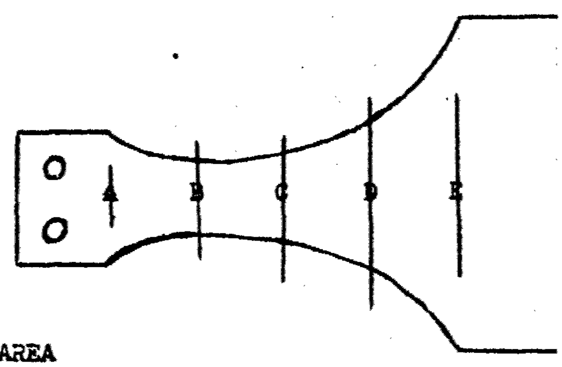
FLEXURE FATIGUE TESTS

MATERIAL - 24ST, .033" TEMPERATURE - Room

DESCRIPTION - Port Side, Station 90.5 to Station 122, Stringer 3 to Stringer 6

SPECIMEN NO.	STRESS PSI	TOTAL CYCLES	REMARKS (FAILURE LOCATION)
		WITH ROLL	
1	18,000	50,000,000	No Failure
2	22,000	7,894,000	B/C
3	25,000	1,073,600	C/D
4	30,000	284,000	B/C
5	23,000	1,090,000	C
6	20,000	15,137,000	C
7	19,000	50,000,000	No Failure
		ACROSS ROLL	
8	18,000	24,531,000	C
9	22,000	2,300,000	C
10	25,000	454,000	B
11	30,000	211,000	B
12	23,000	765,000	C/D
13	20,000	1,050,000	C/D
14	17,000	50,000,000	No Failure

TOTAL CYCLES REQUIRED - 50,000,000



FAILURE AREA

[redacted]

TABLE VII

[redacted]

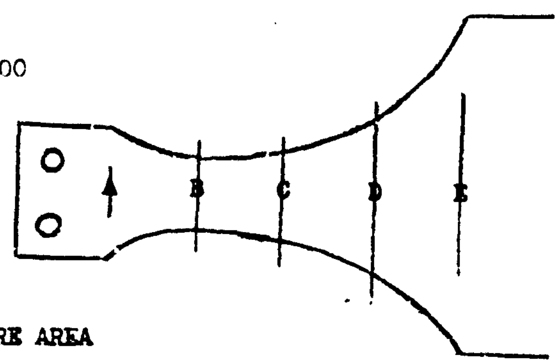
FLEXURE FATIGUE TESTS

MATERIAL - 24ST, .033" TEMPERATURE - Room

DESCRIPTION - Starboard Side, Station 90.5 to Station 122,
Stringer 3 to Stringer 6

SPECIMEN NO.	STRESS PSI	TOTAL CYCLES	REMARKS (FAILURE LOCATION)
		WITH ROLL	
15	30,000	525,000	C
16	23,000	4,555,000	C/D
17	22,000	16,467,000	C
18	20,000	50,000,000	No Failure
19	19,000	50,000,000	No Failure
20	25,000	926,000	C
21	21,000	22,682,000	C
		ACROSS ROLL	
22	30,000	633,000	C
23	23,000	3,040,000	C/D
24	22,000	2,461,000	B
25	20,000	16,562,000	C
26	19,000	50,000,000	No Failure
27	25,000	14,151,000	C
28	21,000	4,608,000	C

TOTAL CYCLES REQUIRED - 50,000,000



FAILURE AREA

[redacted]

TABLE VIII

[redacted]

COMPARISON OF AVERAGE VALUES OBTAINED FROM TESTS OF MATERIAL A* AND MATERIAL B**

TEST	MATERIAL A	MATERIAL B	SPECIFICATION REQUIREMENTS
Ultimate Tensile Strength, psi	7285	4950	6800 (min.)
Elongation, %	2.29	1.28	2.0 (min.)
Index of Refraction	1.489	1.489	1.49 ± 0.01
Angular Deviation, minutes	2.3	2.9	7.0
Light Transmission (Parallel), %	81.9	84.0	90.0
Haze, %	7.4	5.8	3.0
Rate of Burning, in./min.	1.8	0.87	2.4 (max.)
Flexural Deformation, °F.	160	161	137 - 176
Stress-Craze, inches	2-3/8	2-3/8	Visual Insp.
Water Absorption, %	0.31	0.39	0.80
Specific Gravity	1.18	1.18	1.18 ± 0.01

TEST	SPECIFICATION REQUIREMENTS MET BY MATERIAL	SPECIFICATION REQUIREMENTS NOT MET BY MATERIAL	SUPERIOR MATERIAL
Ultimate Tensile Strength, psi	A	B	A
Elongation, %	A	B	A
Index of Refraction	A and B		Neither
Angular Deviation, minutes	A and B		Neither
Light Transmission (Parallel), %		A and B	B
Haze, %		A and B	B
Rate of Burning, in./min.	A and B		B
Flexural Deformation, °F.	A and B		Neither
Stress-Craze, inches		A and B	Neither
Water Absorption, %	A and B		A
Specific Gravity	A and B		Neither

* Acrylic material from test aircraft.
** Acrylic material from control aircraft.

TABLE IX

[redacted]

PLASTIC TEST RESULTS
ULTIMATE TENSILE STRENGTH (PSI)

SAMPLE NO.	U.T.S. (PSI)
MATERIAL A	
A-1(1)	8590
A-1(2)	8800
A-1(3)	8430
A-2(1)	5620
A-2(2)	5580
A-3(1)	7080
A-3(2)	8220
A-3(3)	5970
AVERAGE	7285
MATERIAL B	
B-1(1)	5420
B-1(2)	4760
B-1(3)	4670
AVERAGE	4950

TABLE X

PLASTIC TEST RESULTS
ELONGATION (%)

SAMPLE NO.	%
MATERIAL A	
A-1(1)	3.11
A-1(2)	2.96
A-1(3)	2.92
A-2(1)	1.39
A-2(2)	1.15
A-3(1)	2.13
A-3(2)	3.02
A-3(3)	1.65
AVERAGE	2.29
MATERIAL B	
B-1(1)	1.49
B-1(2)	1.16
B-1(3)	1.19
AVERAGE	1.28

TABLE XI

[redacted]

PLASTIC TEST RESULTS
INDEX OF REFRACTION

SAMPLE NO.	INDEX
MATERIAL A	
A-2(4)	1.489
A-2(5)	1.489
A-2(6)	1.488
AVERAGE	1.489
MATERIAL B	
B-2(1)	1.487
B-2(2)	1.492
B-2(3)	1.486
B-2(4)	1.492
AVERAGE	1.489

TABLE XII

PLASTIC TEST RESULTS
ANGULAR DEVIATION

SAMPLE NO.	HORIZONTAL	VERTICAL
	MATERIAL A	
A-4(1)	.25"	.188"
A-2(7)	.25"	.125"

AVERAGE .203" x 11.45 = 2.32 minutes

SAMPLE NO.	HORIZONTAL	VERTICAL
	MATERIAL B	
B-4(1)	.25"	.25"

AVERAGE .25" x 11.45 = 2.86 minutes

TABLE XIII

[redacted]

[redacted]

PLASTIC TEST RESULTS
PERCENTAGE LIGHT TRANSMISSION

SAMPLE NO.	A (TOTAL %)	B (PARALLEL %)
MATERIAL A		
A-4(2)	91.9	76.9
A-4(3)	92.1	80.3
A-3(4)	91.9	85.2
A-3(5)	91.8	85.0
AVERAGE	91.9	81.9
MATERIAL B		
B-4(1)	89	84
B-4(2)	90	84
B-3(1)	90	84
AVERAGE	89.7	84.0

TABLE XIV

PLASTIC TEST RESULTS
PERCENTAGE HAZE

SAMPLE NO.	%
MATERIAL A	
A-4(5)	16.3
A-4(6)	12.8
A-3(6)	7.3
A-3(7)	7.4
AVERAGE	10.9
MATERIAL B	
B-4(2)	5.5
B-4(3)	6.0
B-4(4)	6.0
AVERAGE	5.8

TABLE XV

[redacted]

[redacted]

PLASTIC TEST RESULTS
RATE OF BURNING

SAMPLE NO.	INCHES/MINUTE
MATERIAL A	
A-1(4)	1.9
A-1(5)	1.8
A-1(6)	1.7
AVERAGE	1.8
MATERIAL B	
B-1(4)	1.4
B-1(5)	0.9
B-1(6)	1.3
AVERAGE	1.2

TABLE XVI

PLASTIC TEST RESULTS
FLEXURAL DEFORMATION

SAMPLE NO.	WIDTH	THICKNESS	STARTING TEMPERATURE	DEFLECTION TEMPERATURE
		MATERIAL A		
A-5(1)	0.503"	0.112"	82°F.	160°F.
A-5(2)	0.495"	0.112"	82°F.	158°F.
A-2(8)	0.486"	0.178"	80°F.	160°F.
A-2(9)	0.497"	0.178"	82°F.	162°F.
A-2(10)	0.500"	0.178"	80°F.	162°F.
			AVERAGE	160°F.
		MATERIAL B		
B-5(1)	0.499"	0.129"	82°F.	158°F.
B-5(2)	0.499"	0.123"	78°F.	162°F.
B-5(3)	0.496"	0.133"	80°F.	162°F.
B-2(4)	0.490"	0.133"	75°F.	162°F.
B-2(5)	0.499"	0.119"	77°F.	161°F.
B-2(6)	0.495"	0.132"	78°F.	165°F.
B-2(7)	0.495"	0.123"	77°F.	156°F.
			AVERAGE	161°F.

[redacted]

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TABLE XVII

PLASTIC TEST RESULTS
STRESS CRAZE

SAMPLE NO.	LENGTH	WIDTH	THICKNESS	PSI	EXTENT OF CRAZE AFTER 24 HRS.	EXTENT OF CRAZE AFTER 17 DAYS
			MATERIAL A			
A-2(1)	4"	0.979"	0.181	4000	1-3/4" slight	2-3/8" severe
A-2(12)	4"	0.996"	0.178	4000	1-3/4" slight	2-3/8" severe
			MATERIAL B			
B-2(8)	4"	0.980	0.179	4000	1-5/8" slight	2-1/2" severe
B-2(9)	4"	0.997	0.178	4000	1-5/16" slight	2-1/2" severe
B-2(10)	4"	0.994	0.180	4000	2-1/16" slight	2-7/16" severe
B-2(11)	4"	0.979	0.178	4000	1-9/16" slight	2-1/16" severe
					AVERAGE	2-3/8"

TABLE XVIII

PLASTIC TEST RESULTS
PERCENTAGE WATER ABSORPTION

SAMPLE NO.	% ABSORBED	LENGTH	WIDTH	THICKNESS	WEIGHT AFTER CONDITIONING	WEIGHT AFTER IMMERSION
			MATERIAL A			
A-1(7)	0.31	3.001	0.991	0.1175	6.7124	6.7336
A-1(8)	0.30	3.008	0.993	0.1215	7.0234	7.0448
A-1(9)	0.32	3.012	0.982	0.1170	6.6272	6.6486
A-1(10)	0.31	3.018	0.999	0.1215	7.0808	7.1031
A-1(11)	0.32	3.005	0.997	0.1175	6.7887	6.8107
AVERAGE	0.31					
			MATERIAL B			
B-1(7)	0.42	3.081	0.972	0.123	7.1512	7.1815
B-1(8)	0.44	3.067	0.997	0.123	7.2752	7.3069
B-1(9)	0.29	3.062	0.967	0.139	7.9338	7.9570
B-1(10)	0.29	3.004	0.961	0.144	8.0206	8.0437
B-1(11)	0.44	3.001	0.995	0.123	7.0591	7.0902
B-1(12)	0.43	2.985	0.980	0.124	7.0054	7.0358
AVERAGE	0.39					

TABLE XIX

[redacted]

PLASTIC TEST RESULTS
SPECIFIC GRAVITY

SAMPLE NO.	WEIGHT IN AIR	WEIGHT IN H_2O	SPECIFIC GRAVITY
	MATERIAL A		
A-2(13)	1.06	0.91	1.16
A-2(14)	1.03	0.88	1.17
A-2(15)	1.03	0.87	1.18
A-2(16)	1.06	0.90	1.18
A-2(17)	1.02	0.87	1.17
A-2(18)	1.09	0.91	1.20
A-2(19)	1.08	0.87	1.18
			AVERAGE 1.18
	MATERIAL B		
B-2(13)	1.93	1.64	1.17
B-2(14)	1.93	1.64	1.17
B-2(15)	1.91	1.61	1.18
B-2(16)	2.15	1.83	1.17
B-2(17)	2.05	1.75	1.17
B-2(18)	1.91	1.61	1.18
B-2(19)	1.72	1.44	1.19
B-2(20)	2.08	1.74	1.19
			AVERAGE 1.18

[redacted]

TABLE XX

[redacted]

REPORT NO. AML NAM AE 540001
SECTION D

PORT TIRE TEST RESULTS

Manufacturer: Goodyear Tire and Rubber Company
Size: 34 x 9
Serial: 183943-510
Fabric Plies: 10 (rayon)
Rubber Grade: S-6
Appearance: No excessive surface deterioration. Slight sidewall cracking due to weathering. Cracking more pronounced on outboard sidewall.

TENSILE STRENGTH TEST RESULTS

SAMPLE NO.	TENSILE STRENGTH, PSI INBOARD SIDEWALL	ULTIMATE ELONGATION, %
1	1570	300
2	1540	280
3	1540	290
4	1500	280
AVERAGE	1540	290
	OUTBOARD SIDEWALL	
1	1450	260
2	1080	240
3	1190	230
4	1230	240
AVERAGE	1240	240

TABLE XXI

[redacted]

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[redacted]

REPORT NO. AML NAM AE 540001
SECTION D

INNER TUBE TEST RESULTS

Manufacturer: Goodyear Tire and Rubber Company
Size: 34 x 9
Composition: Natural rubber

SAMPLE NO.	TENSILE STRENGTH	ULTIMATE PERCENTAGE ELONGATION
1	2060	610
2	2240	620
3	2230	630
4	2190	610
5	2310	620
AVERAGE	2210	620

TABLE XXII

SELF-SEALING FUEL CELL TEST RESULTS

Manufacturer: B. F. Goodrich Company
Date of Manufacture: Nov 44
Manufacturer's Drawing: L-225
Serial No.: 2-292-3
Construction: 898 TBM-3E
Type: Main Cell, 155 gal.

