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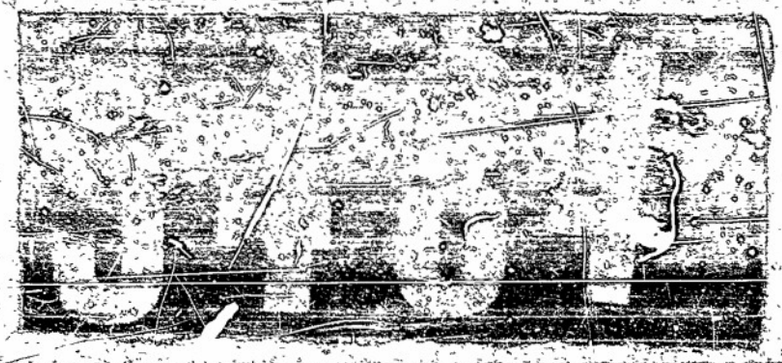

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MC DONNEL AIRCRAFT CORP., ST. LOUIS, MO. (REPORT NO. 2221)

RAM JET HELICOPTER DEVELOPMENT - PROGRESS REPORT 59 - MONTH OF JULY 1951 - MODEL XH-20

WOOD, C.R., JR. 15 AUG'51 26PP PHOTOS, GRAPHS

AF CONTR. NO. AF 33(038)-9845

HELICOPTER - ROTORS, JET
ENGINES, RAM JET
H-20

ROTATING WING AIRCRAFT (34)
DRIVE SYSTEM (6)

UNCLASSIFIED

Enclosure (1)
Ref: 3143-301-2012

MAC 273 (REV. 2-34-50)

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PROPELLER LABORATORY

REPORT 2221

DATE 15 August 1951

REVISED

McDONNELL Aircraft Corporation

ST. LOUIS 3, MISSOURI

PROGRESS REPORT 59

MONTH OF JULY 1951

RAM JET HELICOPTER DEVELOPMENT

SUBMITTED UNDER Contract AF 33 (038)-9805

PREPARED BY C. R. Wood, Jr.

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1. SUMMARY

Preliminary ground and flight evaluation of the first 27-foot diameter rotor were completed. The rotor was removed from the helicopter and installed on the whirl test stand for the rotor calibration and adjustment of Ram Jets Nos. 32 and 33. Installation of the skid type landing gear and instrumentation for measurement of control position and forces and rotor tilt was started.

2. ROTOR DEVELOPMENT

2.1 First 27-Foot Diameter Rotor

A J1-01A8 swivel was installed in the cyclic stick attachment in place of the J1-3119 swivel for continuation of the preliminary ground and flight evaluation, see Figure (1). Rotor operations were marginally improved. Chordwise blade weights have been installed at the trailing edge of the root of each blade, see Figure (2). A maximum of eleven weights, totalling 8 lbs., was installed 11.19 inches aft of the blade feathering axis at each blade root. Further evaluation of the effects of chordwise blade weights is scheduled for the near future.

After completion of the preliminary ground and flight evaluation, the rotor was removed from the helicopter and installed on the whirl test stand. After tests and adjustment of Ram Jets Nos. 32 and 33 for increased thrust, whirl stand torque calibration tests were conducted. The 90 hp added to the whirl stand drive permitted rotor calibration at much higher rotational speeds.

2.1 (cont)

Tests were made with:

a) ram jets replaced with cuff type fairings - faired blade tips

b) ram jets installed and open

c) ram jet exit area reduced

The reduced exit tests were made to determine the external shell drag. The cones attached to the ram jet exit were designed to reduce the internal flow to simulate actual burning external air flow conditions with a temperature rise ratio of 6. This temperature rise had been estimated from blower tests to be typical of the maximum thrust burning condition.

Cross plots of these data are shown in Figures (3), (4), and (5). The equivalent tip drag vs pitch* of the rotor alone is shown in Figure (3) at several tip speeds. The cold drag of the ram jets alone, was deduced from rotor alone and the rotor plus ram jet test data in Figure (4). The average cold ram jet drag coefficient was .18.

* Effective pitch is the average of the measured pitch of the outer 50% of the blade.

2.1 (cont)

Figure (3) shows the results of the reduced exit tests made to determine the external drag coefficient of the ram jet shell. An internal drag was calculated from internal pressure measurements in blower tests. This is subtracted from the reduced exit data, Figure (5), to indicate the ram jet external drag with the ram jet burning, Figure (5). Figure (6) shows the blade twist at various blade stations.

2.2 Second 27-Foot Diameter Rotor

Engineering data re the structural analysis, methods of fabrication, and static and dynamic tests results of the first 27-foot rotor were submitted on 19 July 1951. Fabrication of the second 27-foot rotor awaits the measurement of flight stresses on the first rotor, a restudy of the stress data and WADC approval of the design.

3. RAM JET

3.1 Comparative Study of MAC Ram Jets and Afterburners

MAC has accumulated considerable experience in the design, development and production of afterburners for turbo-jet engines. MAC's Propulsion Division currently is under contract to develop and produce afterburners for several types of USAF turbo-jets.

The fuel distribution characteristics, mixture conditions, etc., of the ram jet and the afterburner are similar. The afterburner can be considered as a ram jet with step-type flame holders. Comparative studies of afterburners and ram jet thrust specific fuel consumption indicate that the actual thrust specific fuel consumption (TSFC) of the MAC ram jet approaches that of the afterburner, see Figure (7). Figure (8) shows relative performance of the ram jet and afterburner. Higher afterburner pressure ratios account primarily for the lower TSFC.

