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MCDONNELL AIRCRAFT CORPORATION
HELICOPTER AND PROPULSION RESEARCH DIVISION

PROGRESS REPORT NO. 44
MONTH OF APRIL 1950
RAM JET HELICOPTER ROTOR DEVELOPMENT
REPORT NO. 1692

REPORT 1692

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MCDONNELL *Aircraft Corporation*

ST. LOUIS 3, MISSOURI

PROGRESS REPORT NO. 44

MONTH OF APRIL 1950

RAM JET HELICOPTER ROTOR DEVELOPMENT

LEGIBILITY POOR

SUBMITTED UNDER AF33(OSS)-9845 E.O. 582-104 (SR-1)

MODEL XH-20

PREPARED BY *A. C. Balleuer*
A. C. Balleuer

APPROVED BY *C. H. Harkamp*
C. H. Harkamp

DATE PREPARED 15 May 1950

APPROVED BY _____

NO. OF SHEETS _____

APPROVED BY _____

DATE 15 May 1950

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PAGE _____

REPORT 1692

MODEL _____

CONTENTS

1. ROTOR DEVELOPMENT
 - 1.1 General
 - 1.2 20 Foot Diameter Rotor
 - 1.3 27 Foot Diameter Rotor
 - 1.4 Autorotation Tests

2. RAM JET DEVELOPMENT
 - 2.1 Blocked Inlet Ram Jet
 - 2.2 High Tip Speed Ram Jet
 - 2.3 Contamination Tests

3. WORK PROGRAM FOR MAY
 - 3.1 Autorotation Tests and Studies
 - 3.2 High Speed Rotor
 - 3.3 Ram Jet Development

4. HELICOPTER TEST DATA

5. FIGURES

The following is a summary of development for the month of April 1950

DATE 15 May 1960

MCDONNELL *Aircraft Corporation*
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PAGE 1

REVISED _____

REPORT 1692

REVISED _____

MODEL _____

PROGRESS REPORT NO. 44 - MONTH OF APRIL 1950

Ram Jet Helicopter Rotor Development

1. ROTOR DEVELOPMENT

- 1.1 General - During April the 20 foot diameter, 10 inch chord rotor was returned to the whirl stand for strain gauge checks of the blade torsion moments. After these tests it was installed on the autorotation tow rig and its autorotation characteristics were measured. The design of the 27 foot diameter rotor was continued, but no actual construction was begun.
- 1.2 20 Foot Diameter Rotor - Results of the blade torsion tests on the whirl stand are shown in Figure 1. The tests were made both with the ram jets installed and removed from the blades. A totally unexpected result of the tests was the fact that, even though the ram jet is set on an angle of -4° to the blade, the pitch angle at which the torsion is least effected by the presence of the ram jet is -2° . Upon further consideration, it was determined that the relation of ram jet C.C. to blade C.G. and C.P. is the primary cause of the torsion moments obtained. As a result of these tests and the qualitative tests conducted on the helicopter, it is believed that no difficulties will be encountered with the pitch change mechanism due to operations with the 10 inch chord blades.
- Following the whirl tests, the twenty foot diameter rotor was installed on the tow rig and tests made at 20° , 30° , 40° , and 50° rotor angle of attack.

DATE 15 May 1950

MCDONNELL *Aircraft Corporation*
ST. LOUIS 3, MISSOURI

PAGE 2

REVISED _____

REPORT 1692

REVISED _____

MODEL _____

- 1.3 27 Foot Diameter Rotor - Considerable progress was made on the design of the 27 foot rotor diameter. Details of the hub portions are complete. The blade design is nearly complete, after considerable correspondence with adhesive manufacturers it has been decided to use Met-L-Bond which is a product of Harnco, Inc. A proposal has been requested from Harnco relative to their assembling the first set of blades in their plant. The adhesive contemplated meets US Air Force Specification 14164 and is on USAF Qualified Products list AFQPL-14164-1. The use of aluminum foil as a filler for the trailing edge is also being investigated. Preliminary checks have indicated that very little weight penalty will be paid for the substitution of lighter skin and foil for the arrangement shown on the original drawings. An investigation is also being made of the changes required to bring the existing XH-20 rotor gear box up to structural strength corresponding to 1800# gross weight. It appears at this time that it will be necessary to modify the gimbal rings, upper portion of the gear box, main rotor shaft and some of the pitch mechanism.
- 1.4 Aut rotation Tests - Autorotation tow tests have been conducted to date on four major configurations, complete data being accumulated on only three. The first runs were made late in 1949 on the 18 foot diameter 8.22 inch chord rotor and the final useable data covers only a limited range of rotor angle of attack. The remaining configurations were (1.) the 20 foot diameter 8.22 inch

DATE 15 May 1950

REVISED _____

REVISED _____

McDONNELL *Aircraft Corporation*
ST. LOUIS 3, MISSOURIPAGE 8REPORT 1692

MODEL _____

chord blades alone. (2.) the 20 foot diameter 8.22 inch chord rotor and ram jets #26 and #27 with reduced exit area and (3.) the 20 foot diameter rotor with 10 inch chord and ram jets #26 and #27 with reduced exit area. Figure 2 shows a plot of test and theoretical data on the 20 foot diameter, 10 inch chord configuration. Plots of the data for the 20 foot diameter, 8.22 inch chord rotor with and without jets are given in Progress Reports No. 38 and No. 39.

In order to complete the data it would be desirable to re-run the 18 foot diameter 8.22 inch chord rotor with the same jets used for the 20 foot diameter tests. This would give a ram jet drag coefficient change, a solidity change, and a diameter change and should be sufficient data to corroborate the methods for calculating autorotational characteristics.

