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MC DONNELL AIRCRAFT CORP., ST. LOUIS, MO. (REPORT 2323)

RAM JET HELICOPTER DEVELOPMENT - PROGRESS REPORT 60 - MONTH OF AUG 1951 - MODEL XH-20

WOOD, C.R. JR. 15 SEPT 51 24PP GRAPHS

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

HELICOPTERS, JET
ENGINES, RAMJET
HELICOPTER ROTORS, JET
H-20

ROTATING WING AIRCRAFT (34)
DESIGN (10)

UNCLASSIFIED

REPORT NO. 2323 15 SEPTEMBER 1951

PROGRESS REPORT NO. 60

RAM JET HELICOPTER DEVELOPMENT

CONTRACT AF 33(038)-9845

Serial No. 3

Enclosure (1)
Ref: 2143-301-2073

MAC 273 (REV. 2-24-50)

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PROPELLER LABORATORY

REPORT 2323
DATE 15 September 1951
REVISED

McDONNELL Aircraft Corporation

ST. LOUIS 3, MISSOURI

PROGRESS REPORT 60

MONTH OF AUGUST 1951

RAM JET HELICOPTER DEVELOPMENT

SUBMITTED UNDER Contract AF 33-(038)-9845

PREPARED BY C. R. Wood, Jr.
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1. SUMMARY

The calibration data of the No. 1, 27-foot diameter rotor were recalculated and revised data are submitted herewith. Tests for accumulation of the data necessary to substantiate the design for the No. 2, 27-foot diameter rotor are next on the schedule. Larger ram jets are being developed for increased thrust. The actual weight and balance of the No. 2, XH-20 are submitted herewith. Preliminary ground evaluation of the instrumented 27-foot rotor installed on XH-20 No. 2, were completed and rotor assembly modifications are in work.

2. ROTOR DEVELOPMENT

2.1 No. 1, 27-Foot Diameter Rotor

The rotor was utilized for improvement of the ram jet thrust on the whirl stand prior to installation on the XH-20, No. 2. Preliminary ground tests of the instrumented 27-foot diameter rotor were completed on 31 August. Tests for the measurement of rotor blade stresses, etc., are next on the schedule.

Preliminary plans have been made for the repair of the adhesive failures reported in Progress Report No. 58, for June 1951. It is proposed to replace panels of the blade covering, utilizing Epon VI adhesive which sets at relatively low curing temperatures.

The rotor calibration data submitted in the July Progress Report have been restudied and recalculated to consider the effective blade angles, the recalibration of the torque measuring system and standard atmospheric conditions. Figures (3), (4), (5), (6), (7) and (8) of Progress Report No. 59, are superseded by Figures (1), (2), (3), (4) and (5) of this Progress Report. A review of the rotor calibration tests follows: original tests were run on 16 July, and a portion of the rotor calibration was rerun on 20 July. When reviewing the

2.1 continued

MAC Report No. 1136, and the values of T/F as derived from the NACA TN 2277 (with the necessary corrections) resulted in an increase in the T/F for the latter of approximately 2½%. The dotted lines in Figure (5) of this Progress Report represent the results of the rotor calibration test and are re-plotted from Figure (1) to show that excellent agreement exists between the MAC rotor calibration tests and the theory as based on the modified NACA test data.

2.2 No. 2, 27-Foot Diameter Rotor

As soon as the qualitative performance tests of the No. 1, 27-foot diameter rotor are obtained, they will be submitted with proposed design changes for the No. 2, 27-foot rotor, details of which were delivered in July. Studies have been made to investigate the suitability of twisting the .0095 aluminum blade covering in accordance with the drawing then submitted. The fabrication of a test sample of the 27-foot rotor, in accordance with the design submitted, resulted in wrinkles in the blade covering. The causes of the wrinkles are being determined so that the design may be modified prior to fabrication of the second 27-foot rotor.

3. RAM JETS

3.1 Modified Radial Finger-Type Ram Jet

Ram Jets Nos. 32 and 33 will be modernized prior to reinstallation on the XH-20, No. 2, for further evaluation of the 27-foot diameter rotor. The modernization will include the installation of a new type fuel system and a modification of the flame holder.