TEMPERATURE	FUEL	RESULTS
-70°F.	115/145 containing 1.3% aromatics	Sealed in less than three (3) minutes

[redacted]

TABLE XXIII

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[redacted]

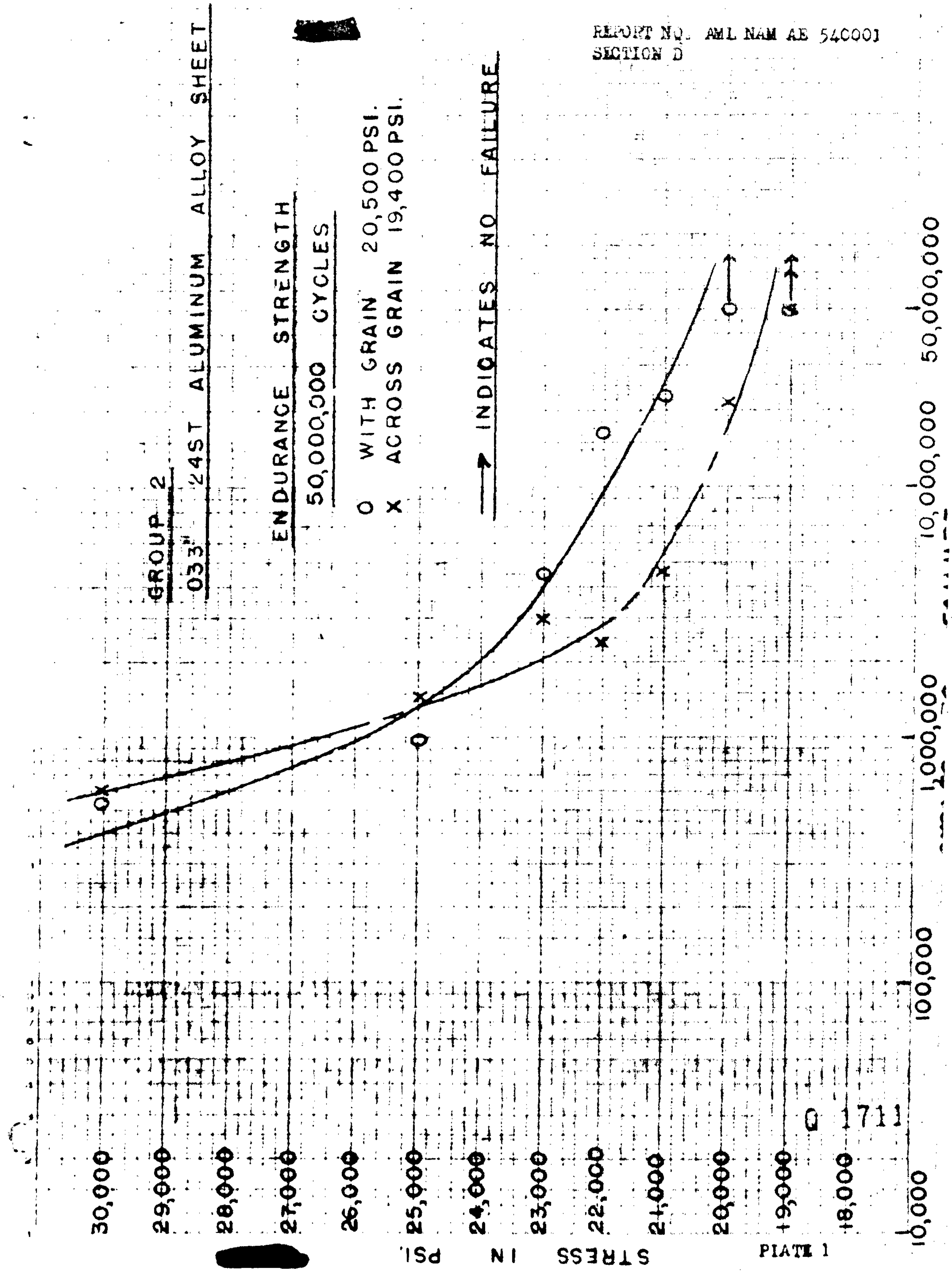

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PLATE 1

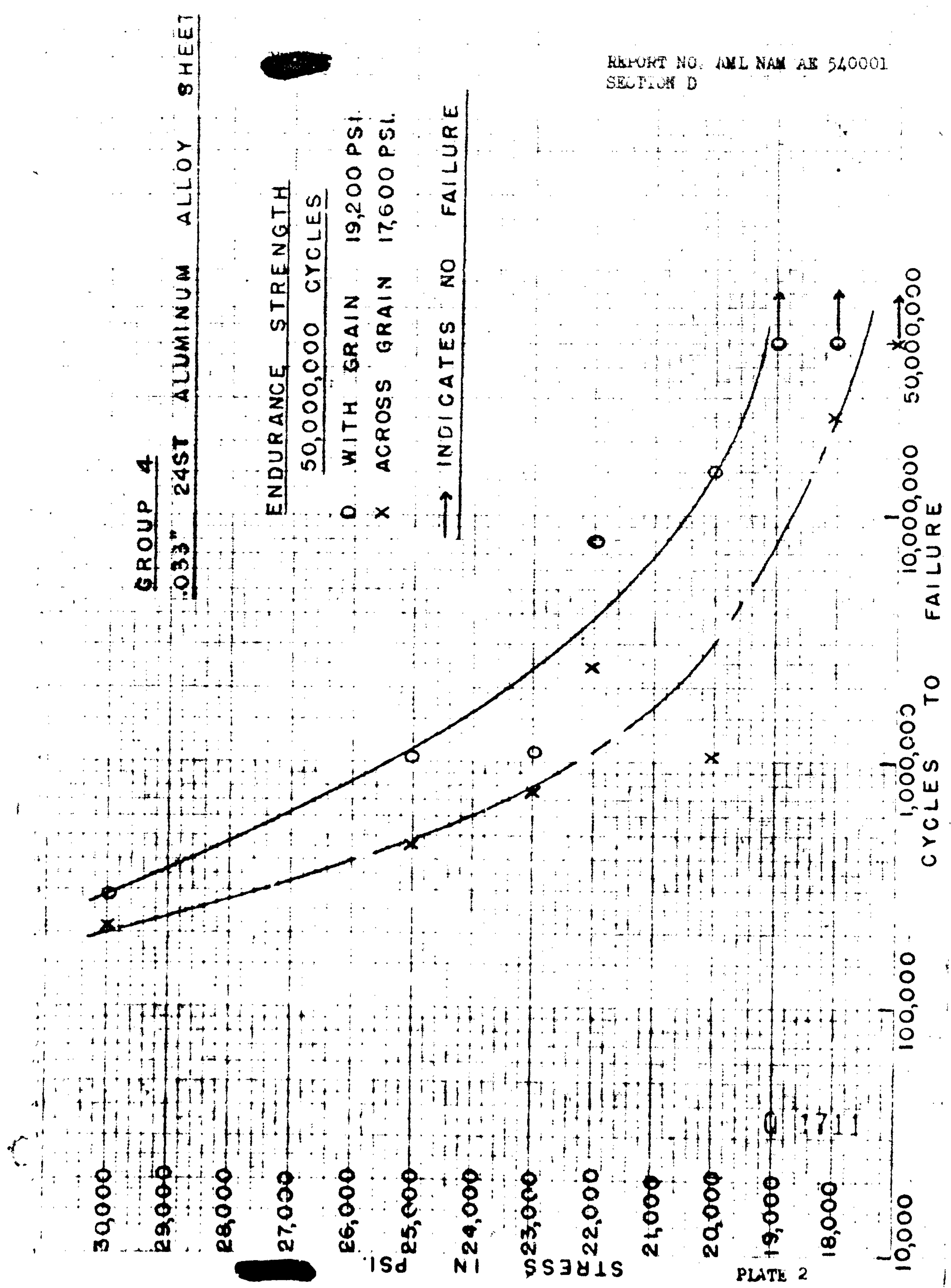
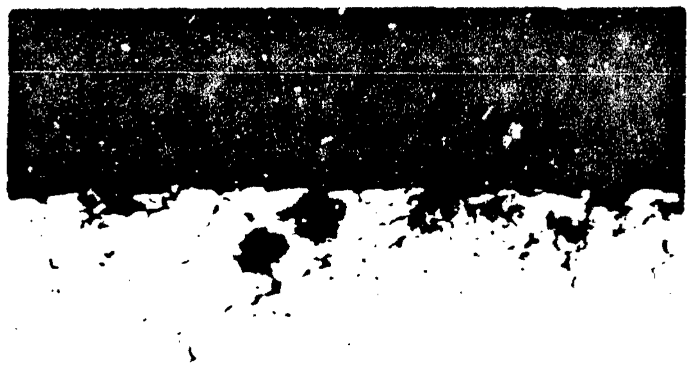

GROUP 4
.033" 24ST ALUMINUM ALLOY SHEET
ENDURANCE STRENGTH
50,000,000 CYCLES
O WITH GRAIN 19,200 PSI
X ACROSS GRAIN 17,600 PSI
→ INDICATES NO FAILURE
STRESS IN PSI
30,000
29,000
28,000
27,000
26,000
25,000
24,000
23,000
22,000
21,000
20,000
19,000
18,000
10,000
100,000
1,000,000
10,000,000
50,000,000
CYCLES TO FAILURE

PLATE 2

[redacted]

REPORT NO. AML NAM AE 549001
SECTION D



UNETCHED
200X

KELLER'S ETCHANT
200X

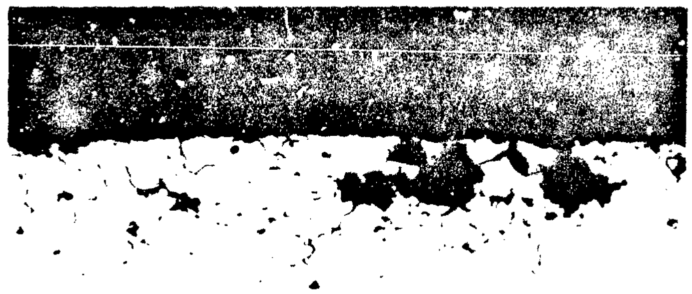
PHOTOMICROGRAPHS SHOWING RESULTS OF INTERGRANULAR CORROSION STUDIES ON METALS

SAMPLE NO. 1

INTERGRANULAR CORROSION AFTER EXPOSURE FOR SIX HOURS IN NaCl + H_2O_2 SOLUTION

NP(3)-262269(L)-2-50

PLATE 3



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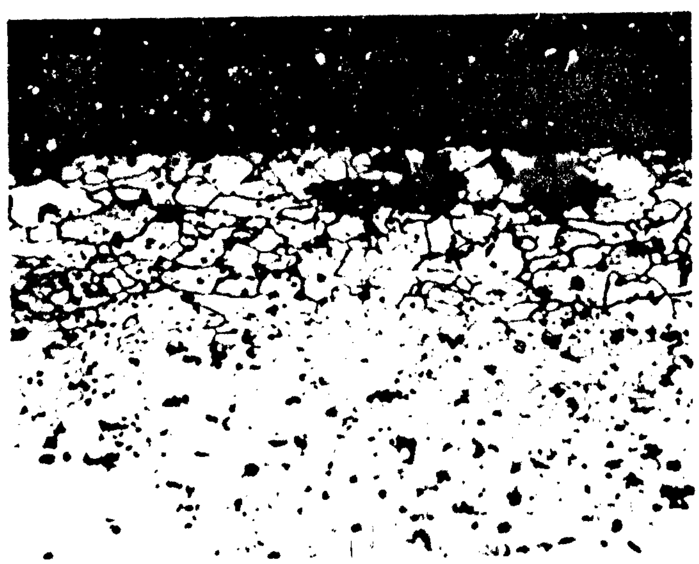

KELLER'S ETCHANT
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PHOTOMICROGRAPHS SHOWING RESULTS OF INTERGRANULAR CORROSION STUDIES ON METALS

SAMPLE NO. 2

INTERGRANULAR CORROSION AFTER EXPOSURE FOR SIX HOURS IN NaCl + H_2O_2 SOLUTION

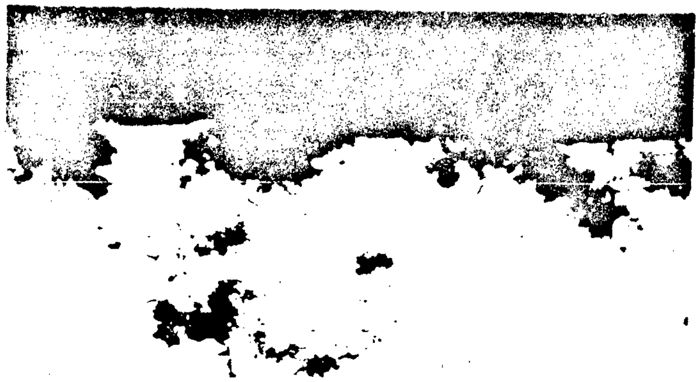
UNETCHED
200X

KELLER'S ETCHANT
200X

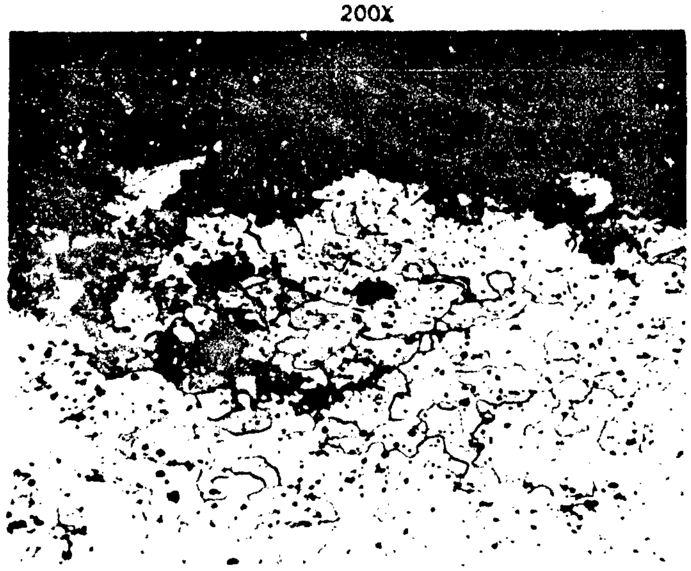
PHOTOMICROGRAPHS SHOWING RESULTS OF INTERGRANULAR CORROSION STUDIES ON METALS

SAMPLE NO. 3
INTERGRANULAR CORROSION AFTER EXPOSURE FOR SIX HOURS IN NaCl + H_2O_2 SOLUTION

PLATE 5



UNETCHED
200X



KELLER'S ETCHANT
200X

PHOTOMICROGRAPHS SHOWING RESULTS OF INTERGRANULAR CORROSION STUDIES ON METALS

SAMPLE NO. 4
INTERGRANULAR CORROSION AFTER EXPOSURE FOR SIX HOURS IN NaCl + H_2O_2 SOLUTION

NP(3)-262272(L)-2-50

PLATE 6

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[redacted]

REPORT NO. AML NAM AE 540001
SECTION E

NAVY DEPARTMENT
BUREAU OF AERONAUTICS

REPORT ON

STATIC TESTS OF OPERATION CROSSROADS, TARGET AIRPLANE, TBM-3E, BUNO 69169

BY

R. S. DUSENBERRY, LT, USNR

AERONAUTICAL STRUCTURES LABORATORY
NAVAL AIR EXPERIMENTAL STATION
NAVAL AIR MATERIAL CENTER PHILADELPHIA

Authorization . . . . BuAer Confidential ltr Aer-AE-45 C08267 of 29 Nov 46.