3.2 How Modified Radial Finger-Type Ram Jets

Ram Jets Nos. 32 and 33 fitted to the 27-foot diameter rotor were utilized to complete the primary evaluation of control forces and control response characteristics. They were then utilized for calibration of the 27-foot diameter rotor. The ram jets are to be adjusted for improved thrust subsequent to further flight tests of the 27-foot diameter rotor.

3.3 MAC Ram Jet Development

Thirty-five ram jets have been designed, developed, and tested under Contracts w33-038-ac-14856, AF 33(038)-937, and AF 33(038)-9845. The first 16 ram jets were of the swirl-vane flame holder type and used propane as fuel. The ram jets were of the swirl-vane type with internal gasoline vaporizer. All subsequent ram jets have been of the liquid fuel injection type with either gutter cone flame holders or radial finger type flame holders. The maximum diameter has been varied from 7.25 to 8.7 inches; the exit diameter from 4.5 to 5.7 inches; the inlet diameter from 3 to 4.40 inches, and the length from 14 to 22 inches. Ram jets have been constructed of stainless steel, Inconel "X", and L-605 material. The ram jet weight has varied from 9.5 lbs. to 11.3 lbs.

Test ram jets - 8.7 inches maximum diameter, 22 inches length, radial finger liquid injector type - have been fabricated and are being tested in the free air jet test stand prior to whirl testing. These larger ram jets are designed for improved rotor performance of the XH-20.

3.3 (cont)

MAC has financed development of 8 additional ram jets of maximum diameter from 7.25 to 8.7 inches; exit diameter from 5.0 to 5.7 inches; inlet diameter, 4.40 inches; length from 21.5 to 22 inches. All ram jets were of Inconel "X" material. The ram jets weight has varied from 12.22 to 16.21 pounds.

3.4 Modified Whirl Stand

The preliminarily modified whirl stand supplemented by a 90 hp engine was utilized for the calibration of the first 27-foot diameter rotor. Marginally sufficient power was available to permit completion of cold drag test of the 27-foot diameter rotor. An improved whirl test stand is being developed, to be supplemented by a 150 hp engine, and will soon be available for tests of rotors under simulated actual operative conditions.

4. [redacted] XH-20, USAF NO. 46-690

4.1 Preliminary Tests

Preliminary ground and flight tests of the XH-20, No. 2, fitted with the first 27-foot diameter rotor were conducted in July. The effects of control changes, changing blade weights, etc., were measured. Tests produced small reductions in control forces with little improvement in control response. Collective pitch control sensitivity was reduced and was satisfactory with J1-3024 pulley installed in place of J1-0150 pulley. See Figure (2).

4.2 Skid Gear and Extended Tail Boom

The landing gear stability of the XH-20 had been reduced by the installation of the 27-foot diameter rotor and the raising of the vertical CG of the helicopter. Therefore, a wide skid gear was installed after completion of the preliminary tests. For improved directional control an extended tail boom with swiveling rudder was also installed.

4.3 Control System Design

Studies of the control system design have been conducted in order to reduce control forces and to improve control response. The XH-20 is being fully instrumented for the measurement of stick forces, stick position and blade see-saw motions. Test operations are scheduled for August to measure the actual forces and conditions encountered to permit study of changes necessary for satisfactory flight operations.

5. DAILY FLIGHT SHEETS - XH-20 Helicopter Test Data

Test No.: 130 Pilot: C. E. Wood, Jr.

Date: 3 July 1951 Helicopter: No. 2

Rotor: 27-Foot Diameter 12-inch Chord Rotor Blade Powered By Ram Jets Nos. 32 and 33

Purpose: Evaluate Control Changes of 27-Foot Rotor and Effect of C. G. Variation

Remarks: Rotor acceleration was slow; ram jet fuel pressure is inadequate for rotor acceleration; there was little stick shake during rotor run-up or in hovering. The helicopter was nose heavy, longitudinal stick forces were high, and lateral forces not noticeably reduced by the installation of J1-0168 swivel in place of J1-3119 cyclic stick attachment. The lateral displacement required was increased. The movement of the cyclic pitch stick neutral position aft interfered with controllability. Collective pitch control sensitivity was reduced and was satisfactory as a result of change of J1-3024 for J1-0150 pulley. Landing gear stability is reduced with the 27-foot rotor.

Flight Time: 00:06

Running Time: 00:36

Total Flight Time to Date: 32:03*

Total Running Time to Date: 125:45*

*Total for Nos. 1 and 2, XH-20

Test No.: 131 Pilot: C. R. Wood, Jr.

Date: 5 July 1951 Helicopter: No. 2.

Rotor: 27-Foot Diameter 12-inch Chord Rotor Blade Powered by Ram Jets Nos. 32 and 33

~~Purpose:~~ Evaluate Changes in Blade Characteristics C. G. Tied Down and In Hovering

Remarks: Ground tied down tests indicated that although cyclic control forces were high, they were controllable; the tie down was removed. With eleven weights, totalling 8 pounds per blade, the helicopter was uncontrollable on lift-off from the ground. Conditions were only marginally improved by removal of five, 3.5 pounds, of the weights from each blade.

Flight Time: 00:01

Running Time: 00:25

Total Flight Time to Date: 32:05*

Total Running Time to Date: 126:10*

*Total for Nos. 1 and 2, XH-20

Test No.: 132 Pilot: C. R. Wood, Jr.

Date: 6 July 1951 Helicopter: No. 2.

Rotor: 27-Foot Dismotor 12-inch Chord Rotor Blade Powered By Ram Jets Nos. 32 and 33

Purpose: Further Evaluation of Chordwise Blade Weights

Remarks: Hovering evaluation tests were conducted with three weights per blade; the helicopter became uncontrollable on lifting-off the ramp. All weights were removed and spacer wood blocks installed in the brackets. Momentary flight characteristics without weights were improved; the over-balancing forces were reduced, but the steady stick forces were increased.