3.2 Fabrication of 8.71-Inch Diameter Ram Jet

A larger cross sectional area ram jet has been designed to produce the increased thrust required for higher gross weights with the 27-foot diameter rotor. Four (4) test ram jets of 8.71-inch diameter are being fabricated for test and evaluation. The first unit has been completed and tested in the free air jet test stand in order to obtain smooth and non-destructive burning. The original tests of the 8.71-inch diameter ram jet were made with the exit diameter reduced from 5.7" to 5.4". This reduction in exit diameter resulted in the same inlet area to exit area ratio as that of an 18" long, 7.25" maximum diameter ram jet which had consistently developed high thrust and satisfactory tsfc at 800 fps in the free air jet. With the reduced exit diameter, the new 8.71" ram jet developed 59.5 lb. of thrust at tsfc of 10.

3.2 continued

The exit diameter is to be increased to the designed diameter of 5.7", and the inlet diameter is to be increased proportionately to retain the same inlet-exit area ratios, but to investigate the possibility of increased thrust. The 8.7" diameter ram jet will have the flame holder installation modified to reduce ram jet shell cracking.

3.3 A thorough investigation is being made of available ignition wire insulation materials, in an effort to increase the durability of ram jet insulators.

3.4 <u>Modified Whirl Stand</u>

The MAC sponsored installation of a R-985, 450 hp engine, in the whirl stand is 85% complete. The whirl-stand is scheduled to be ready for initial operation with the supplementary horse power on or about 1 October 1951. This additional power will permit the calibration of the 27-foot diameter rotor throughout the normal operating range of collective pitch and rotor RPM. A single blade club rotor has been designed, and construction is scheduled to start about 1 October. This club rotor will permit the calibration of individual ram jets on the whirl test stand.

4. XH-20, USAF NOS. 46-690 and 46-689

4.1 Modified XH-20, No. 2, USAF 46-690

4.1.1 The actual weight and balance of the XH-20, No. 2, as weighed on 17 August 1951 is as follows:

		Weight Lbs.	C.G. Fwd or Aft of Rotor ℄
Helicopter As Weighed		643.2	0.1 aft
Deduct Flight Test Instrumentation		-121.2	
Weight Empty		522.0	5.0 aft
Useful Load		341.0	
Pilot	185.		
Fuel (26 gals)	156.		
Gross Weight (Normal)		863.0	1.9 aft
Gross Weight (Including Flight Test Instrumentation)		984.2	0.9 fwd

The helicopter has been placarded requiring the battery to be installed for all flights with skid gear and extended tail boom.

4.1.2 Group Weight Statement

ROTOR GROUP		224.8 lbs.
Blades	96.1 lbs.	
Blade Retention	63.7 "	
Hubs	65.0 "	
TAIL GROUP (VERTICAL FIN)		12.8 lbs.
BODY GROUP		51.9 lbs.
Forward Section	44.6 lbs.	
Tail Section	7.3 "	
ALIGHTING GEAR (SKIDS)		109.4 lbs.
POWER PLANT GROUP		69.7 lbs.
Engines	31.7 lbs.	
Starting System	5.0 "	
Fuel System	33.0 "	
FIXED EQUIPMENT		44.0 lbs.
Instruments	8.0 lbs.	
Flight Controls	15.0 "	
Electrical	6.0 "	
Furnishings	15.0 "	
ACTUAL WEIGHT ADJUSTMENT		9.4 lbs.
WEIGHT EMPTY	522.0 lbs.	
USEFUL LOAD	341.0 lbs.	
NORMAL GROSS WEIGHT	863.0 lbs.	

4.1.3 Flight Test Instrumentation

The following flight test instrumentation has been installed:

Fuel Flow Meter Installation	10.6 lbs.
Cerro Bend in Control Stick	8.7 "
Battery Shelf	4.7 "
24-Volt Battery	56.0 "
6-Volt Batteries (3 Required)	8.1 "
Oscillograph	11.0 "
Oscillograph Shelf	2.0 "
Bridge Balance Box	.5 "
Control Stick Holder	5.3 "
Rotor Balance Plates	11.3 "
Misc. Test Wiring, Plugs and Gages	3.0 "
Total Instrumentation Weight	121.2 lbs.