Dates of Test . . . . From 17 Feb 48 to 10 Aug 48.

Approved by . . . . J. S. Kean — Head Engineer, Aero. Struc. Lab.

Approved by . . . . Oliver H. Coté, Jr. CDR, USN — Superintendent, Aero. Struc. Lab.

DATE ISSUED 1 Apr 1950

[redacted]

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RECOMMENDATIONS	9
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REFERENCES

(a) ILWR #465-47 of 26 Jun 47.
(b) Confidential Memo AM-44-AH:rmcg (1780) of 5 Jun 47.
(c) NAES Report No. 15072-48 - Report on Test Loads for the Static Tests of TBM-3E Airplane.
(d) NAES Report TED No. NAM 2479, Part I - Static Tests of TBF-1 Airplane - of 4 Apr 45.
(e) ASL Confidential Memo XT-21-MSR:hg (764) of 10 Mar 48.
(f) NAES Report TED No. NAM 2419, Part I - Special Static Tests of Model TBF-1 Airplane of 5 Apr 44.
(g) NAES Report TED No. NAM 2479, Part III - Model TBF-1 Elevators - Comparative Blow-Up Tests of - of 5 Apr 45.

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ABSTRACT

(a) This is a report of tests conducted on various components of the structure of an Operation CROSSROADS target airplane. This structure was originally designed to withstand service usage. This usage does not include either exposure to extreme blast pressure, unshielded tropical weathering, or atomic radiation. This airplane was exposed to all three of these phenomena in addition to previous service usage. No unique tests were devised, although test methods in some cases were necessarily modified due to such factors as damage to the airplane's structure by blast and the necessity of personnel protection against radiation hazards. Where applicable, standard tests against specifications were employed.

(b) The report describes the various points of failure and deformation of the structural components, deduces the probable failing points of those components not carried to destruction, discusses the reasons for non-failure of various components and discloses that the results are attributable to effects of phenomena other than atomic radiation.

1. AUTHORIZATION

The subject tests were authorized by refs (a) and (b).

2. OBJECT

These tests were conducted to determine the effects, if any, on the structural components of an aircraft which had been exposed to atomic radiation during Operation CROSSROADS.

3. DESCRIPTION

These tests were conducted on a wing, stabilizer, rudder, and engine mount of Model TBM-3E airplane, BuNo 69169. The above components were essentially the same structurally as those tested under BuAer Project TED No. NAM 2479 and reported in ref (d).

4. METHOD

(a) Engine Mount Test

(1) The engine mount was removed from the airplane and mounted on a rigid jig. The engine mount was tested by applying the loads shown in Figure 6-1 of ref (c). The test set-up is shown in Plates 1 and 2.

(2) Insamuch as no comparable test data was available, the engine mount was tested to failure with no deflection, strain or set data taken.

(b) Horizontal Stabilizer Test - For this test, the fuselage was supported in the region of the stabilizer carry-through structure. Because of excessive blast damage to the port stabilizer, a replacement stabilizer was obtained from TBM-3E airplane, BuNo 68074, and was used in the test. The loads shown in Figure 2-1 of ref (c) were applied to the stabilizer by use of formers instead of tension pads as were used in TED No. NAM 2479. Wooden blocks were placed on the ribs of the elevator just aft of the beam and the load was applied to them along the hinge centerline just aft of the beam in the same direction as the stabilizer loads. The test set-up is shown in Plates 4, 5 and 6.

(c) Rudder Blow-Up Test - The rudder was held in a vertical jig and pressure was applied to the interior of the specimen by means of compressed air. The pressure was increased slowly until the fabric burst. Both sides of the surface were observed during the test. The fabric deflection at the points shown in Plate 11 were recorded at each 1/4 psi. The test set-up is shown in Plate 12.

(d) Wing Test - The starboard outer panel only was tested for this condition for the following reasons as outlined in para 2 of ref (e):

(1) The port outer panel was more severely damaged than the starboard outer panel and would require repairs to such an extent that the results of tests of the port outer panel would be invalid.

(2) Since the repairs which were required in the wing center section were so extensive, and since the wing fold joint loads are statically determinate, it is believed that the effect of the center section on the outer panel would be approximately the same as if the outer panel were mounted on a jig.

(3) Similar tests performed under projects TED Nos. NAM 2419 and 2479 showed the outer panel to be critical.

(4) Mounting the outer panel on a jig would expose the workmen to radiation effects for a shorter period of time, since the jig could be built in an uncontaminated area and assembled in the test area. Dummy beams were attached to the wing hinge fittings and to the wing lock fitting and were mounted in a jig so that the wing and beams were free to rotate around an axis parallel to the chord line. The dummy beams are shown in Plate 16. The loads were applied to the wing by use of formers as shown in Plates 17 and 18.

5. RESULTS

(a) Engine Mount Test

(1) In the first test, 200% of limit load, as given in Figure 6-1 of ref (c), was applied to the engine mount as shown in Plates 1 and 2. After reaching 200% limit load, all load was removed and the tubes were checked. No permanent bending of the tubes was apparent at this time. The mount was then reloaded to 200% limit load when the lower starboard tube (Tube D) failed in compression as shown in Plate 3. It is to be noted that Tubes B and D are critical in tension and compression, respectively, instead of Tubes E and C as stated on Page 21 of ref (c). For this condition, the contractor's stress analysis (Grumman Report No. 2012, Page 30) shows Tube D to be the critical member with a calculated margin of safety of 6.5%. Q 17

(2) In view of the high failing load obtained in this test, it is believed that there was no appreciable reduction in strength even

though no comparable tests were performed on an unexposed engine mount. The test of the exposed engine mount has shown an adequate margin of safety (approximately 30%) over the required design strength.

(b) Horizontal Tail Surface Test

(1) At 60% limit load, buckles appeared on the leading edge and under surfaces of both stabilizers at approximately Station 60. Plates 7 and 8 show these buckles at 155% limit load. At 100% limit load, shallow buckles appeared on the underside of the leading edge of both stabilizers at approximately Station 30. At 212% limit load, the port stabilizer, which had not been exposed to radiation, failed in bending. This failure extended from the leading edge at approximately Station 33 aft and slightly outboard to the main beam at approximately Station 36. At Station 36, the main beam lower capstrip failed as a column as shown in Plate 9. As reported in ref (d), the stabilizer of a Model TBF-1 airplane with 17 months service life (1165 flight hours) failed in the same manner at 224% limit load. A plot of semi-span versus deflection at 150% limit load is shown in Plate 10, and is compared therein to the deflection obtained during the test reported in ref (d).

(2) At approximately 210% limit load, the appearance of both port and starboard stabilizers was identical. This indicates that failure of the starboard stabilizer, which was exposed to radiation, was imminent. It is concluded, therefore, that failure of the starboard stabilizer would have occurred within the range of failing load experienced by stabilizers not exposed to radiation.

(c) Rudder Blow-Up Test

(1) Numerous holes in the fabric of the rudder were patched prior to the test. The failure occurred under pressure of 2.00 psi when the fabric tore at Station 51 on the port side. The rib stitching at Station 30 also failed at the same pressure. Plate 13 is a photograph of the fabric tear at Station 51. The fabric deflections are tabulated in Plates 14 and 15.

(2) A comparison of the results of this test with tests conducted on the elevators of a Model TBF-1 airplane and reported in ref (g) is as follows:

SURFACE	HISTORY	FAILING PRESSURE (PSI)	MAX. DEFLECTIC (APPROX. 1.75 I
Elevator	New	2.46	.76 in.
Elevator	17 mos. service (1165 flight hours)	2.70	.65 in.
Rudder	Unknown service life + exposure to radiation	2.00	1.08 in.

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[redacted]

(3) The results of this test are not directly comparable to the results of the previous tests of the elevator fabric since the surfaces are different and since the rudder fabric required extensive patching (see Plates 12 and 13) prior to conducting this test. As noted in the table above, there is a considerable spread between the results obtained on a new and an old elevator with the new elevator exhibiting a lower bursting pressure than the old one. The rudder bursting pressure is lower than the pressure obtained for the new elevator. However, due to the many variables which may affect the bursting pressure (i.e. relative initial fabric tension, amount of dope applied and exposure to severe weathering for at least six months prior to this test), it is believed that the rudder bursting pressure falls within the range of strength that is to be expected for this airplane.

(d) Wing Test

(1) Upon inspection of the starboard wing, it was found that the main beam had been twisted by blast damage. Prior to starting this project, it was believed that the wing repairs might fail during the test, thus invalidating the results. However, since a wing test was specificall requested, it was decided to repair the wing and perform one wing test for which comparable data existed. By applying pressure to the lower hinge fitting, the beam was brought into its original position and riveted into place. An additional stiffener was added to the lower surface of the skin picking up the rivets through angles attached to the main beam. The stiffener and angles are shown in Plates 19 and 20. Additional plate and angle stiffeners were riveted to the main beam web as shown in Plate 21. Repairs were also made on the inboard bulkhead as shown in Plates 21 and 2

(2) At 120% limit load, the repairs, made in an attempt to hold the main beam in place, failed. The angle added to the capstrip failed in tension; the attachment of the inboard bulkhead to the spar failed as shown in Plates 21 and 22.

(3) Since the failure occurred in the repaired region of the wing, the results of this test are not considered valid for determining the effects of radiation on the wing structure. No attempt was made to repair the wing and retest after this failure, since it is believed that the amount of reinforcement and repairs required would invalidate any further test results due to the stiffening effect of the additional members required.

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6. CONCLUSIONS

As a result of these tests, it is concluded that there was no appreciable change in the structural strength of this airplane due to the effects of radiation.

7. RECOMMENDATIONS

No recommendations are required as a result of these tests.

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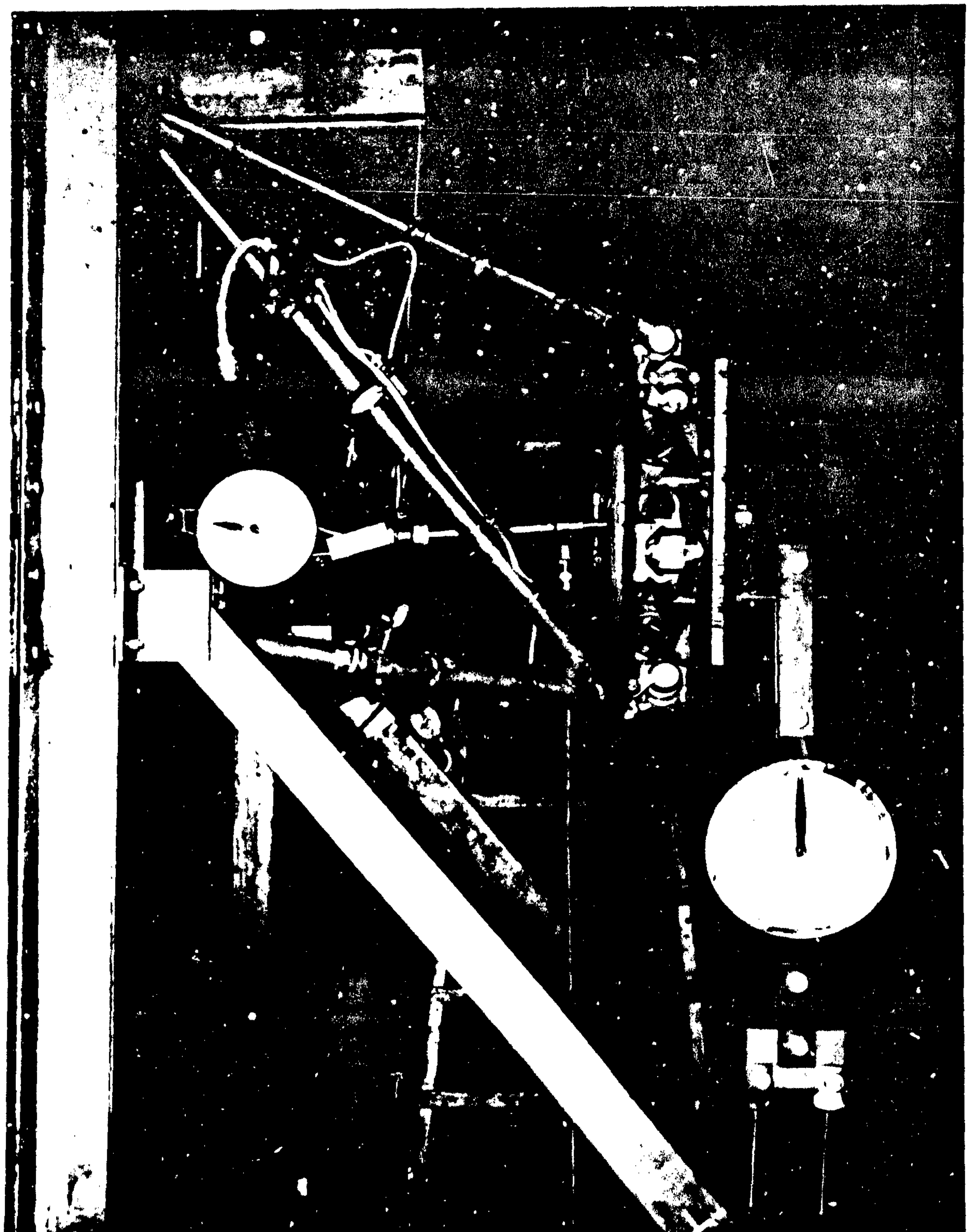