Flight Time: 00:02

Running Time: 00:16

Total Flight Time to Date: 32:06*

Total Running Time to Date: 126.26*

*Total for Nos. 1 and 2, XH-20

6. WORK PROGRAM FOR MONTH OF AUGUST

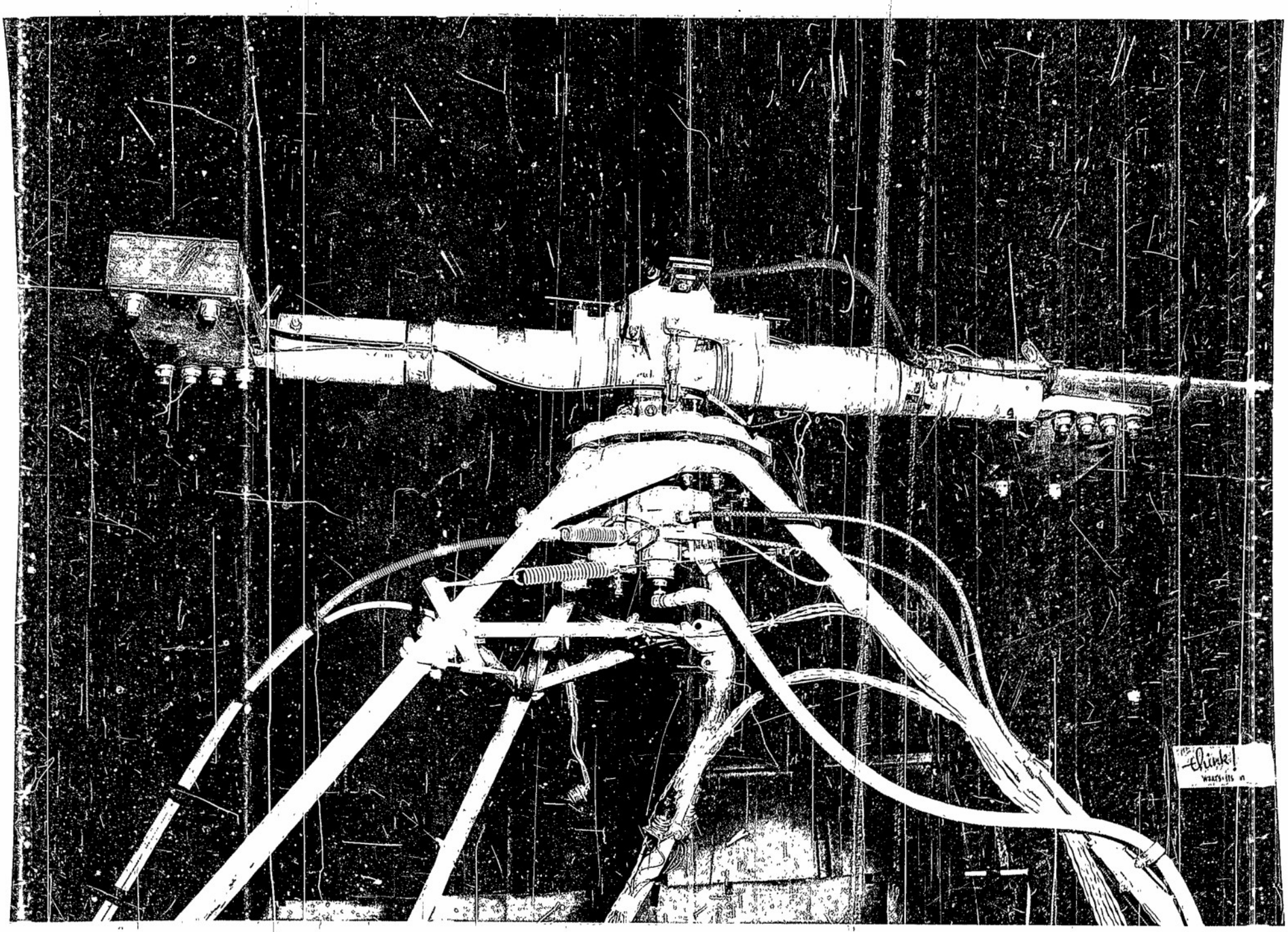
6.1 Modified XH-20, No. 2

The installation of the skid type landing gear, extended tail boom, and swiveling rudder will be completed. Instrumentation for measurement of control position and forces and rotor tilt will be installed.

Ground and flight tests are scheduled for measurement of stick forces, stick positions, and blade see-saw motions in order to determine necessary information to permit modifications for satisfactory ground and flight evaluation of the 27-foot diameter rotor.

6.2 Ram Jets Nos. 32 and 33

Ram Jets Nos. 32 and 33 are to be assembled for increased thrust and improved rotor performance. Development of improved ram jets has been accelerated.