4.2 XH-20, NO. 1, USAF 46-689

The re-building of the XH-20, No. 1, was started in August upon receipt of authority from WADC. The ram jet helicopter is scheduled for completion by 19 September, to be ready for pick-up by WADC aircraft on 20 September. After display by the Propeller Laboratory to Ordnance personnel visitors, it will be returned to MAC.

4.3 Preliminary Evaluation of Instrumentation 27-Foot Diameter Rotor, XH-20, No. 2

Flight tests conducted in July confirmed higher control forces and reduced control response of the 27-foot rotor from those obtained with the 20-foot diameter rotor. As reported in Progress Report No. 59 for July 1951, the XH-20, No. 2, has been instrumented for the measurement of stick forces and stick position and blade see-saw motions. After tracking the rotor blades and adjusting the ram jets for increased thrust, instrument ground tests were conducted on 31 August. An evaluation of the qualitative and quantitative data obtained is underway to determine the additional tests necessary.

Test Nos: 134 and 135 Pilot: C. R. Wood, Jr.

Dates: 18 and 20 August 1951 Helicopter: No. 2.

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

Purpose: To Track Blades and Adjust Ram Jets for Increased Thrust

Remarks: The helicopter was tied down to track the blades and to adjust the thrust of the ram jets to produce the increased thrust indicated during Test No. 133.

Flight Time: 00:00

Running Time: 00:14

Total Flight Time to Date: 32:06*

Total Running Time to Date: 126.50*

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

Test No.: 136 Pilot: C. R. Wood, Jr.

Date: 24 August 1951 Helicopter: No. 2.

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

Purpose: To Evaluate Controllability of Rotor Assembly

Remarks: Oscillograph traces data were obtained at 500 to 580 RPM at 2°, 3° and 4° indicated pitch# while displacing the cyclic stick longitudinally approximately full travel at higher than normal rate of control displacement. The rotor was rough, required tracking, and the data were unusable.

Flight Time: 00:00

Running Time: 00:18

Total Flight Time to Date: 32:06*

Total Running Time to Date: 127:08*

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

The indicated pitch is to be checked.

Test No.: 137 Pilot: C. R. Wood, Jr.

Date: 25 August 1951 Helicopter: No. 2.

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

Purpose: To Evaluate Controllability of Rotor Assembly

Remarks: The ram jets lighted satisfactorily at low speed but did not develop normal thrust for rotor acceleration. The instrumentation was inoperative because of moisture in the thermocouples. The test was terminated for the strain gauges to dry.

Flight Time: 00:00

Running Time: 00:08

Total Flight Time to Date: 32:06*

Total Running Time to Date: 127:16*

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

Test No.: 138 Pilot: C. R. Wood, Jr.

Date: 31 August 1951 Helicopter: No. 2.

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

Purpose: To Measure Control Force and Position and Rotor Blade Data

Remarks: The XH-20 was tied down for these tests. Ram jet operation was satisfactory for the recording of oscillograph data under the following conditions:

RPM	FUEL FLOW (LBS/HR)	ACTUAL PITCH
560	760	2 3/4°
600	760	3°
560	780	3°
540	720	2°
560	740	2°
560	680	1 1/2°
560	700	1 1/2°

Preliminary qualitative control force and position and blade flapping data were obtained at 3 rates of longitudinal control displacement; slow, medium and fast control forces.