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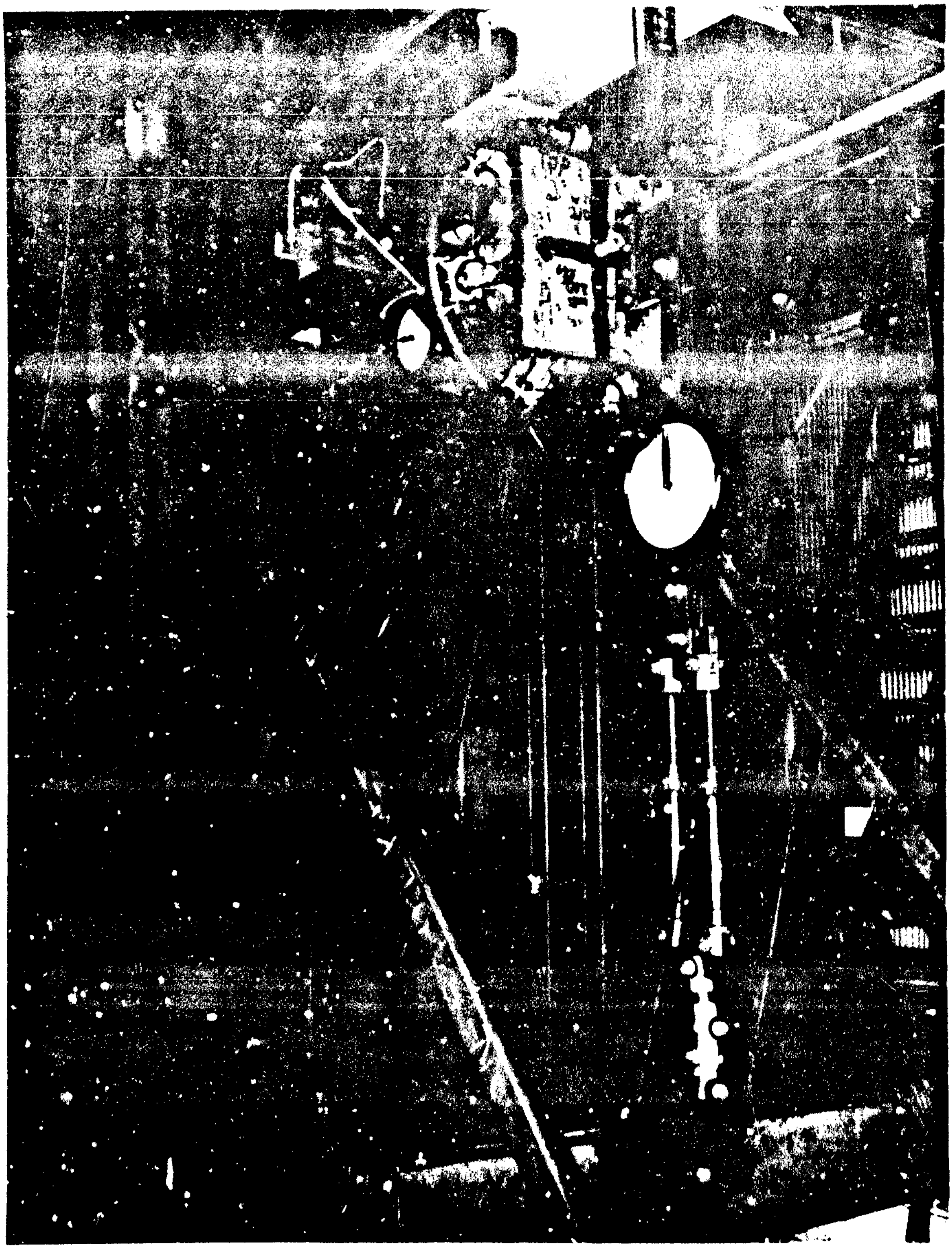
TBM-3E TARGET AIRPLANE - ENGINE MOUNT TEST SET-UP
SIDE VIEW

PLATE I



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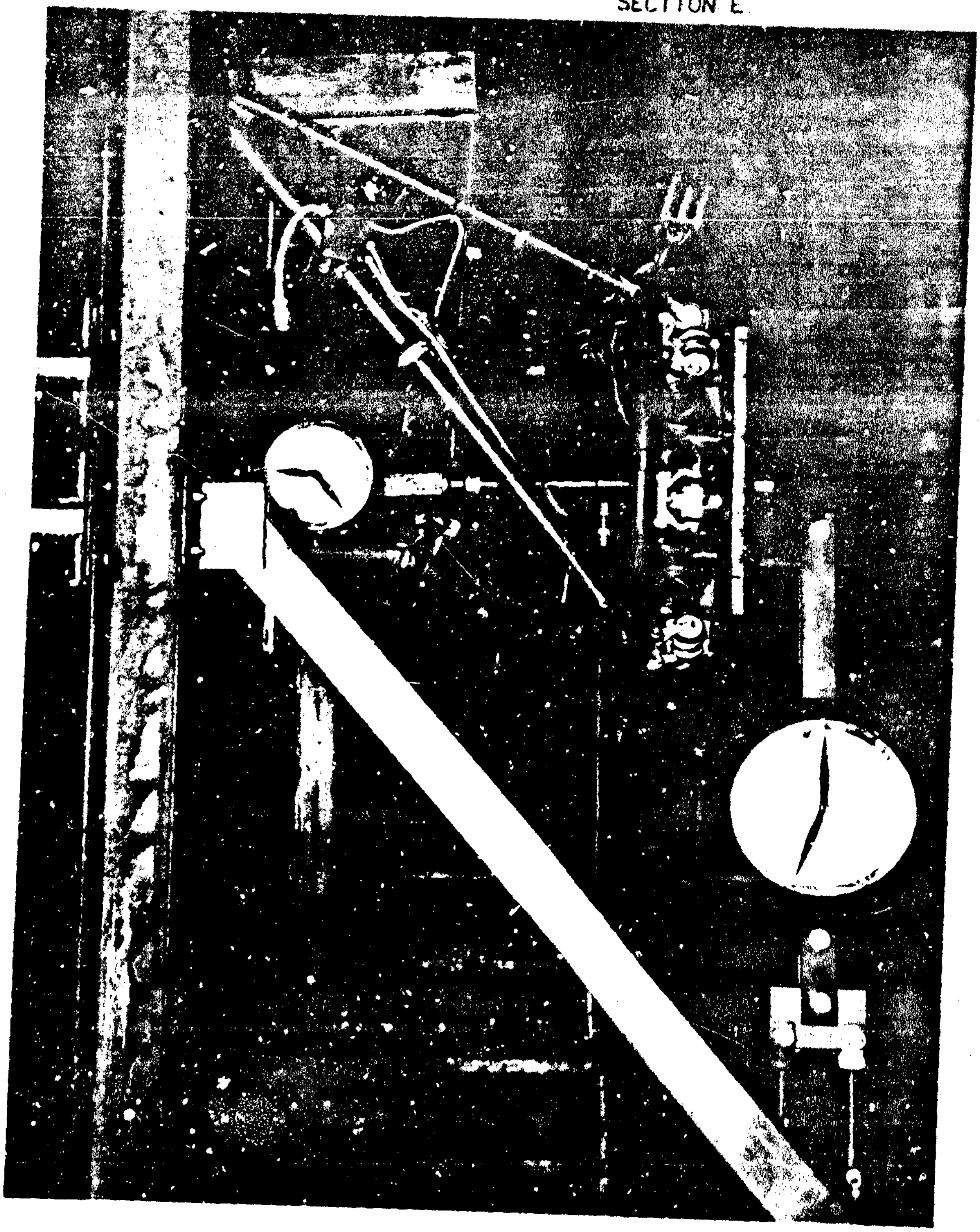
TBM-3E TARGET AIRPLANE - ENGINE MOUNT TEST SET-UP
FORWARD VIEW

PLATE 2



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TBM-3E TARGET AIRPLANE - ENGINE MOUNT TEST
TUBE D FAILURE

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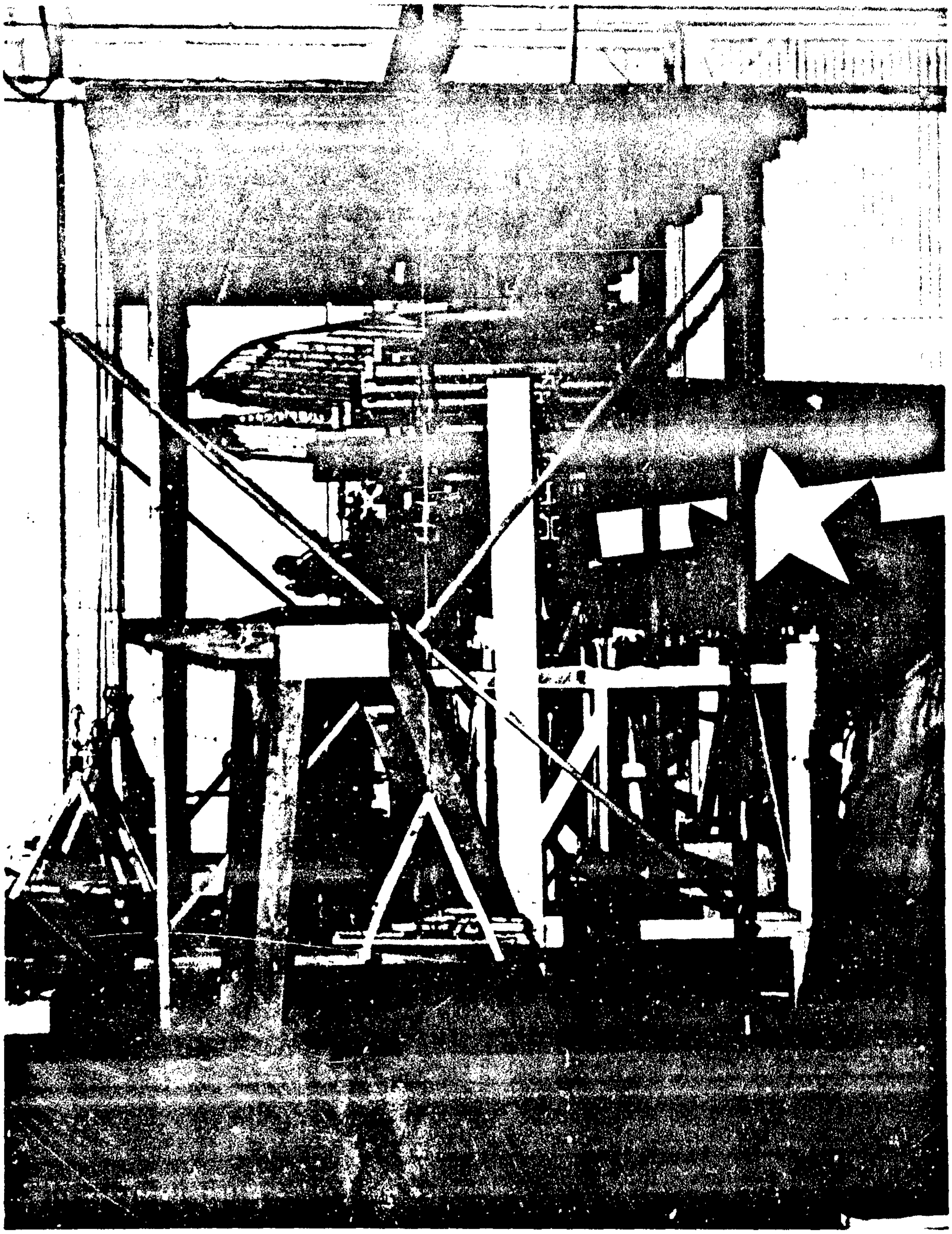
PLATE 3



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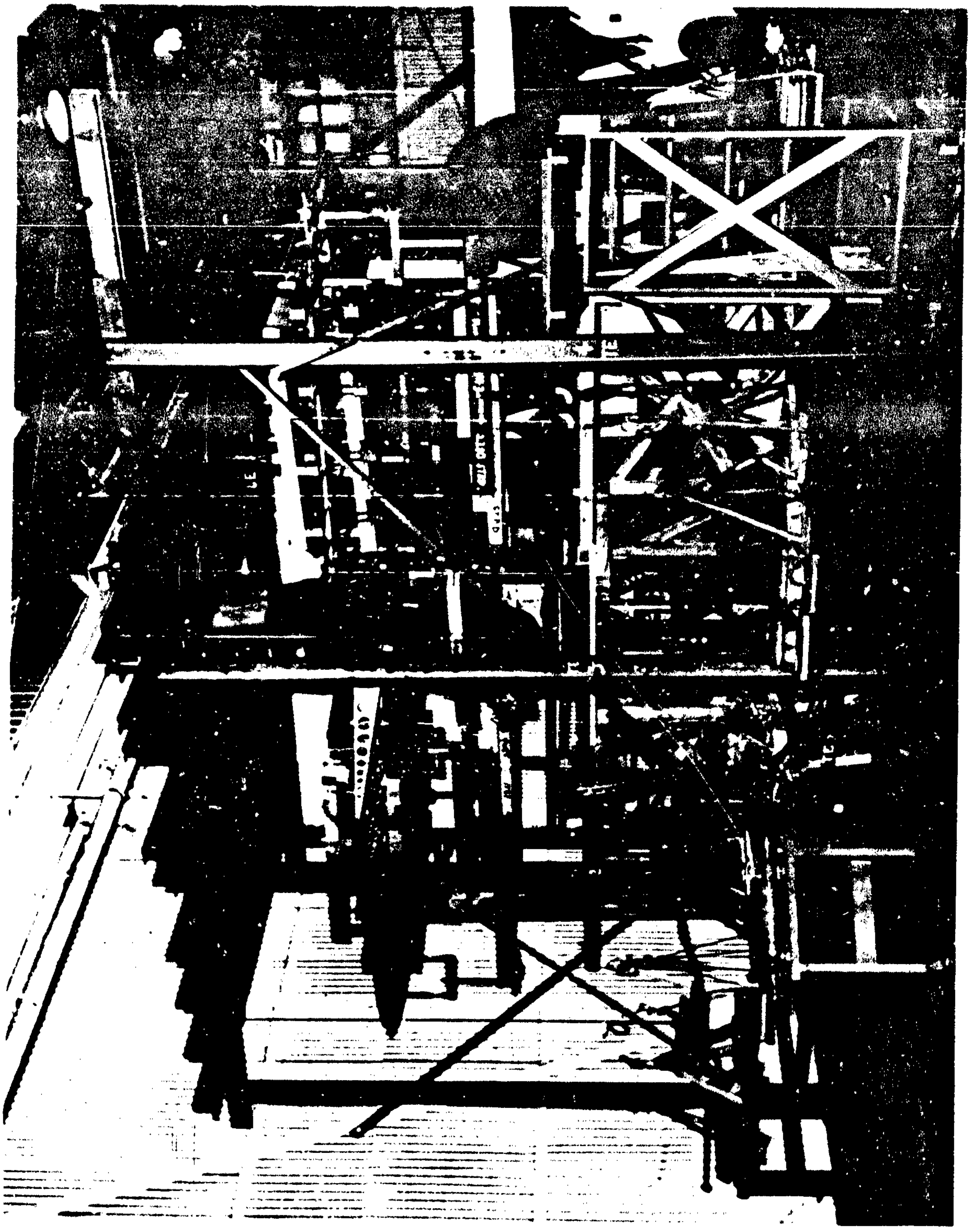
TBM-3E TARGET AIRPLANE - STABILIZER TEST SET-UP
SIDE VIEW