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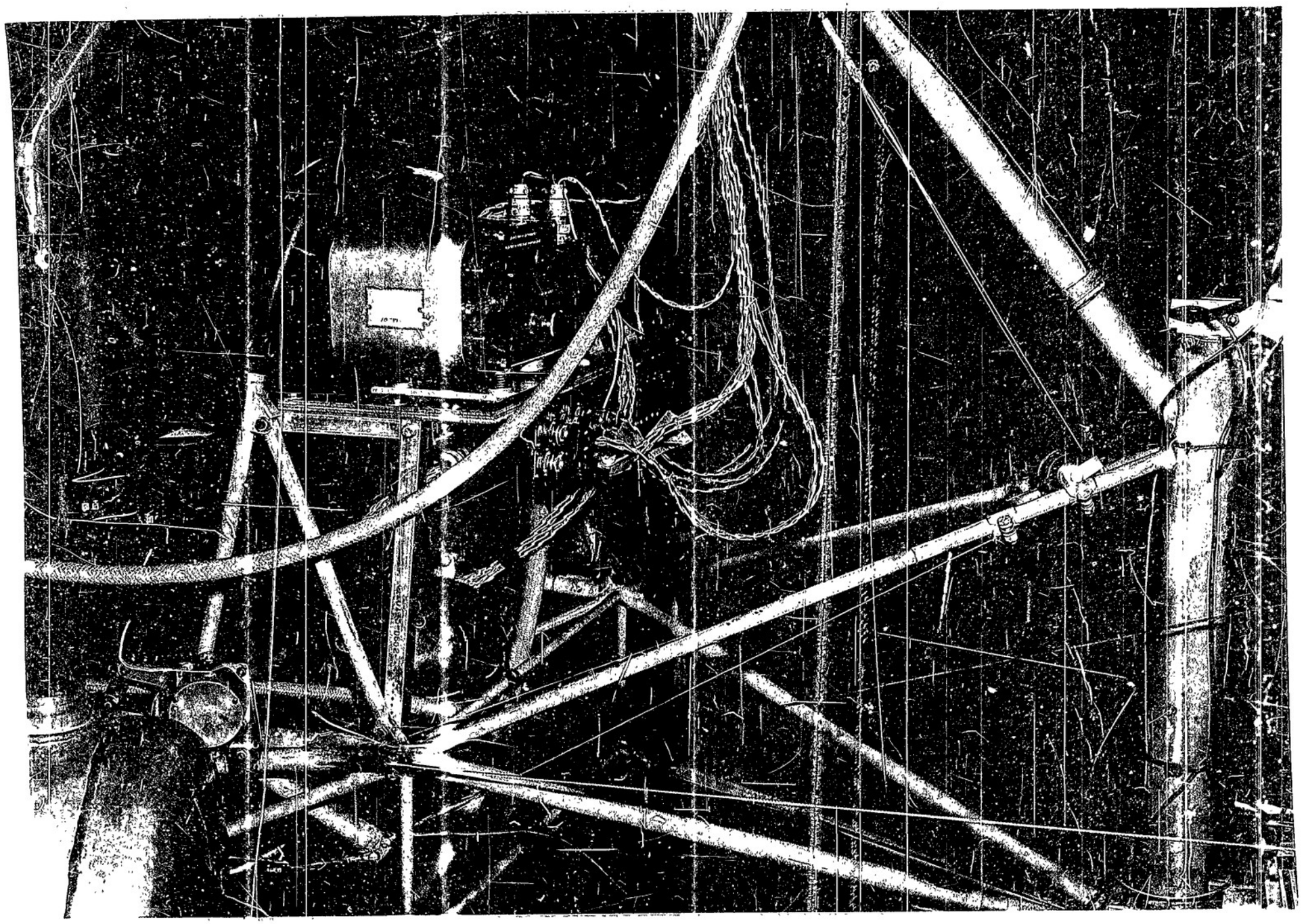
CHORDWISE BLADE WEIGHTS AND CYCLIC STICK ATTACHMENT SWIVEL FIGURE (1) PAGE 19



REPORT 222.
D4E 2 179

COLLECTIVE PITCH CONTROL PULLEYS, J1-3024;
PARTIALLY INSTALLED OSCILLOGRAPH, ETC.

FIGURE 92) PAGE 20

FIG 3

WHIRL STAND TORQUE CALIBRATION

26.4 FT. ROTOR WITH RAM JET & FAIRING REPLACED BY CUFF.
DATA CORRECTED TO 13.5 FT. RADIUS & TO STD. S.L. COND.
TEST DATE: 7-20-51