Flight Time: 00:00

Running Time: 00:42

Total Flight Time to Date: 32:06*

Total Running Time to Date: 127:58*

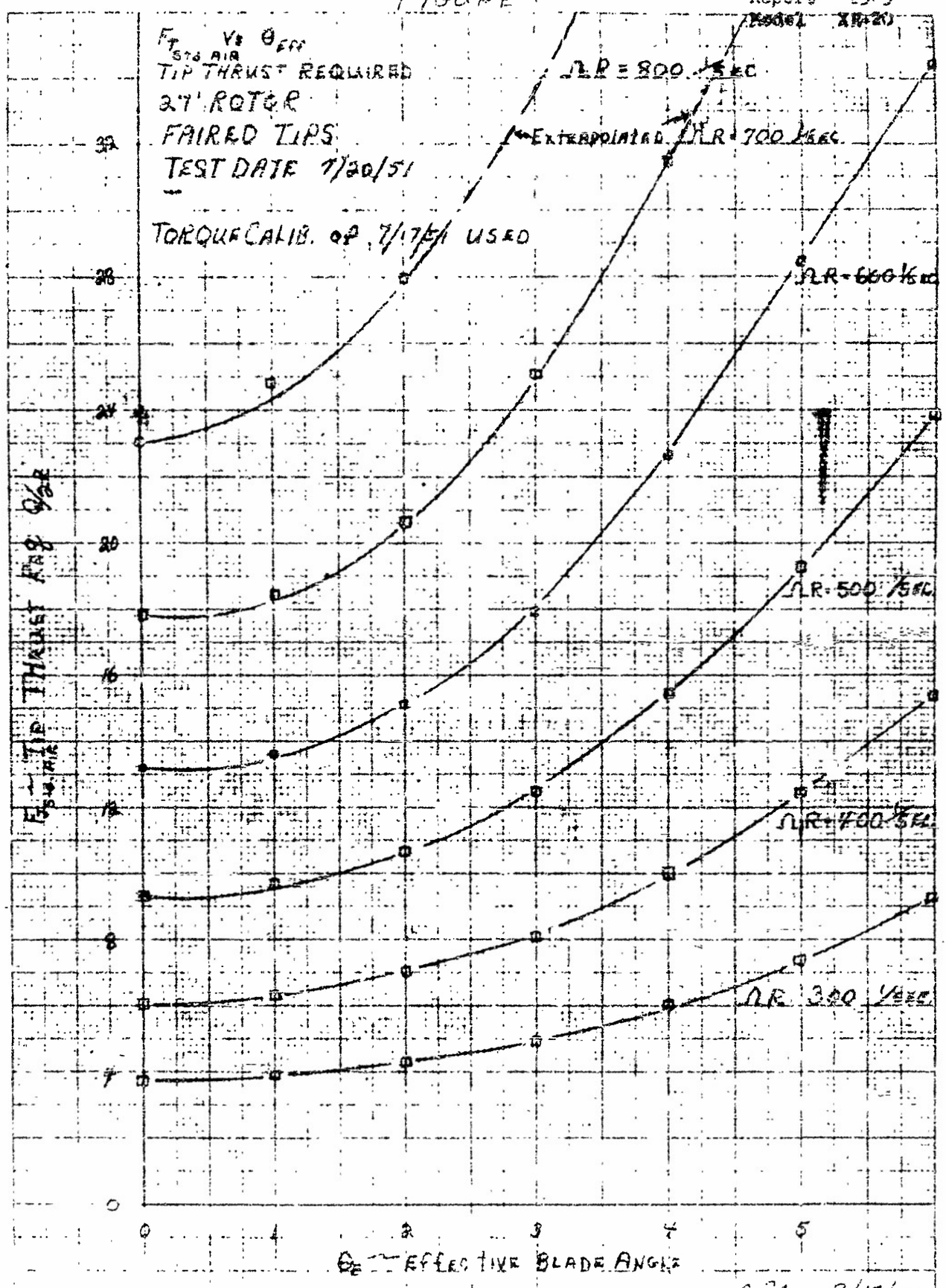
* Total for XH-20, Nos. 1 and 2

6. WORK PROGRAM FOR THE MONTH OF SEPTEMBER

6.1 Modified XH-20, No. 2

Further evaluation of the 27-foot diameter rotor will be conducted upon repair and modification of Ram Jets Nos. 32 and 33.