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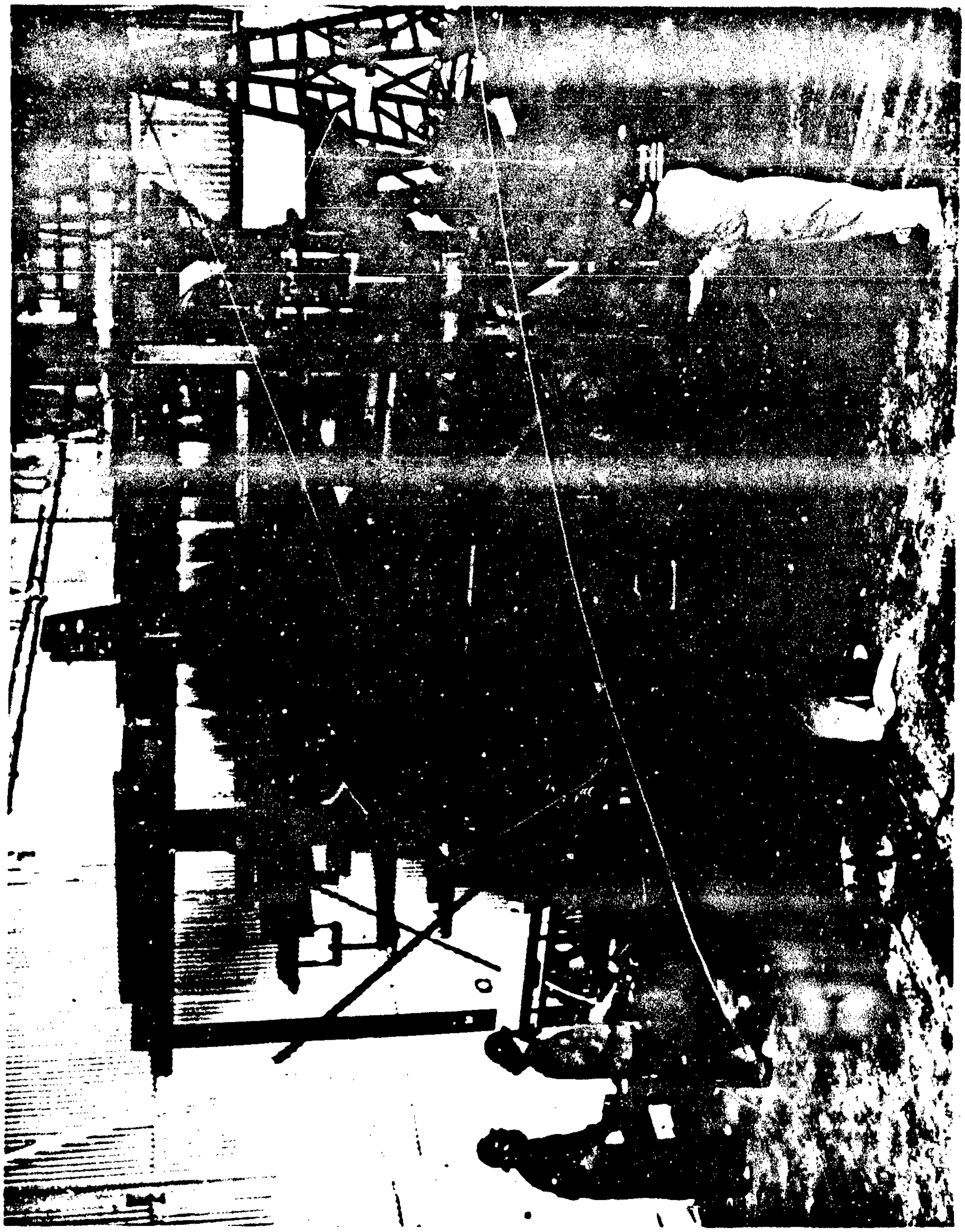
TBM-3E TARGET AIRPLANE - STABILIZER TEST SET-UP
AFT VIEW

PLATE 5



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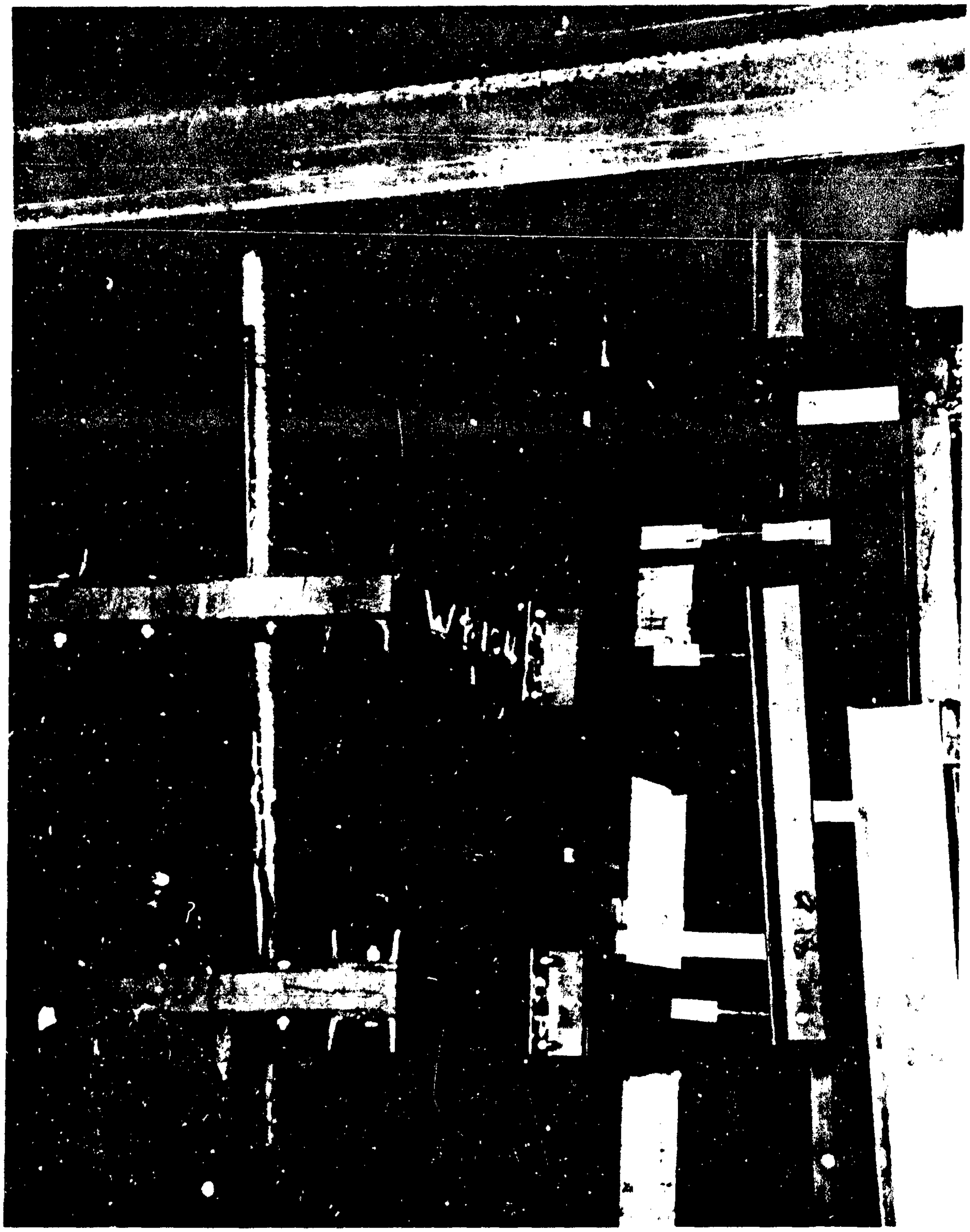
TBM-3E TARGET AIRPLANE - HORIZONTAL TAIL SURFACES
UNDER 115% LIMIT LOAD



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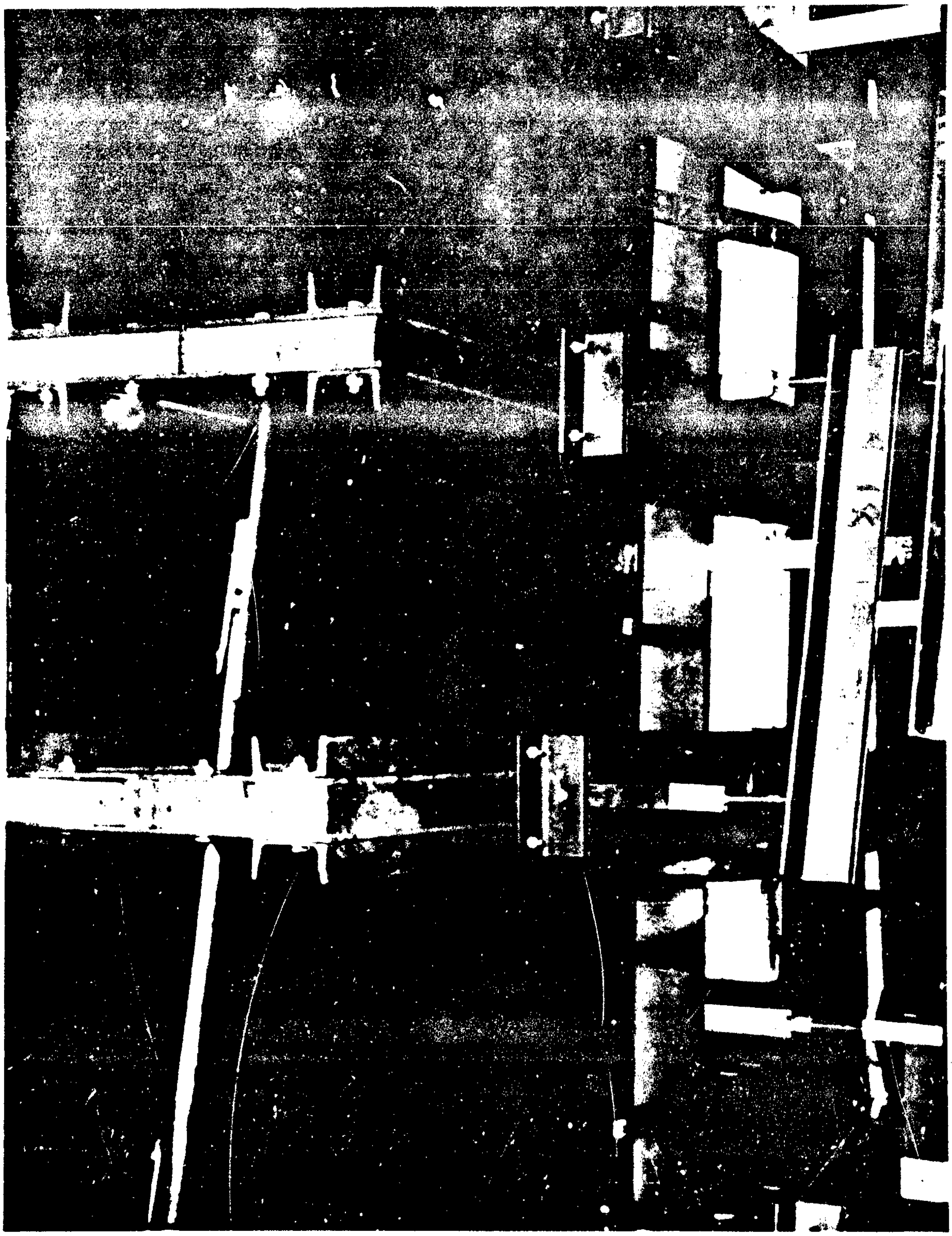
TBM-3E TARGET AIRPLANE - STARBOARD STABILIZER - STATION 60
LEADING EDGE BUCKLE AND UNDERSURFACE WRINKLES AT 115% LIMIT LOAD

PLATE 7



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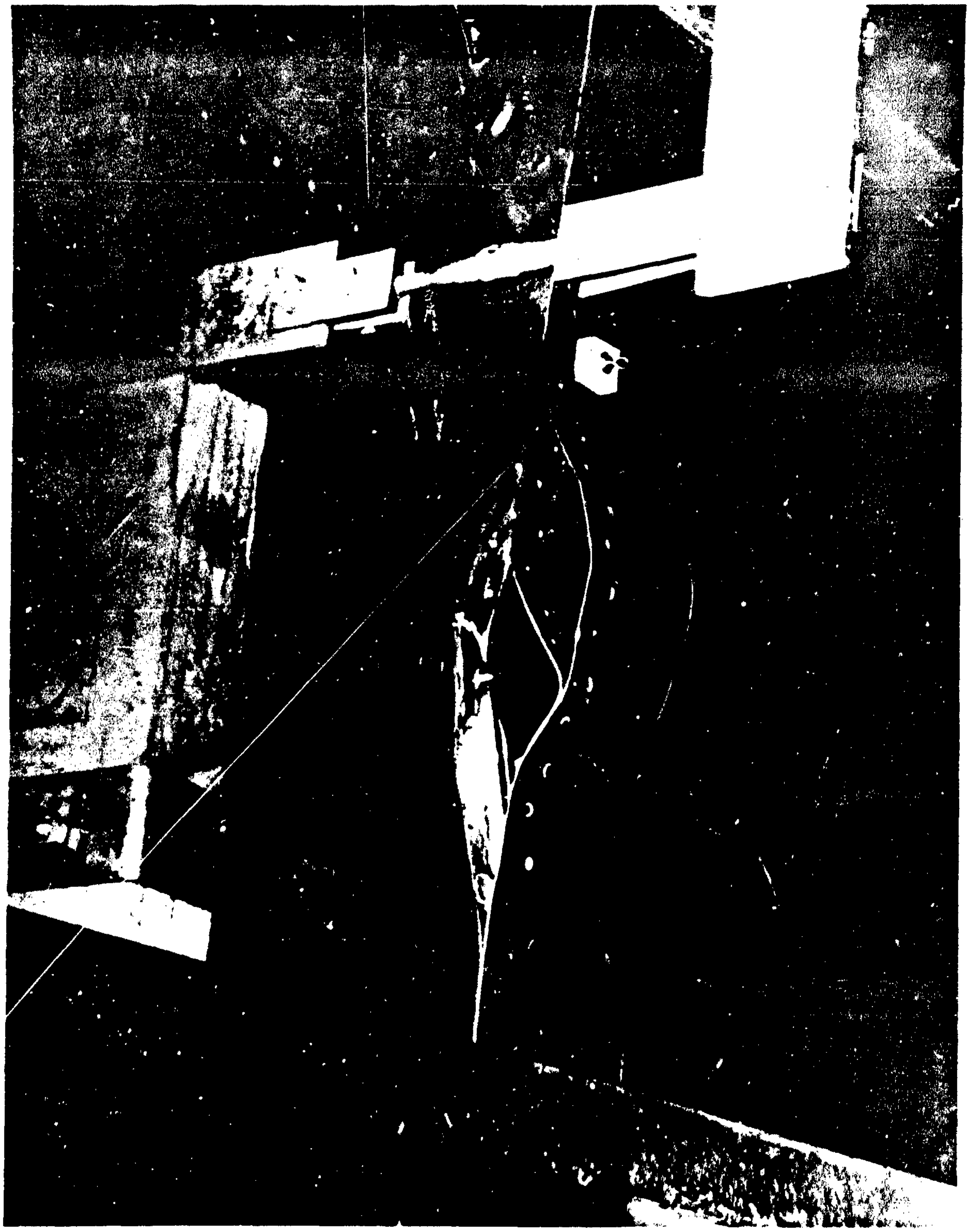
TBM-3E TARGET AIRPLANE - PORT STABILIZER - STATION 60
LEADING EDGE BUCKLE AND UNDERSURFACE WRINKLES AT 155% LIMIT LOAD