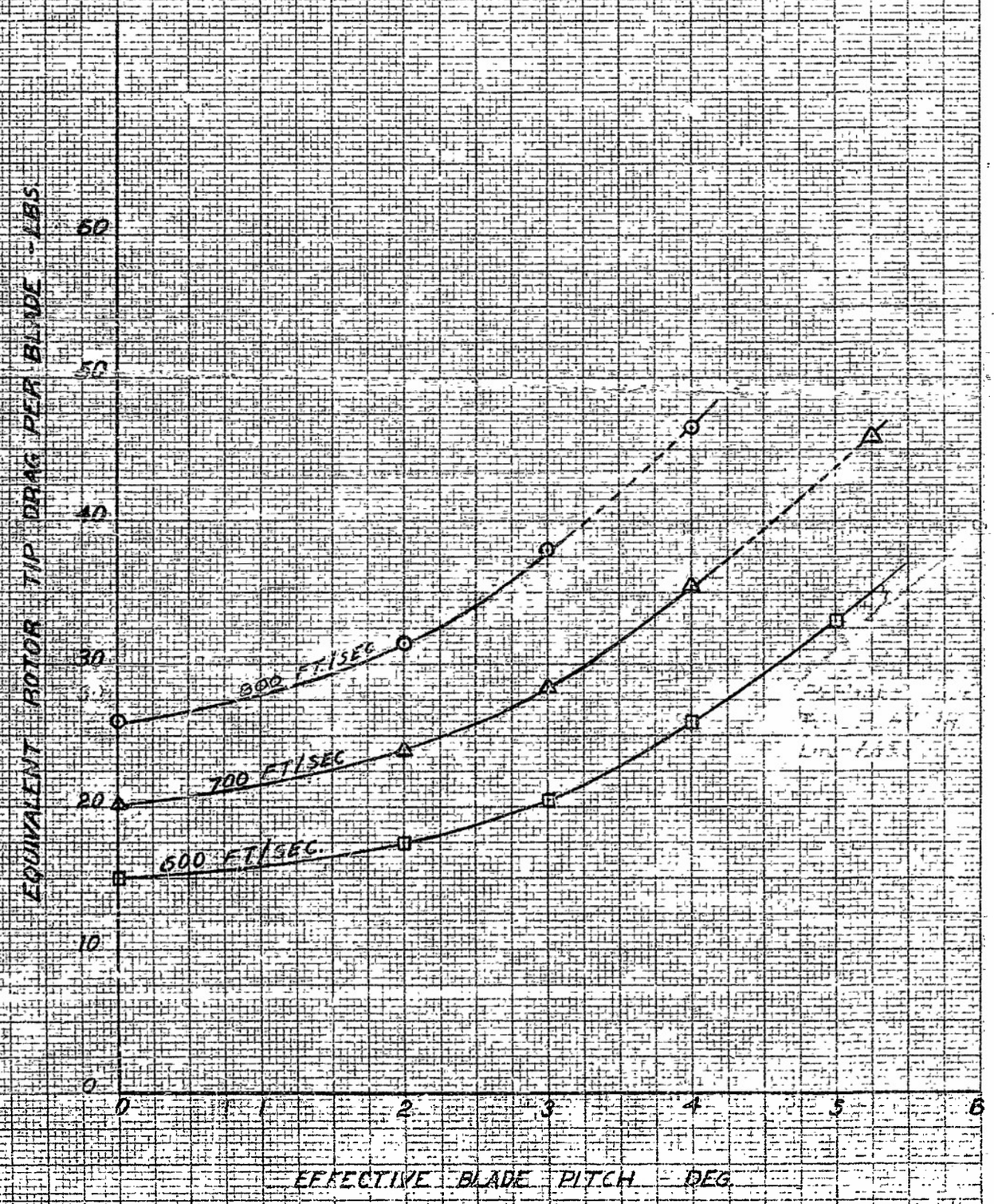
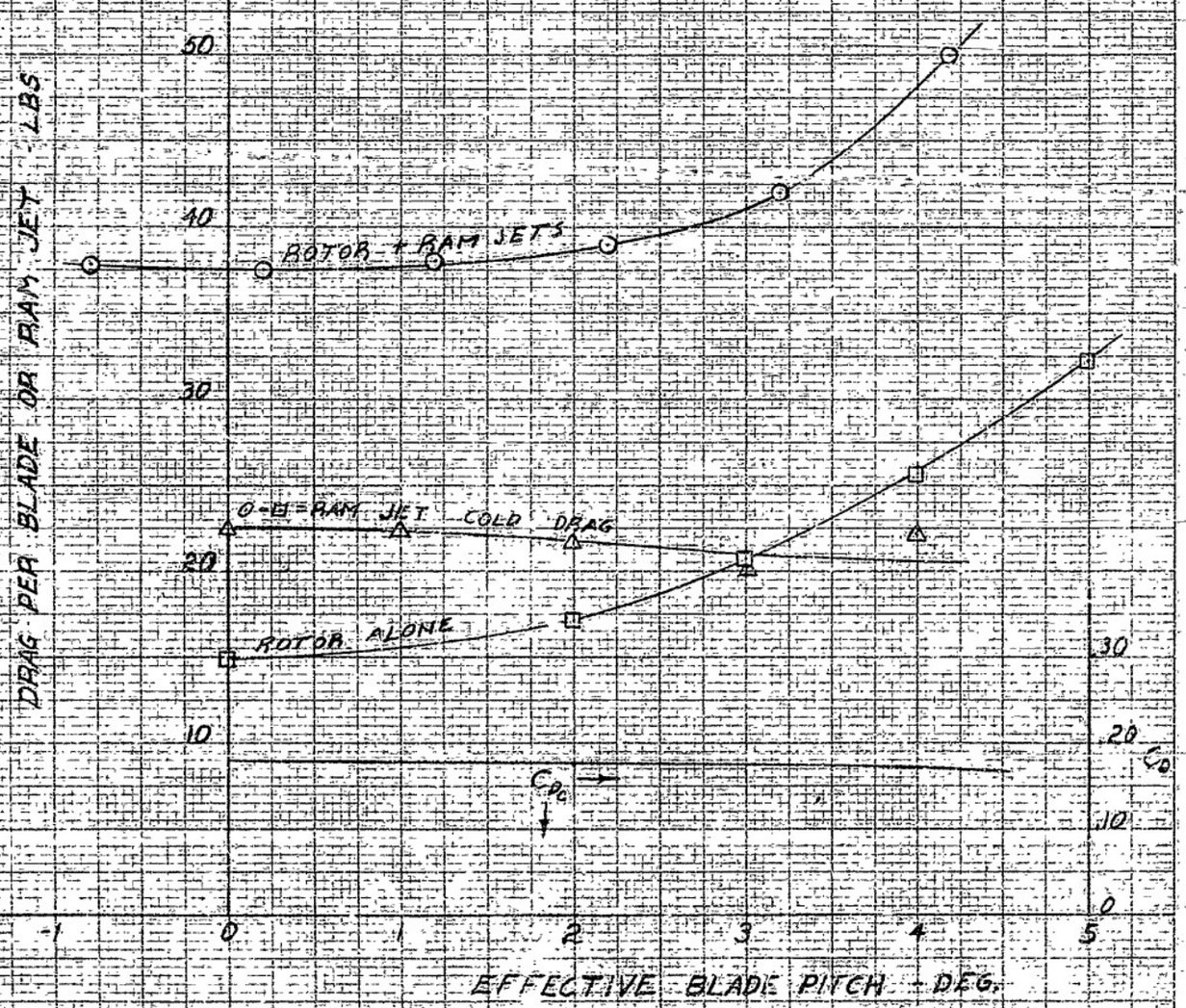


FIG 4

RAM JET COLD DRAG

DETERMINED BY WHIRL STAND TESTS
TIP SPEED: 600 FT/SEC
27 FT ROTOR WITH RAM JETS 32 & 33
TEST DATE: 7-11-51
DATA CORRECTED TO 13.5 RADIUS & TO STD S.L. COND.