FIGURE



CRC 9/18/51

FIGURE 2

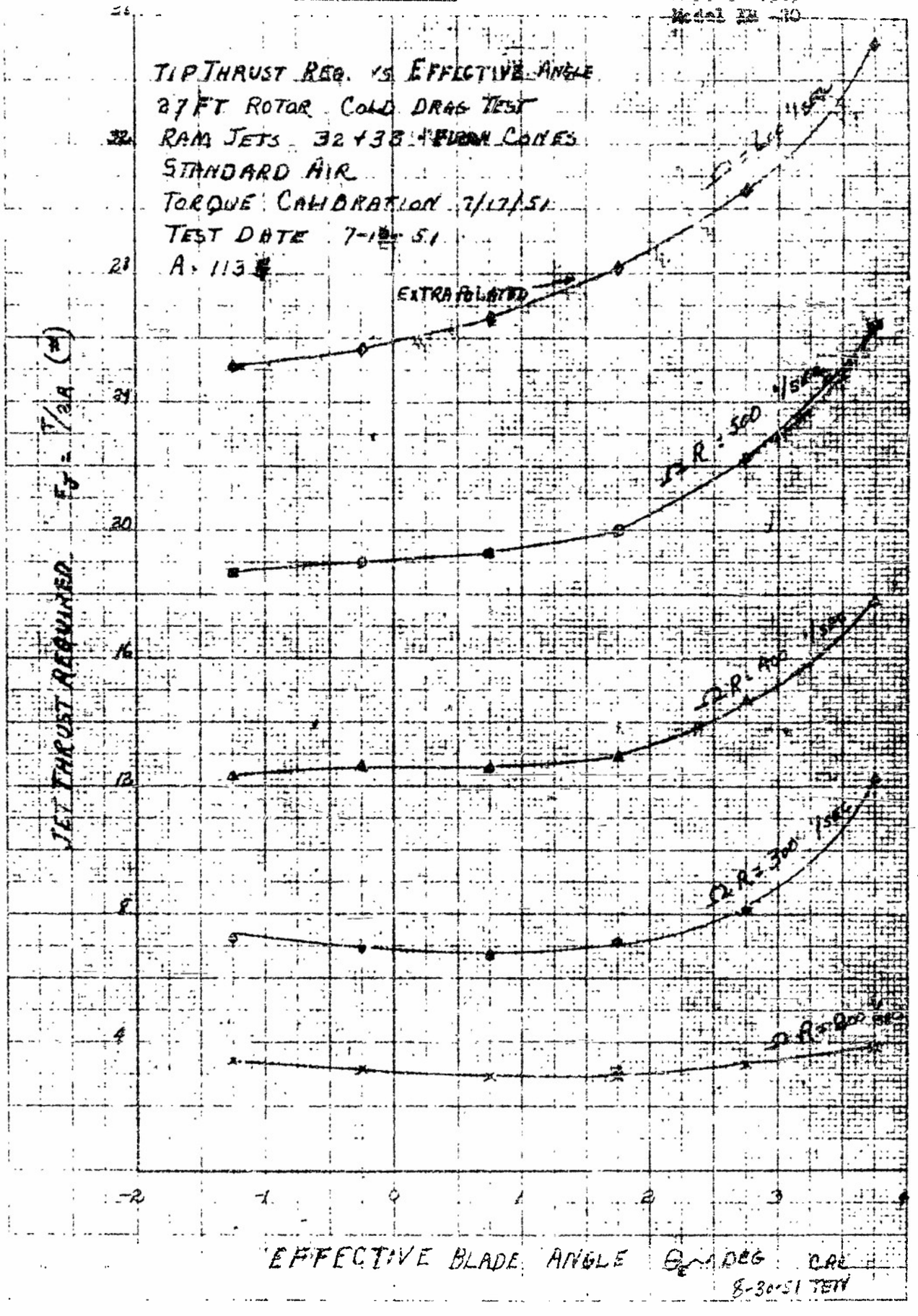

TIP THRUST REQ. VS EFFECTIVE ANGLE
27 FT ROTOR COLD DRAG TEST
RAM JETS 32 + 38 FROM CONES
STANDARD AIR
TORQUE CALIBRATION 7/17/51
TEST DATE 7-18-51
A = 113
EXTRAPOLATED
Ω R = 500
Ω R = 400
Ω R = 300
JET THRUST REQUIRED $F_J = T/2A$ (#)
EFFECTIVE BLADE ANGLE θ_e ~ DEG
CAL
8-30-51 TEW