PLATE 8



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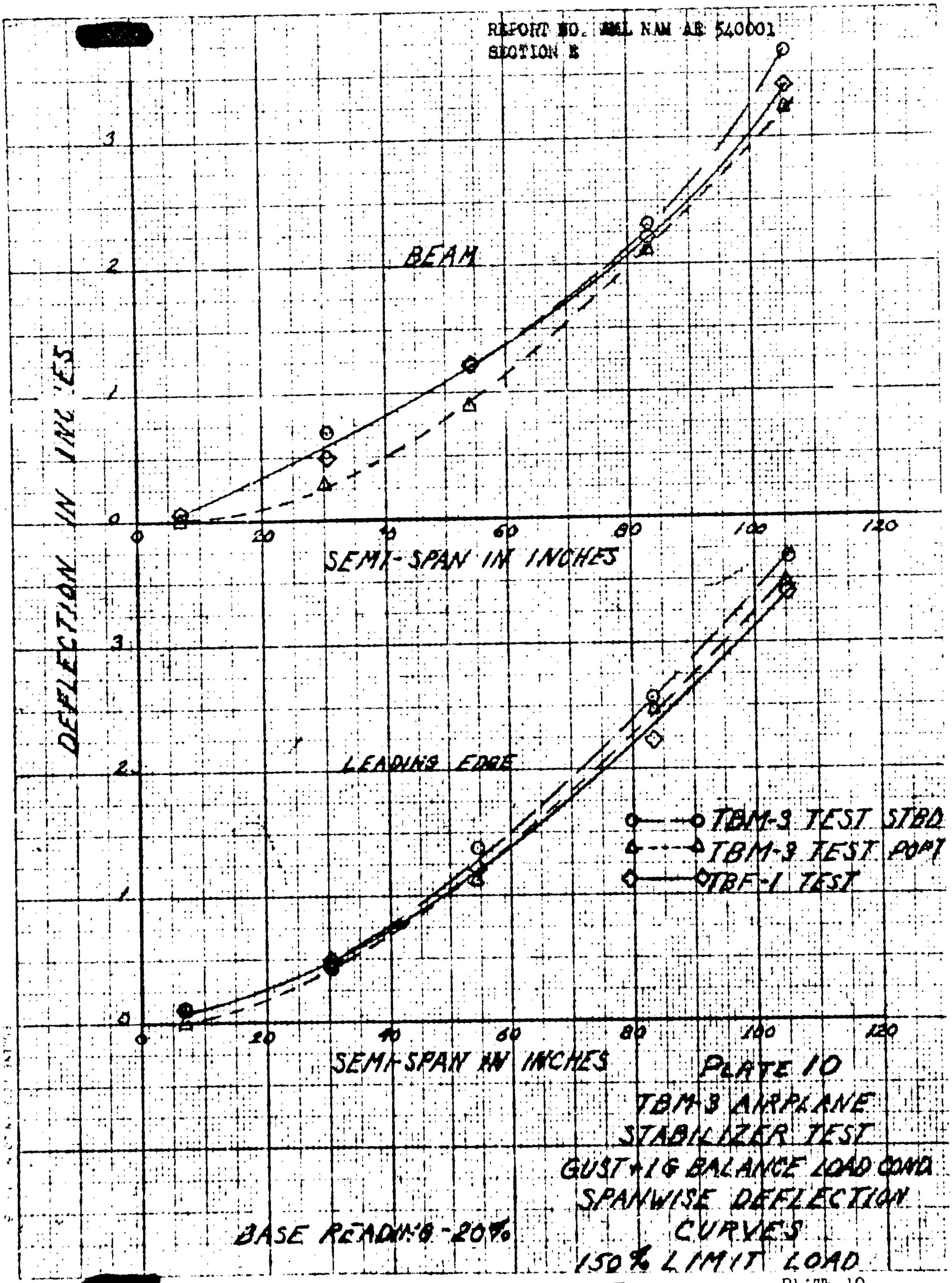
TBM-3E TARGET AIRPLANE - PORT STABILIZER
BEAM FAILURE AT STATION 33 AT 212% LIMIT LOAD

PLATE 9


BEAM
LEADING EDGE
DEFLECTION IN INCHES
SEMI-SPAN IN INCHES
0
1
2
3
20
40
60
80
100
120
TBM-3 TEST STBD
TBM-3 TEST PORT
TBF-1 TEST
BASE READING - 20%
PLATE 10
TBM-3 AIRPLANE
STABILIZER TEST
GUST + 1G BALANCE LOAD COND
SPANWISE DEFLECTION
CURVES
150% LIMIT LOAD

0 171

TBM-3 RUDDER BLOW-UP TEST

LOCATION OF DEFLECTION MEASUREMENTS

REPORT NO. AML NAM AE 540001
SECTION E

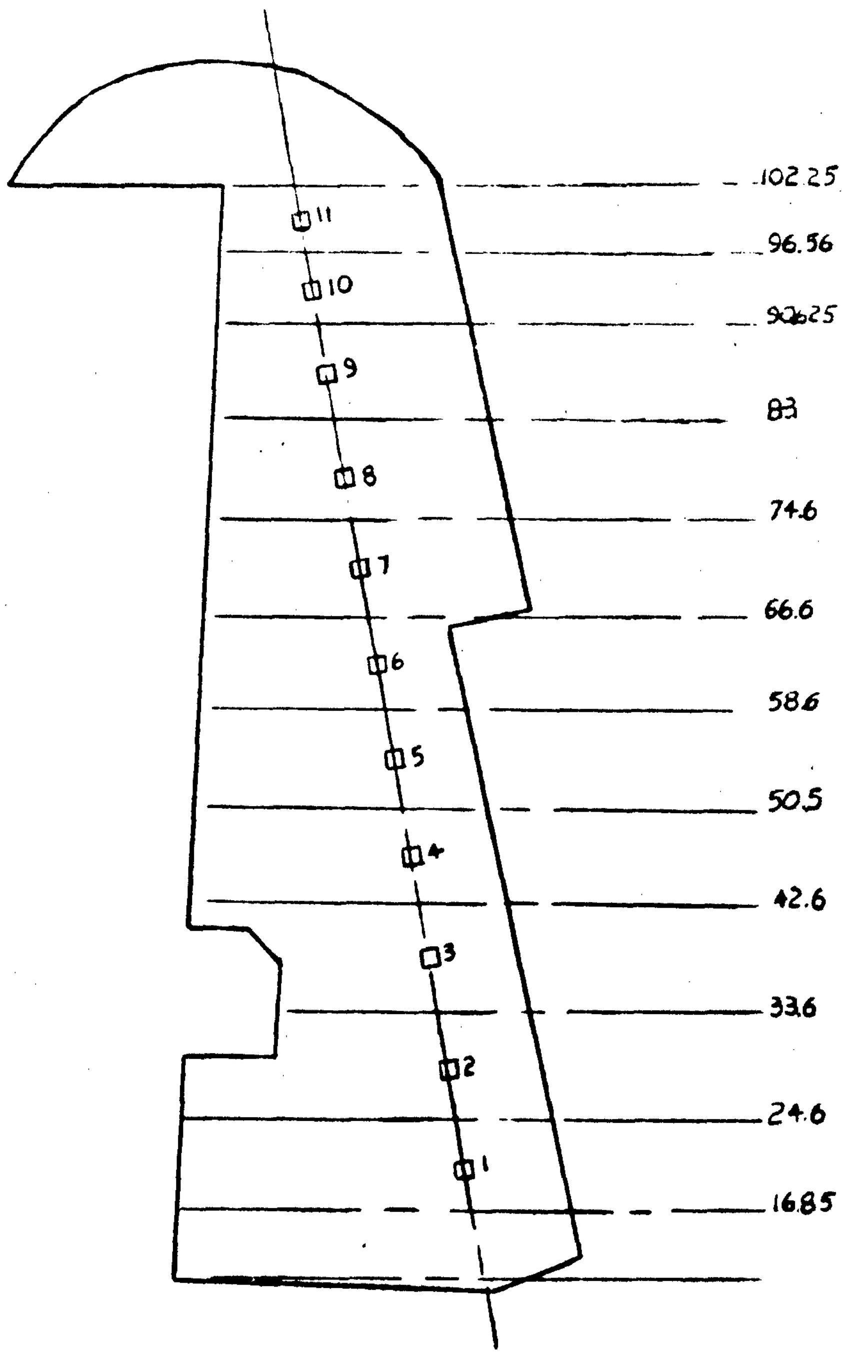


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PLATE II

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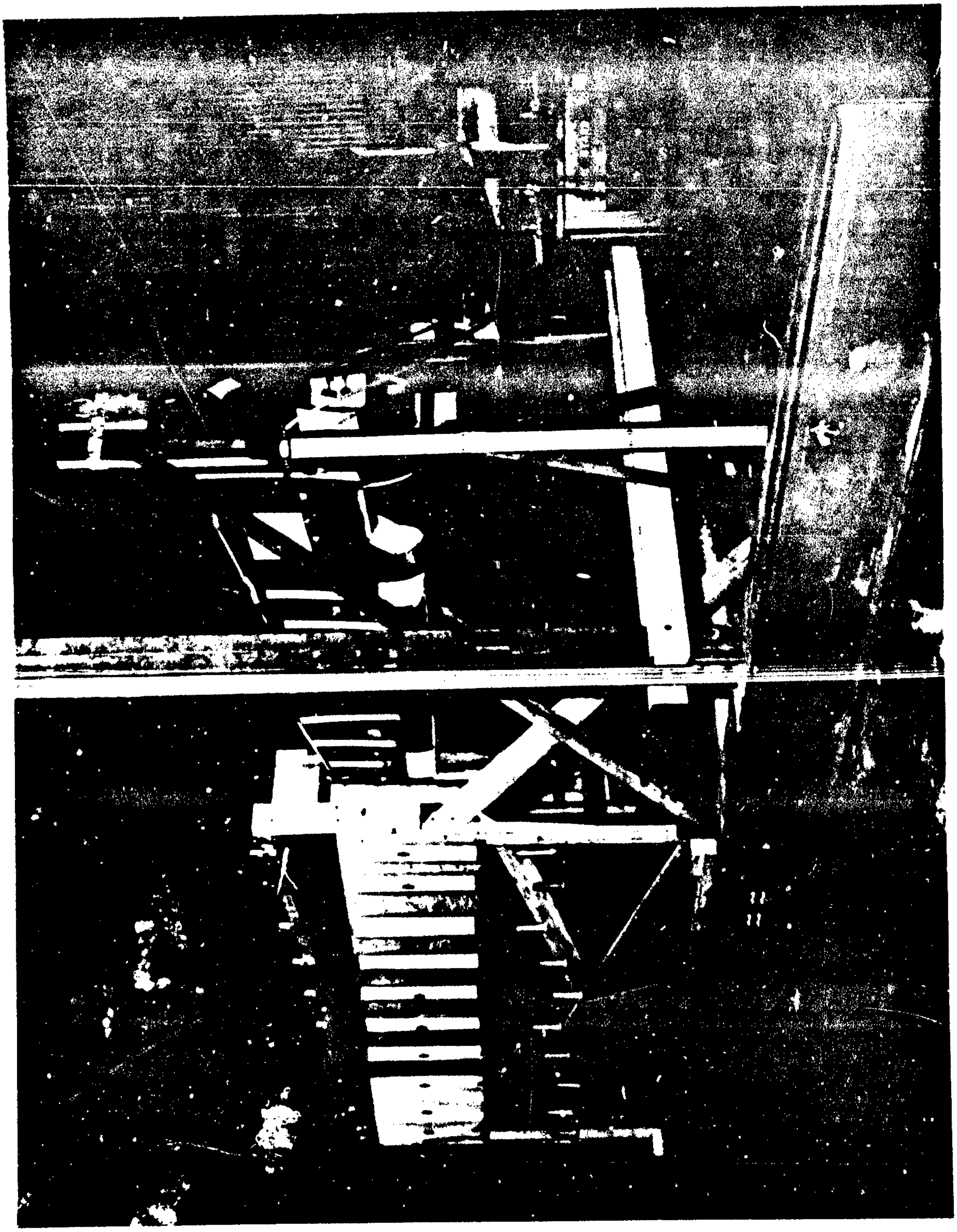

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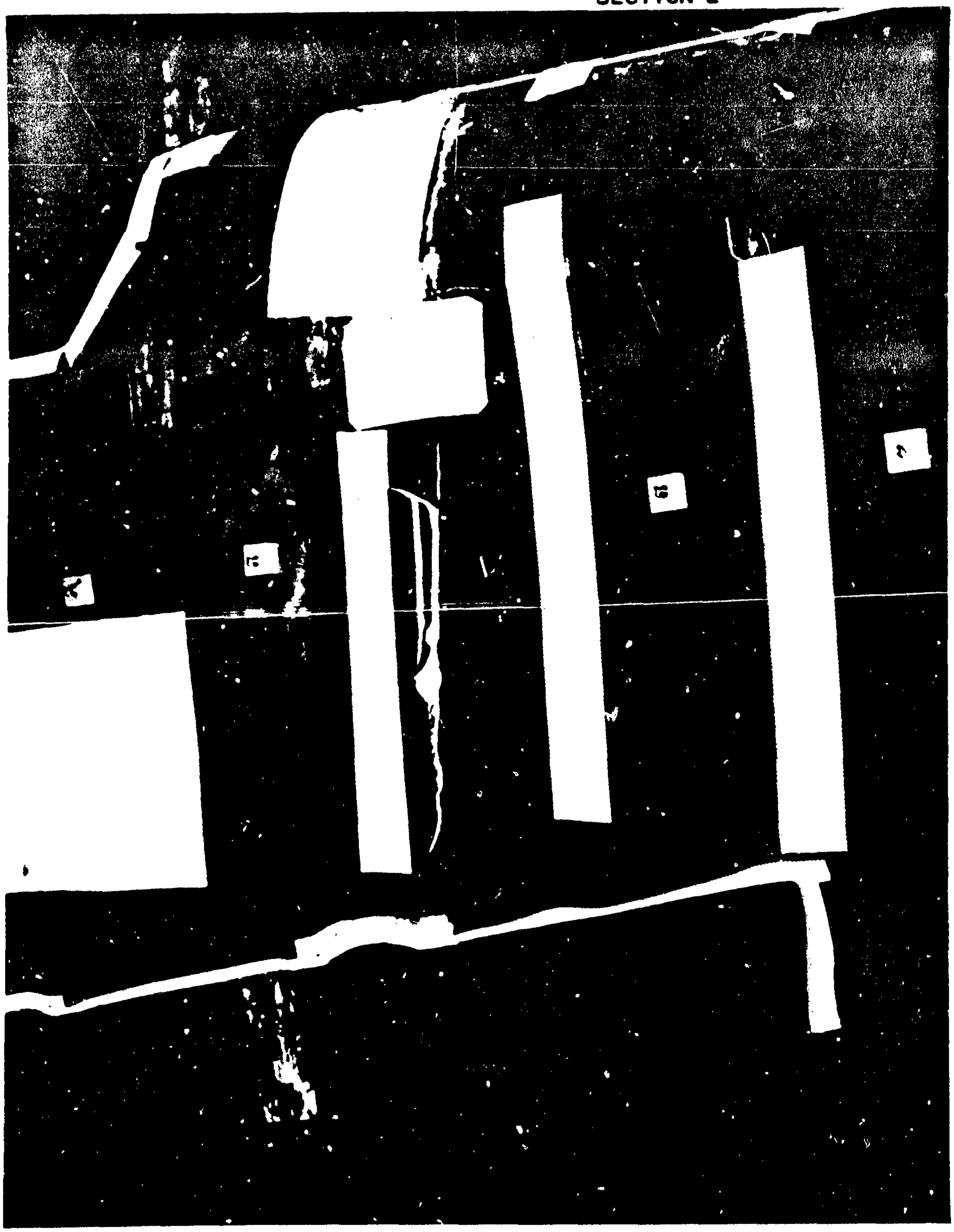
TBM-3E TARGET AIRPLANE - RUDDER BLOW-UP TEST
TEST SET-UP - VIEW FROM PORT SIDE