8-15-51

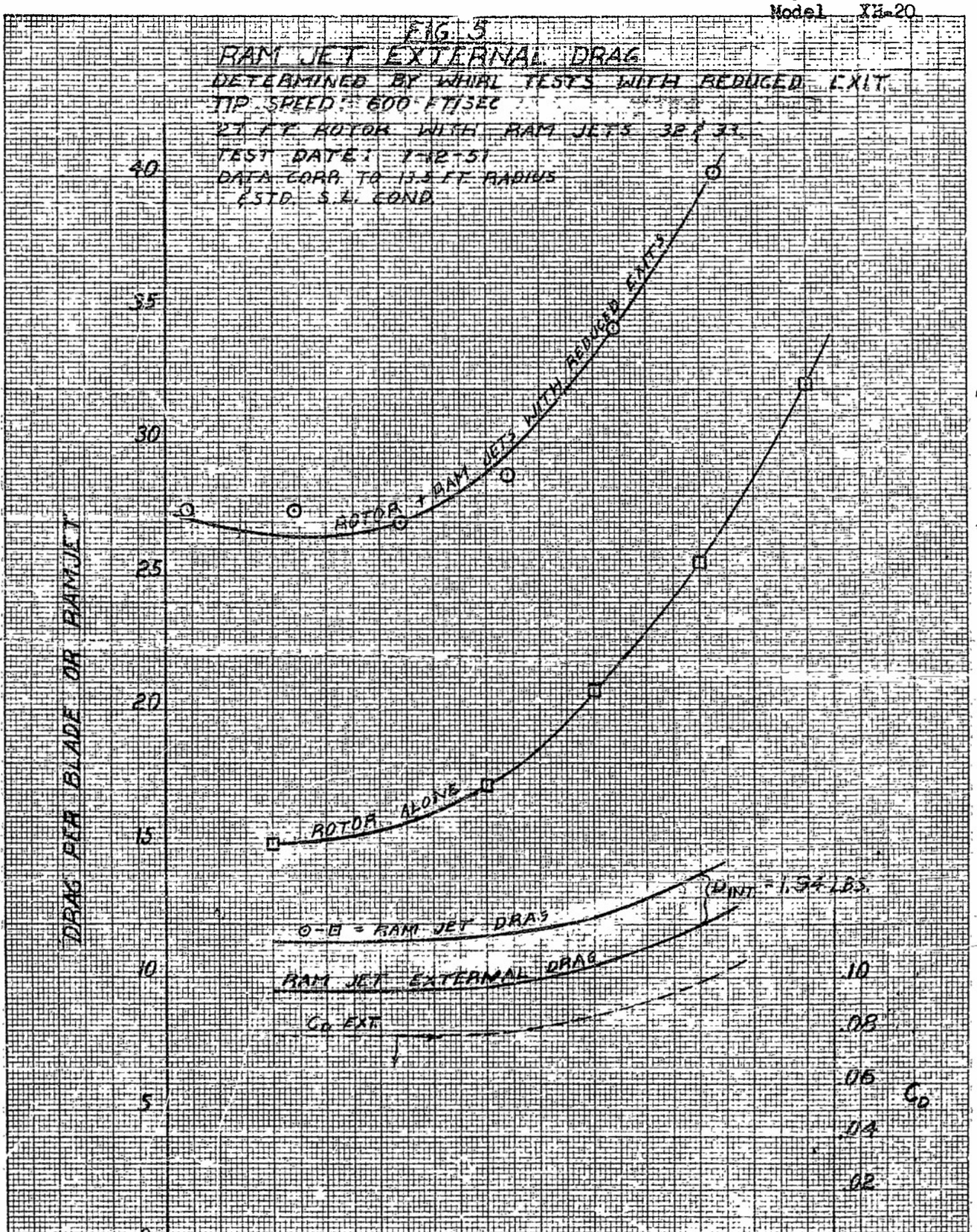


FIG. 5
RAM JET EXTERNAL DRAG
DETERMINED BY WHIRL TESTS WITH REDUCED EXIT
TIP SPEED: 600 FT/SEC
27 FT ROTOR WITH RAM JETS 32 & 33
TEST DATE: 7-12-51
DATA CORR. TO 13.5 FT RADIUS
& STD. S.L. COND.
ROTOR + RAM JETS WITH REDUCED EXITS
ROTOR ALONE
⊙-⊡ = RAM JET DRAG
RAM JET EXTERNAL DRAG
C_D EXT.
D_{INT} = 1.94 LBS.
DRAG PER BLADE OR RAMJET
EFFECTIVE BLADE PITCH - DEG.
C_D
0
5
10
15
20
25
30
35
40
-1
0
1
2
3
4
5
.02
.04
.06
.08
.10