FIGURE 3

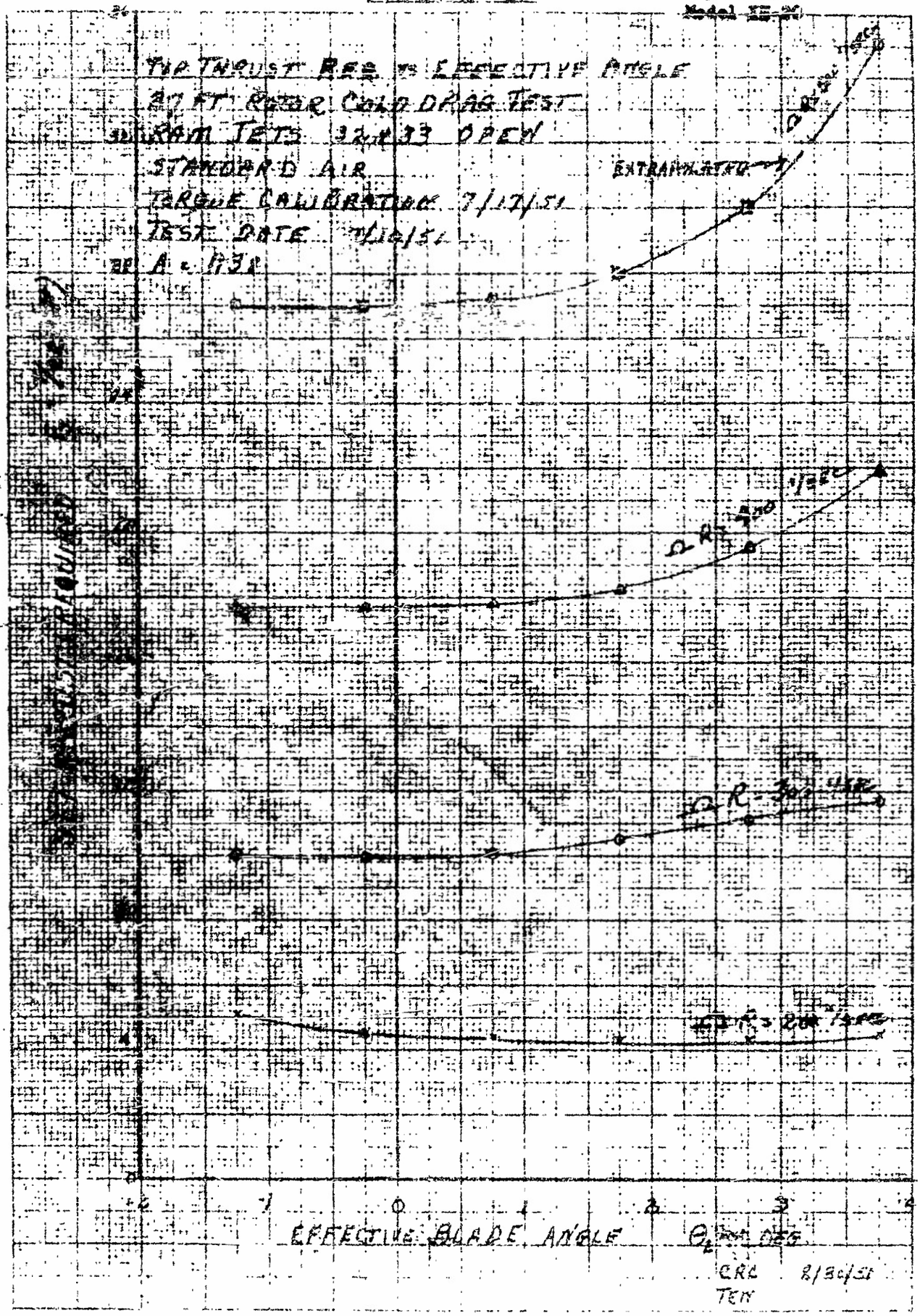
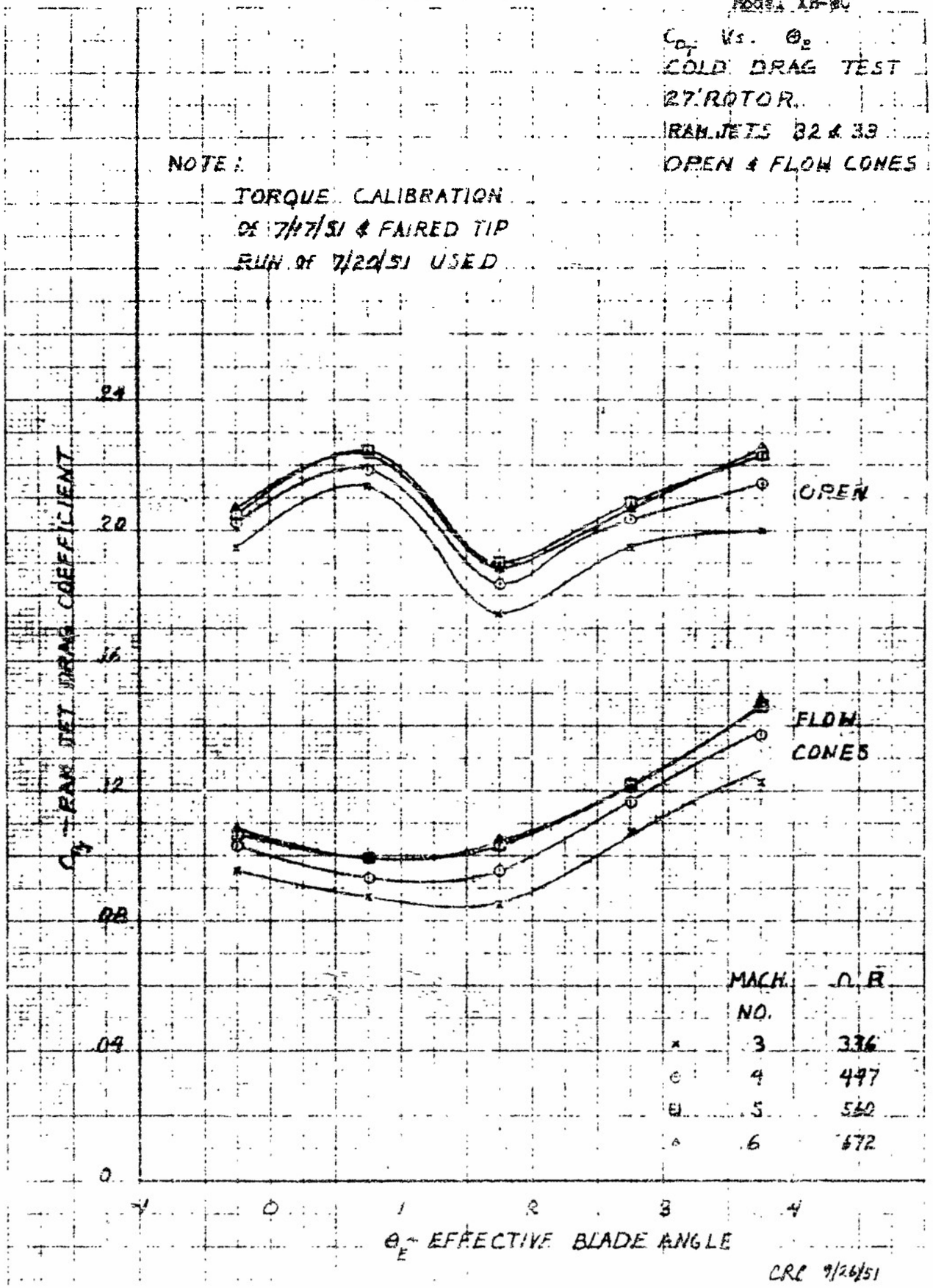
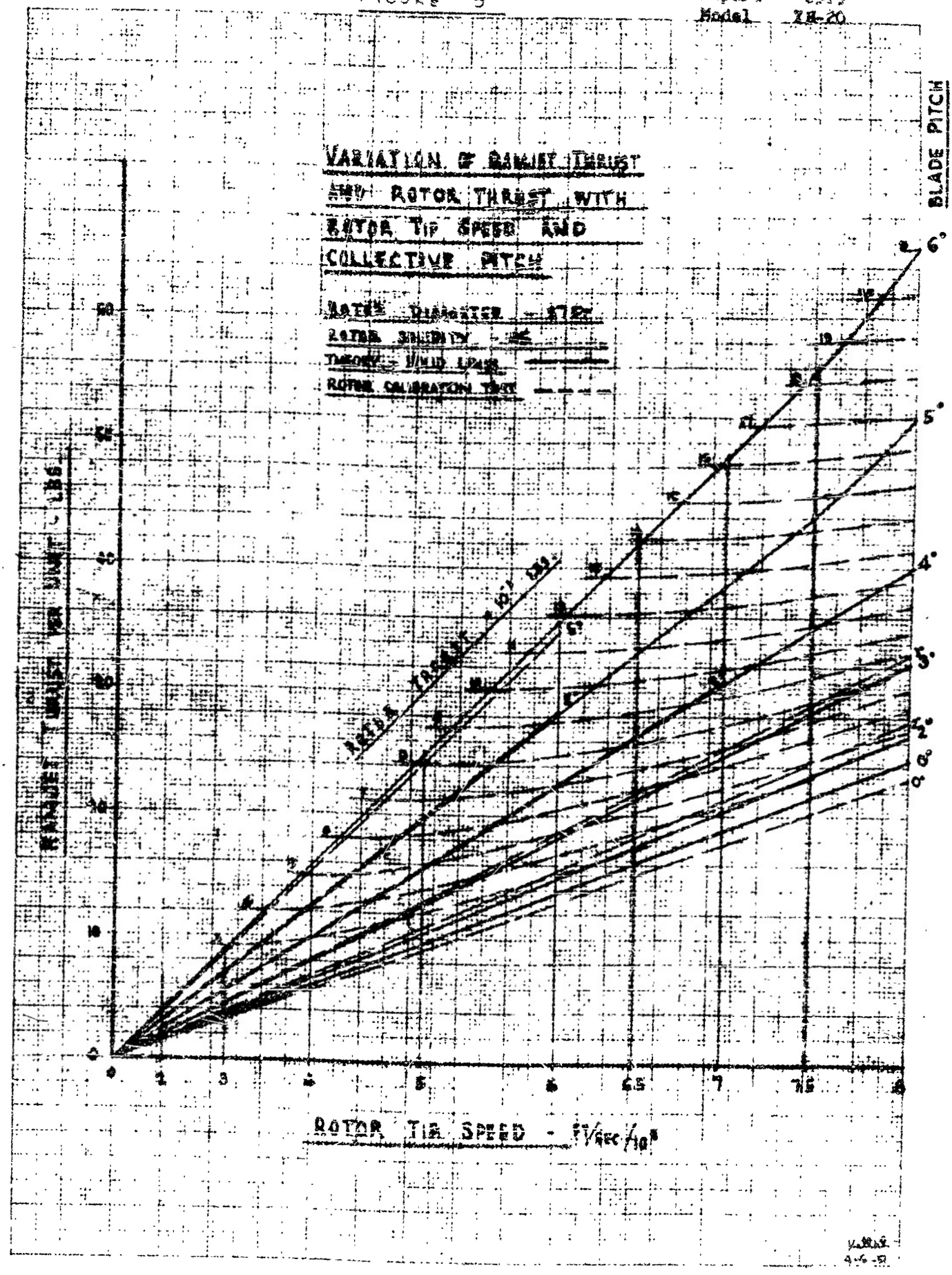

TOP THRUST REQ vs EFFECTIVE ANGLE
27 FT ROTOR COLD DRAG TEST
RAM JETS 32 & 33 OPEN
STANDARD AIR
TORQUE CALIBRATION 7/17/51
TEST DATE 7/10/51
EXTRAPOLATED
EFFECTIVE BLADE ANGLE
CRC 8/30/51
TEN

FIGURE 4



CRC 9/26/51

FIGURE 5


VARIATION OF RAMJET THRUST
AND ROTOR THRUST WITH
ROTOR TIP SPEED AND
COLLECTIVE PITCH
ROTOR CALIBRATION TEST
BLADE PITCH
6°
5°
4°
3°
2°
0°
RAMJET THRUST PER UNIT - LBS
ROTOR TIP SPEED - FT/SEC/10³
0
2
3
4
5
6
6.5
7
7.5
8
10
20
30
40
50
60