PLATE 12



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TBM-3E TARGET AIRPLANE - RUDDER BLOW-UP TEST
FABRIC FAILURE - PORT SIDE - STATION #51

PLATE 13

[redacted]

TBM-3E TARGET AIRPLANE - RUDDER BLOW-UP TEST - FABRIC DEFLECTION - PORT SURFACE

PSI	1	2	3	4	5	6	7	8	9	10	11
0	0	0	0	0	0	0	0	0	0	0	0
.25	.10	.33	.21	.13	.04	.12	.12	.16	.14	.11	.08
.50	.14	.43	.30	.20	.08	.18	.19	.22	.17	.18	.10
.75	.18	.50	.37	.27	.12	.25	.23	.30	.22	.21	.14
1.00	.21	.58	.42	.31	.14	.28	.25	.32	.26	.25	.17
1.25	.24	.65	.47	.35	.16	.31	.30	.39	.30	.29	.19
1.50	.27	.77	.62	.40	.19	.36	.34	.45	.34	.38	.21
1.75	.29	.95	.85	.43	.21	.40	.38	.49	.38	.41	.22

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[redacted]

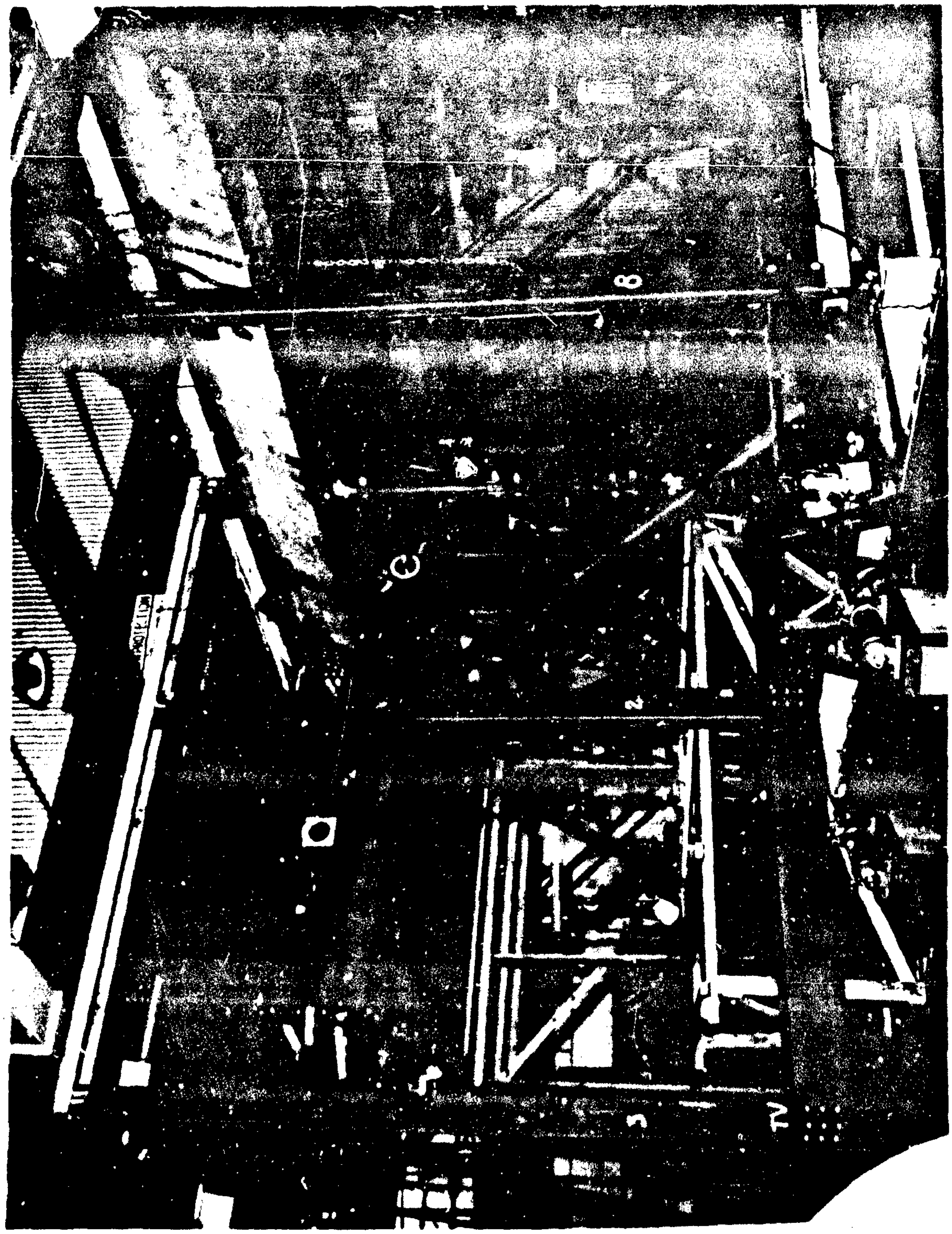
[redacted]

TBM-3E TARGET AIRPLANE - RUDDER BLOW-UP TEST - FABRIC DEFLECTION - STARBOARD SURFACE

PSI	1	2	3	4	5	6	7	8	9	10	11
0	0	0	0	0	0	.01	0	0	0	0	.01
.25	.13	.49	.42	.18	.10	.22	.21	.19	.15	.12	.11
.50	.19	.62	.54	.22	.15	.29	.27	.23	.20	.18	.13
.75	.21	.72	.65	.30	.19	.36	.35	.31	.26	.21	.17
1.00	.26	.82	.71	.33	.21	.39	.37	.33	.28	.24	.19
1.25	.29	.89	.78	.38	.23	.42	.41	.39	.31	.28	.20
1.50	.32	1.00	.89	.42	.28	.48	.47	.42	.36	.31	.22
1.75	.35	1.08	.95	.48	.31	.50	.51	.45	.39	.34	.22

[redacted]

[redacted]



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TBM-3E TARGET AIRPLANE - WING TEST SET-UP
DUMMY BEAM SIDE

PLATE 16

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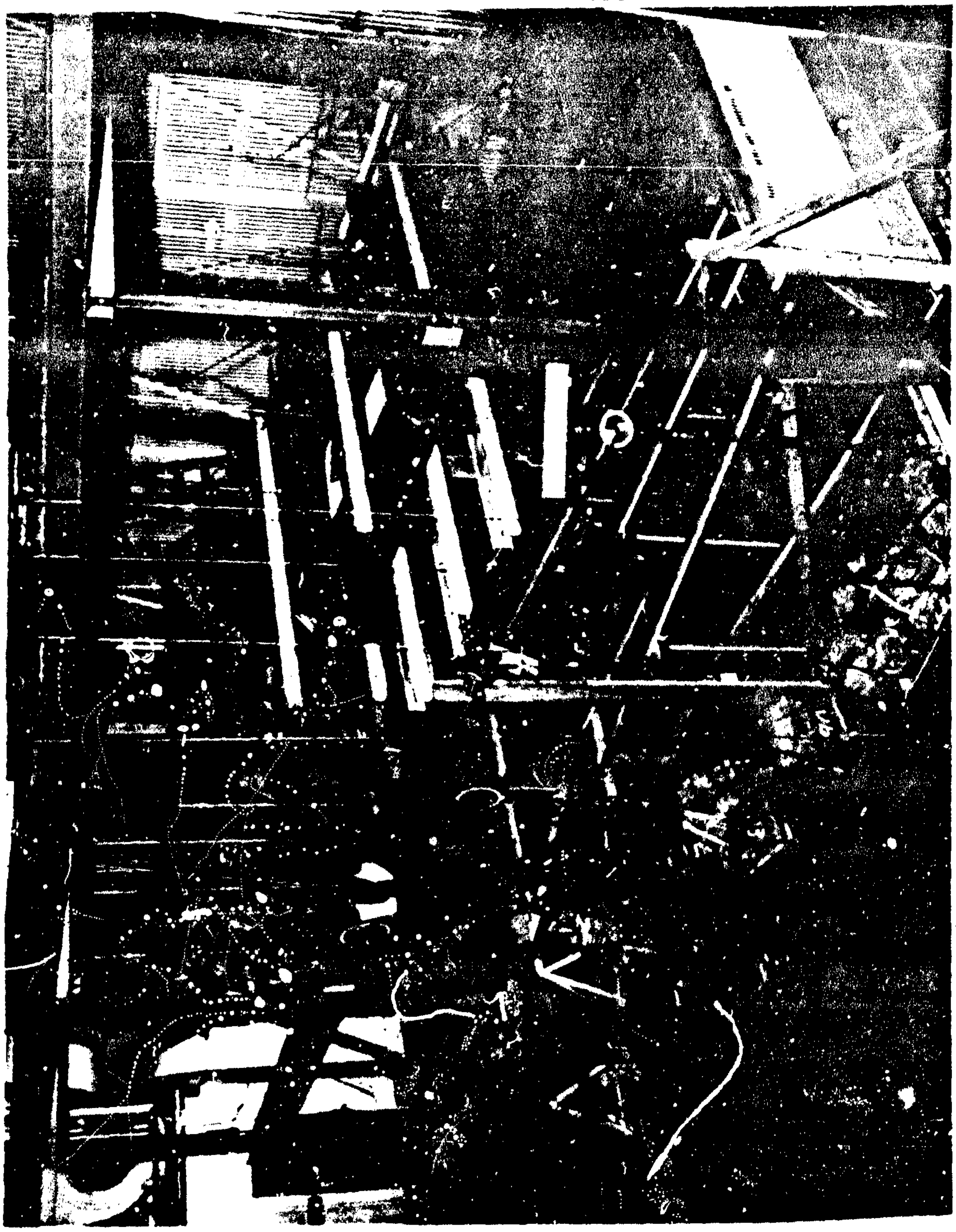

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TBM-3E TARGET AIRPLANE - WING TEST SET-UP
LEADING EDGE VIEW

PLATE 17

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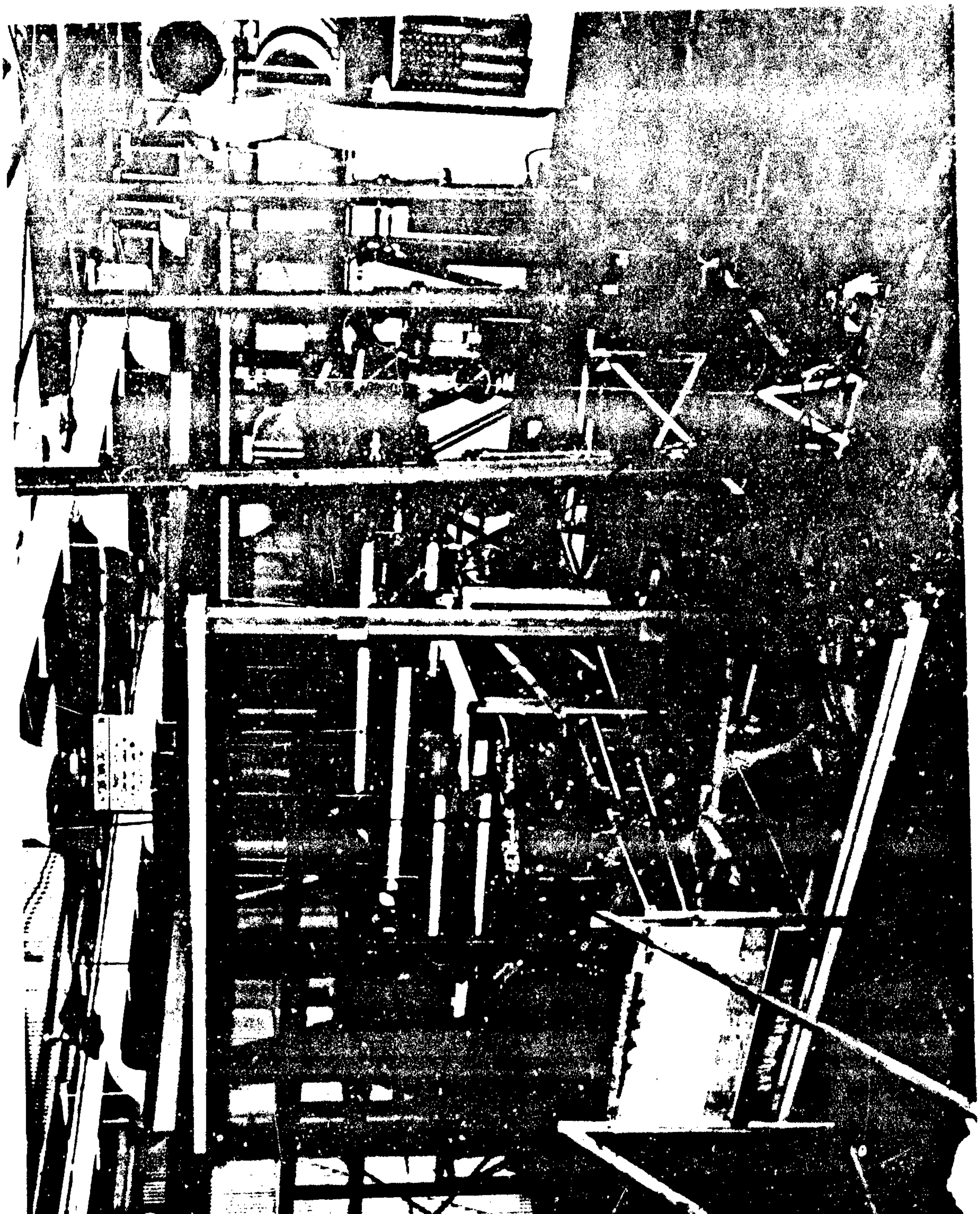