339-11 KEUFFEL & ESSER CO.
10 × 10 to the ½ inch, 5th lines accented.
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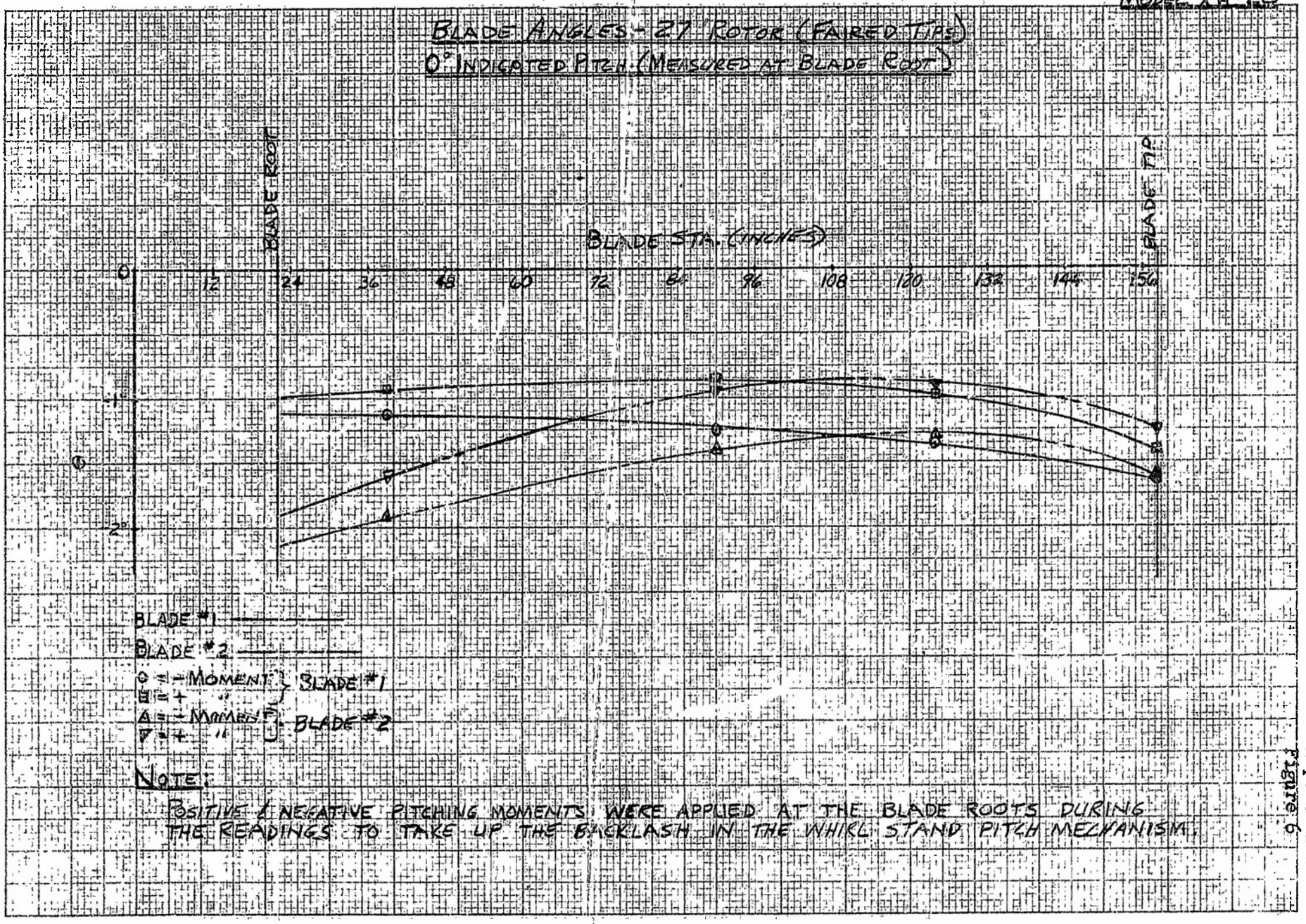
MODEL XH-26

BLADE ANGLES - 27' ROTOR (FAIRED TIPS)
0° INDICATED PITCH (MEASURED AT BLADE ROOT)



NOTE:
POSITIVE & NEGATIVE PITCHING MOMENTS WERE APPLIED AT THE BLADE ROOTS DURING THE READINGS TO TAKE UP THE BACKLASH IN THE WHIRL STAND PITCH MECHANISM.

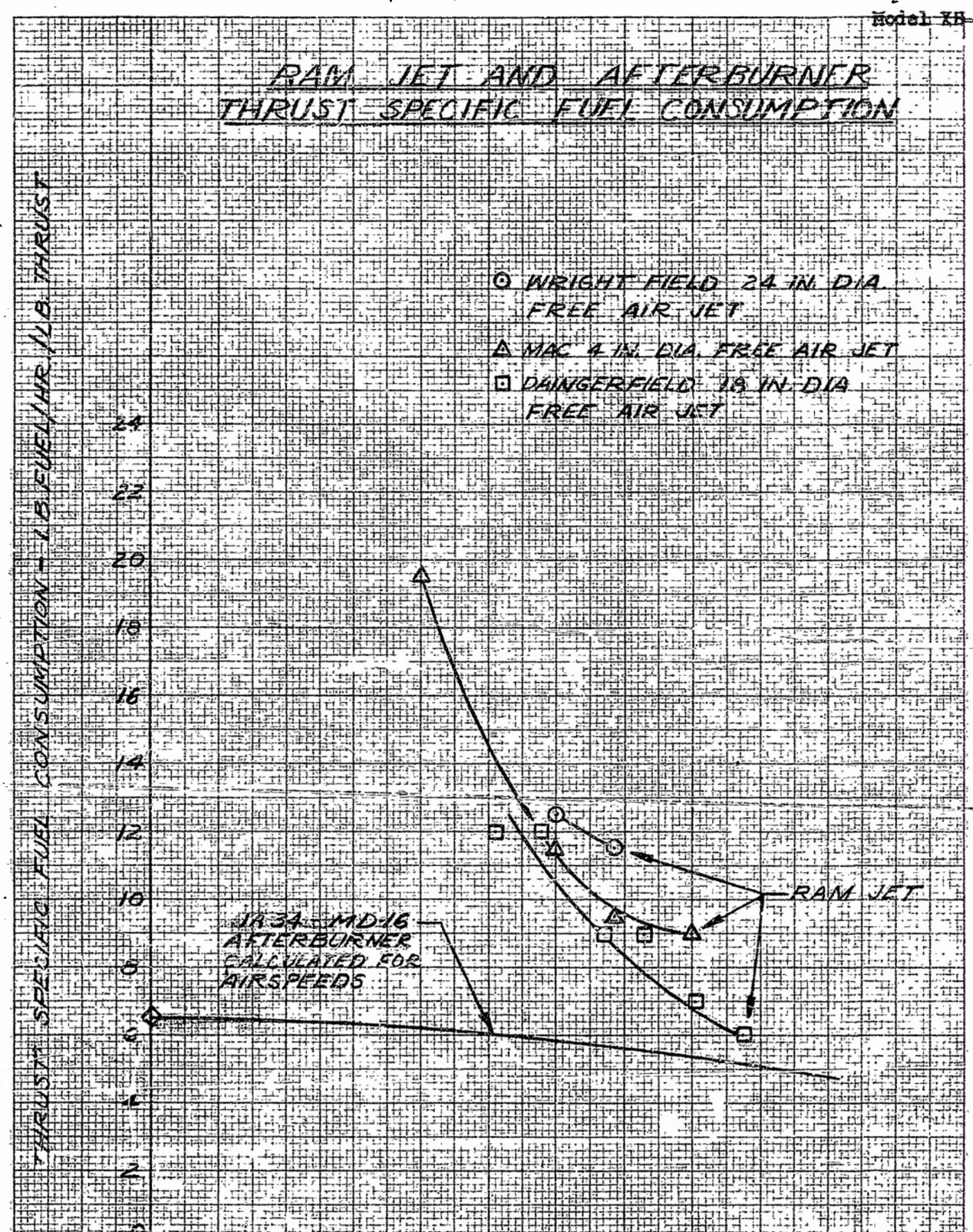


Figure 7

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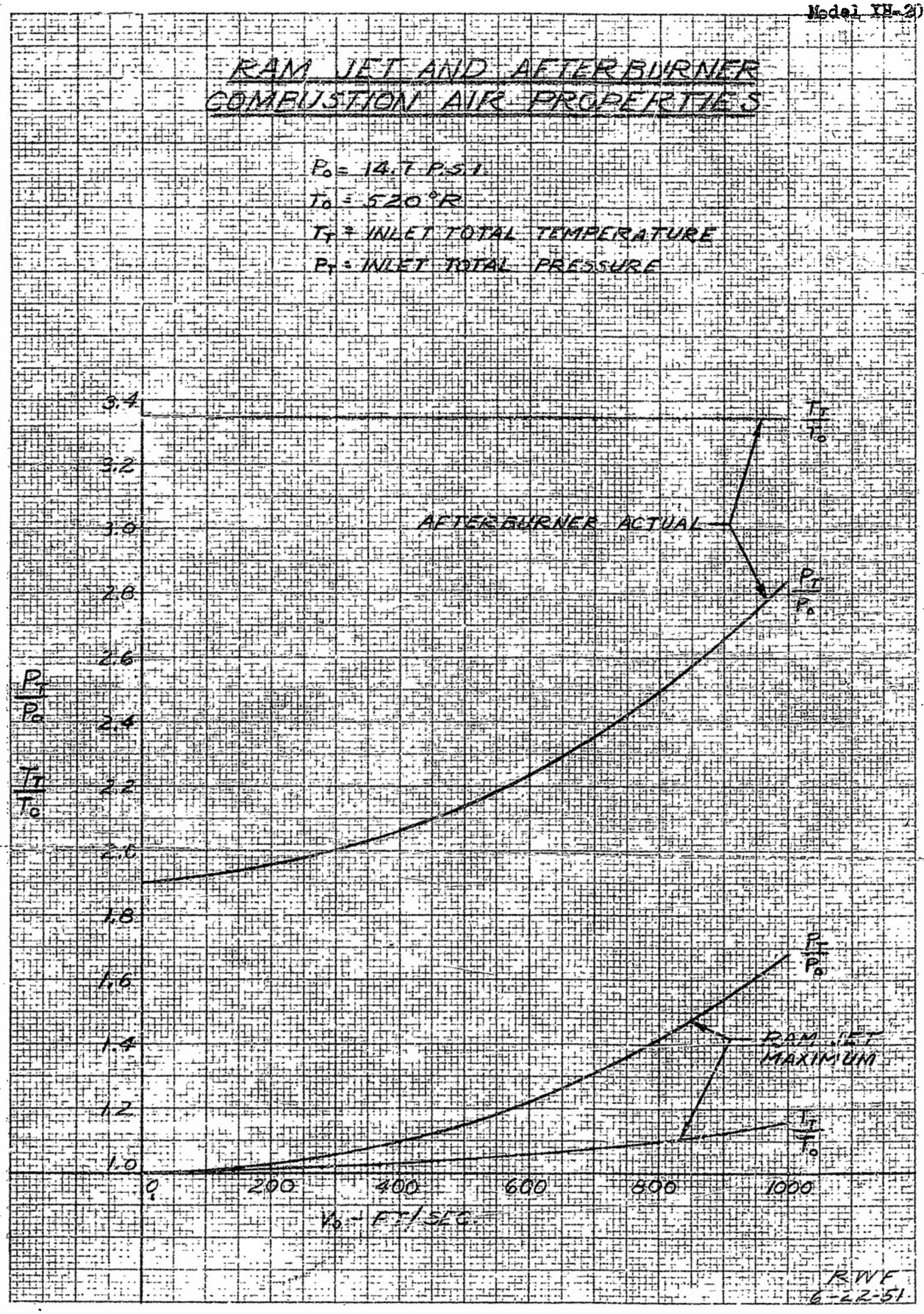

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Figure 8