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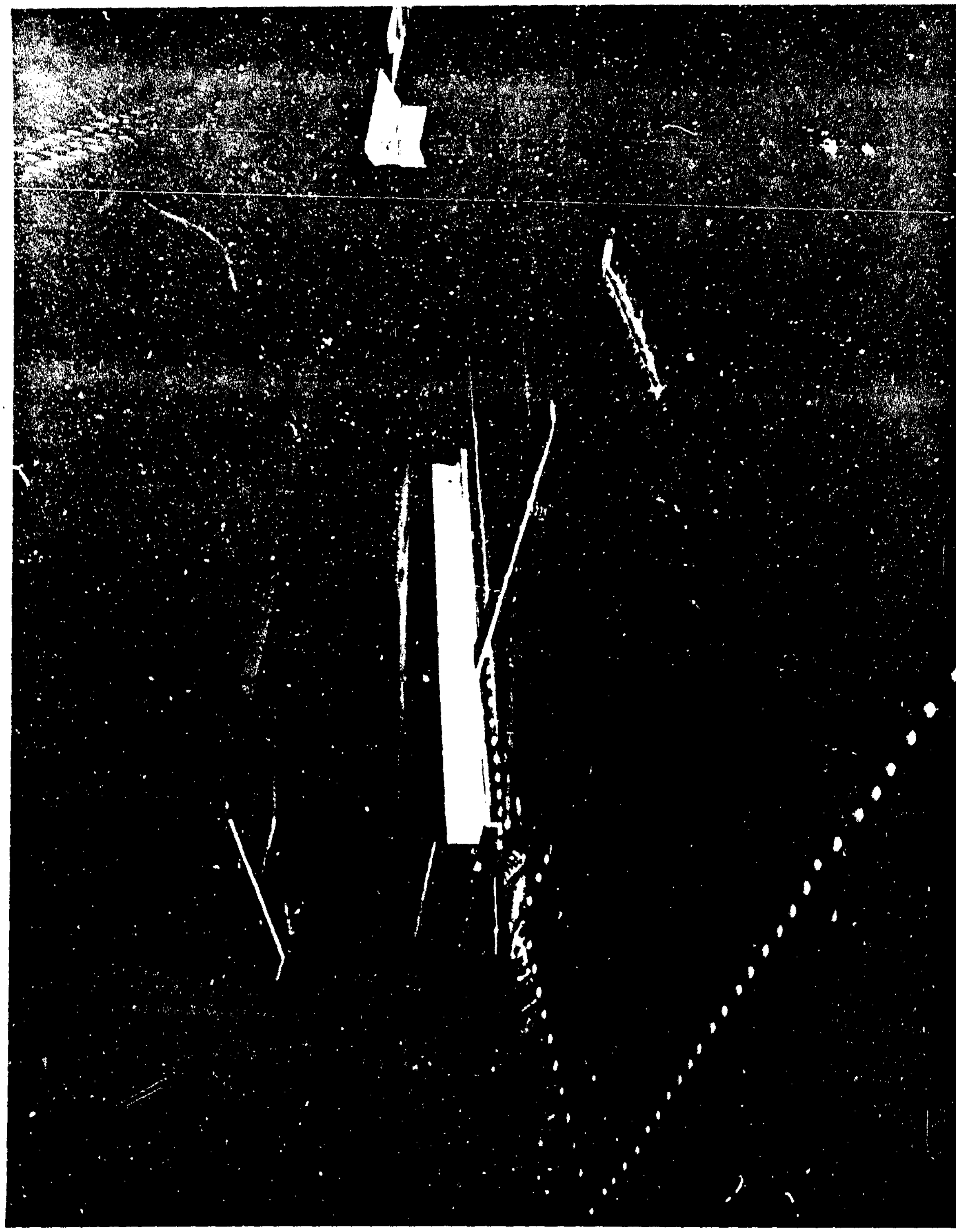
TBM-3E TARGET AIRPLANE - WING TEST SET-UP
TRAILING EDGE VIEW

PLATE 18



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TBM-3E TARGET AIRPLANE - STARBOARD WING LOWER SURFACE - STIFFENER INSTALLATION

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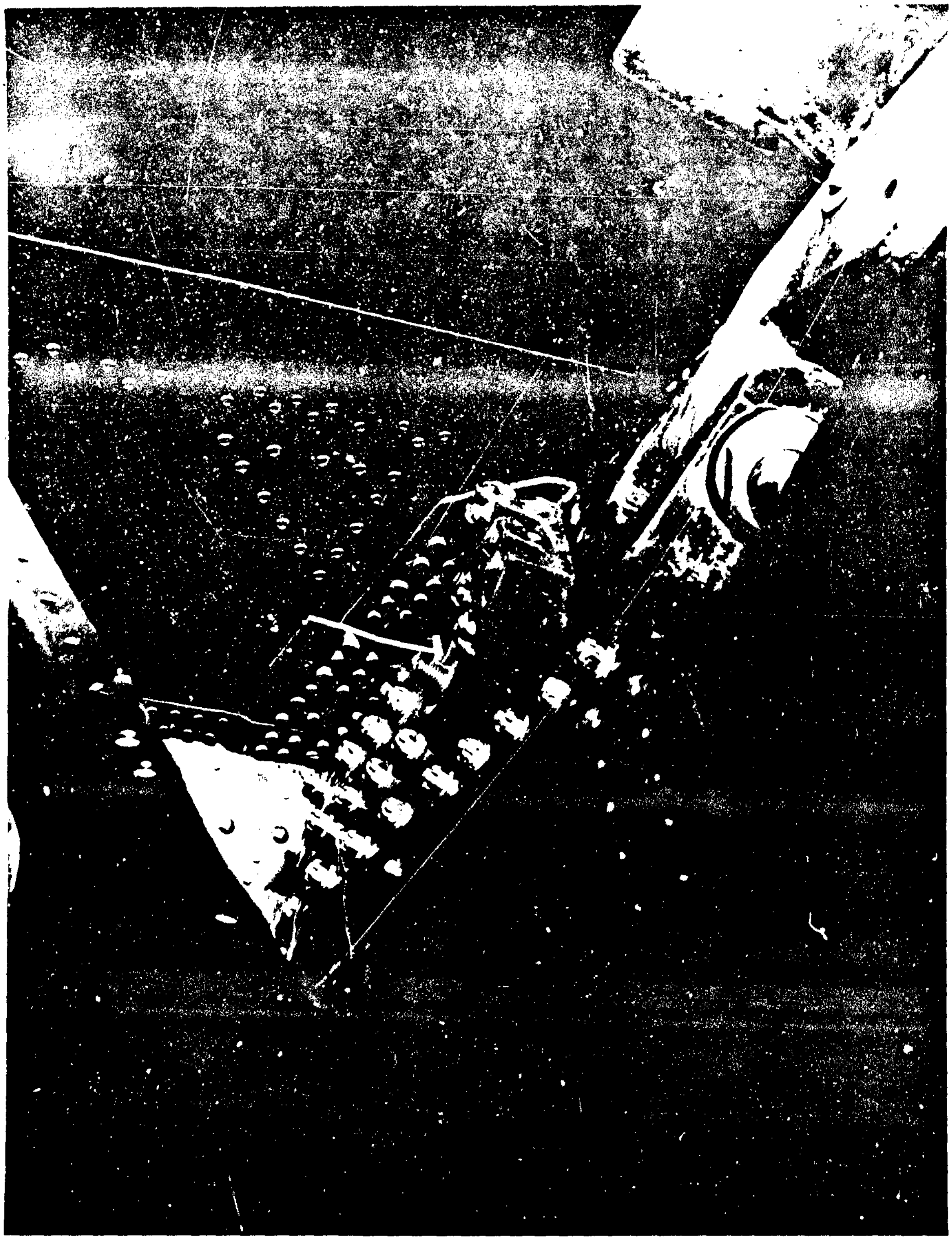
PLATE 19



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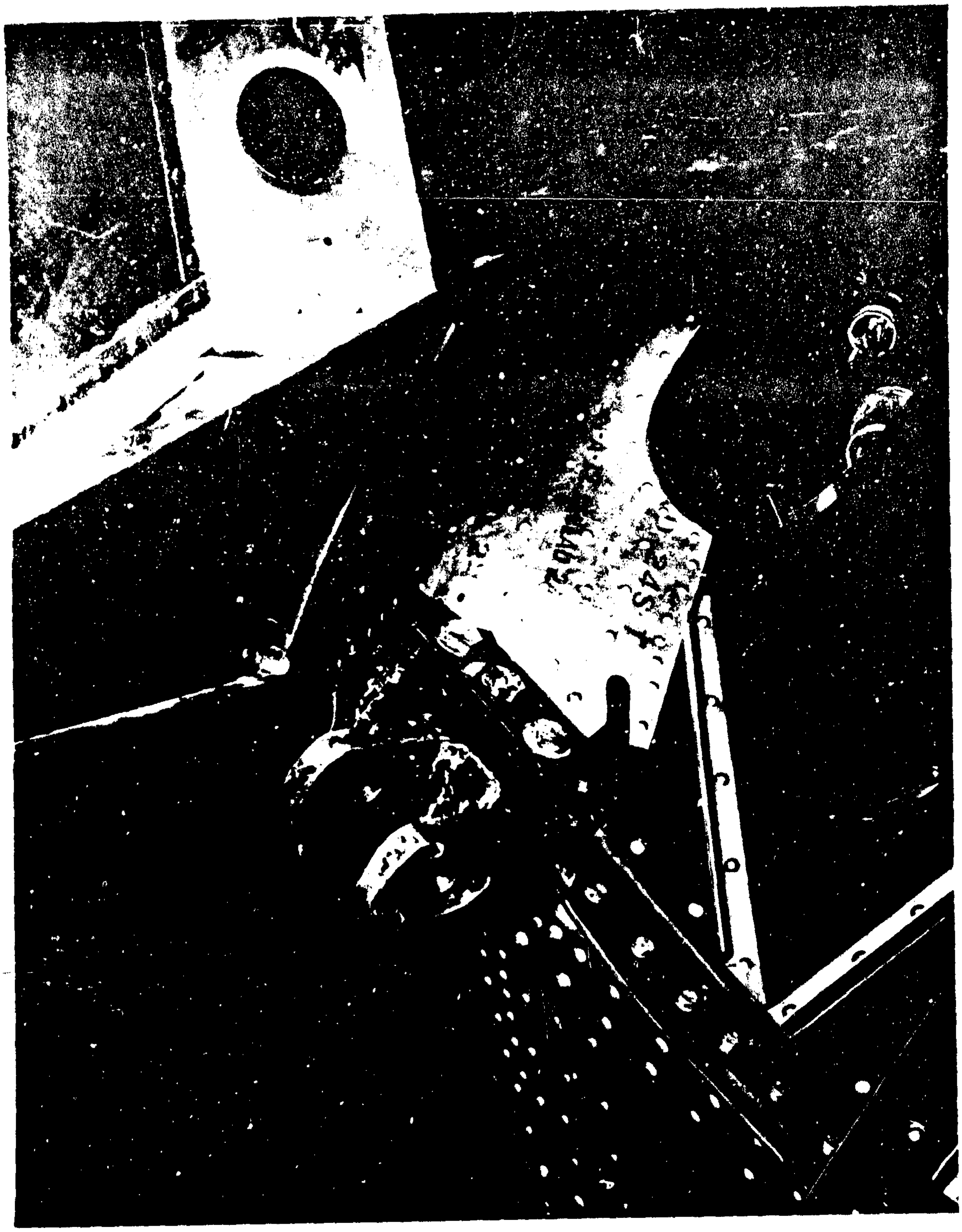
TBM-3E TARGET AIRPLANE - STARBOARD WING
LOWER HINGE FITTING - ADDITION OF ANGLE BRACES PLATE 20



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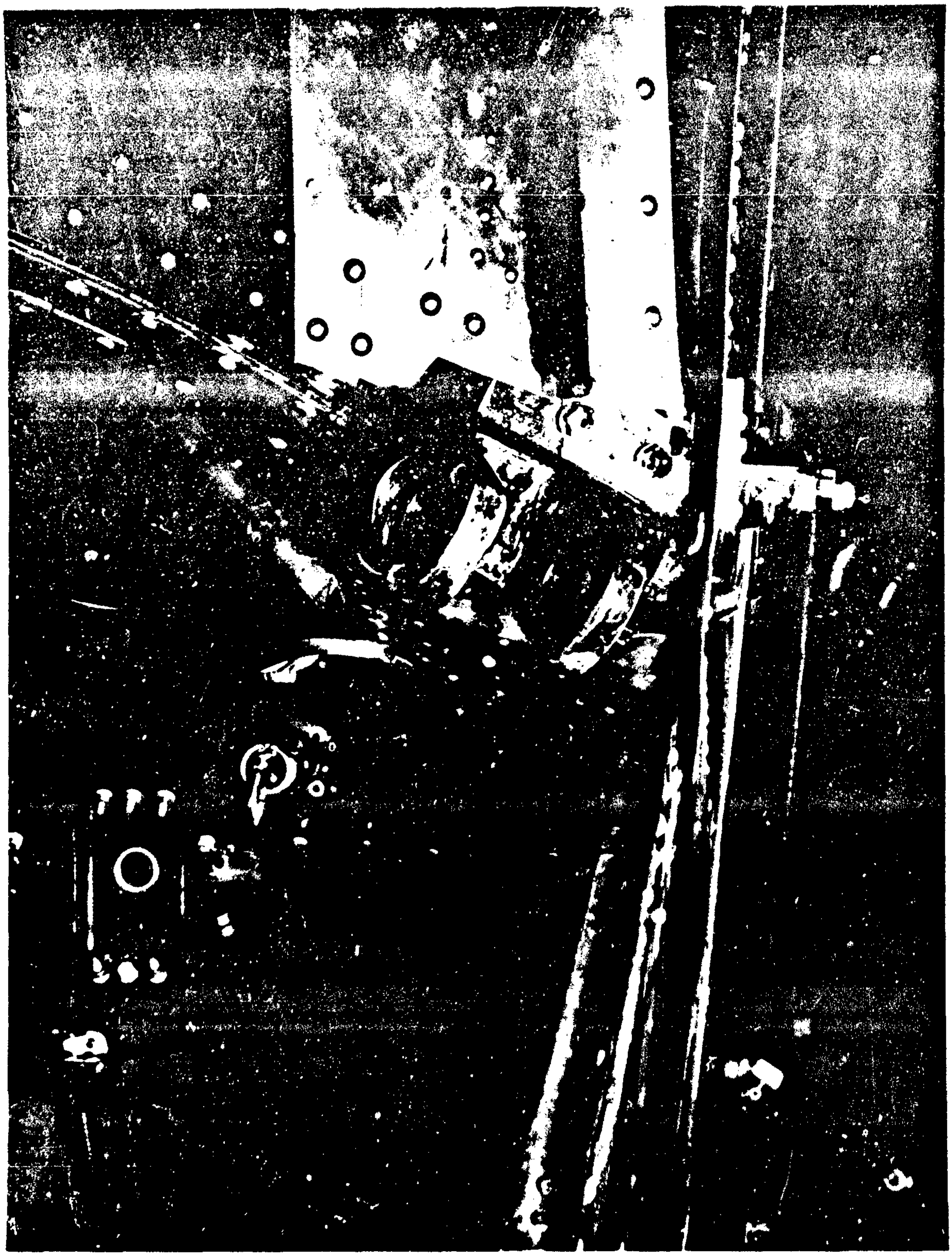
TBM-3E TARGET AIRPLANE - STARBOARD WING
LOWER MAIN BEAM CAPSTRIP FAILURE - OUTBOARD

PLATE 21



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TBM-3E TARGET AIRPLANE - STARBOARD WING
LOWER MAIN BEAM CAPSTRIP FAILURE - INBOARD

PLATE 22