A review of the actual procedure followed in obtaining autorotational data with the tow rig is given as follows - (See also Progress Report No. 36, August 1949).

The rig is towed on the airport runways with rotor angle of attack α , blade pitch Θ and airspeed held constant.

Rotor thrust and RPM are then measured for α - 20°, 30°, 40°, and 50°, Θ - -4°, -2°, 0°, 2°, 4° and several airspeeds.

The airspeed is determined largely by the power of the tow truck and is recorded by means of an anemometer and a recording oscillograph. Rotor thrust, RPM and blade pitch setting are

DATE 15 May 1950**MCDONNELL** *Aircraft Corporation*
ST. LOUIS 3, MISSOURIPAGE 4

REVISED _____

REPORT 1692

REVISED _____

MODEL _____

also recorded by the oscillograph. The rotor is usually started manually in the horizontal position (low α) with the rig stationary. After a suitable rotor speed is reached the rotor is tilted to the desired angle, the rig is accelerated to the desired speed and the ram jets are shut off. Whenever the rotor decelerates to a speed close to its critical speed the jets are ignited and are used to prevent further deceleration. At the end of a run the rotor is returned to the horizontal position with ram jets operating, before it is allowed to decelerate through its critical speed.

2. RAM JET DEVELOPMENT

2.1 Blocked Inlet Ram Jet - No further whirl tests of the blocked inlet ram jets were made in April. A layout of the operating mechanism was made, however, which provided porting in the cylinder so as to prevent any fuel flow to the spray nozzles until the doors are opened. This change is necessary because the corrective measures, described in Report No. 41, January 1950, which prevented the doors from closing too rapidly also allowed the ram jets to become flooded upon starting them again. No further rework of this type of ram jet is planned until a final decision is reached as to how much actual drag improvements can be gained this way. (Progress Report 43)

DATE 15 May 1950

MCDONNELL *Aircraft Corporation*
ST. LOUIS 3, MISSOURI

PAGE 5

REVISED

REPORT 1692

REVISED

MODEL

2.2 High speed Ram Jet - Work on the high speed ram jet in April consisted mainly of tests of configurations intended to improve flameholder and diffuser life. It is expected that construction of a set of engines for whirl stand operation will be initiated late in May.

2.3 Contamination Tests - Considerable progress was made during April in establishing the technique of using a high speed motion picture camera to photograph the flow around the blade tip during whirl stand operation. Figures 3, 4, and 5 are photographs made of the ram jet passing through the steam trail described previously. The condition shown is as follows, 18 foot diameter rotor, 8.22 inch chord blades, 5° pitch setting, 575 RPM, ram jets not burning. It will be noted in frame 16 that a small swirl of steam is forming at a point where the ram jet has just passed. If the history of this swirl is followed in subsequent frames it will be seen that the next ram jet passes right through the swirl of steam. It is readily apparent that with the present orientation the ram jets are operating in their own wakes. Temperature measurements made on the blades and in the ram jet inlets and also adjacent to the rotor tip path plane indicate contamination by temperatures as high as 100° F above ambient. It is planned to continue this investigation by building an adapting fitting which will allow the angle of the ram jet relative to the blade to be varied so that

DATE 15 May 1950

MCDONNELL *Aircraft Corporation*
ST. LOUIS 3, MISSOURI

PAGE 6

REVISED _____

REPORT 1692

REVISED _____

MODEL _____

temperature surveys and photographs can be made to determine optimum orientation.

5. WORK PROGRAM FOR MAY

- 3.1 Autorotation Tests and Studies During May. No tow tests of the ram jet rotor are contemplated in as much as the 18 foot diameter, 8.22 inch chord rotor is being used on the whirl stand for contamination tests and ram jet development and it is expected flight autorotation tests will be attempted with a 20 foot diameter rotor. These studies of the extent of improvements in autorotation to be gained by variation of rotor parameters will be continued and completed during May.
- 3.2 High Speed Rotor Design of the high speed rotor will continue throughout May and it is expected that drawings for the blade spars and rotor hub parts will be released for fabrication about mid May. Delivery of the blade spar extrusion has been promised for 20 May.
- 3.3 Ram Jet Development - The major effort on ram jet development will be with regard to determining the proper ram jet blade orientation to minimize or eliminate contamination. No ram jets will be constructed until this problem has been solved. Tests will continue however on various configurations of the high tip speed ram jet.

DATE 15 May 1950**MCDONNELL** *Aircraft Corporation*
ST. LOUIS 3, MISSOURIPAGE 7

REVISED _____

REPORT 1692

REVISED _____

MODEL _____

J1 HELICOPTER TEST DATA

DATE: 24 April 1950 OPERATOR: E. Toney
TEST STAND: #2 on tow rig
ROTOR: 20 foot diameter, 10 inch chord jets #26 and #27
PURPOSE: Run up for check prior to autorotation test

TEST SET-UP:

REMARKS: Rotor run up in horizontal position to check balance
and operation prior to tow tests

Flight time for day 00:00

Running time for day 00:05

Total flight time to date 2 hours 58 minutes

Total running time to date 19 hours 0 minutes

DATE 16 May 1950

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ST. LOUIS 3, MISSOURI

P/

P. 1001

MODEL _____

J1 HELICOPTER TEST DATA

DATE: 26 April 1950 OPERATOR: C. Wood
TEST STAND: #2 on tow rig
ROTOR: 20 foot diameter 10 inch chord jets #26 and #27
PURPOSE: Autorotation tests at 20°, 30° rotor angle of attack

TEST SET-UP;

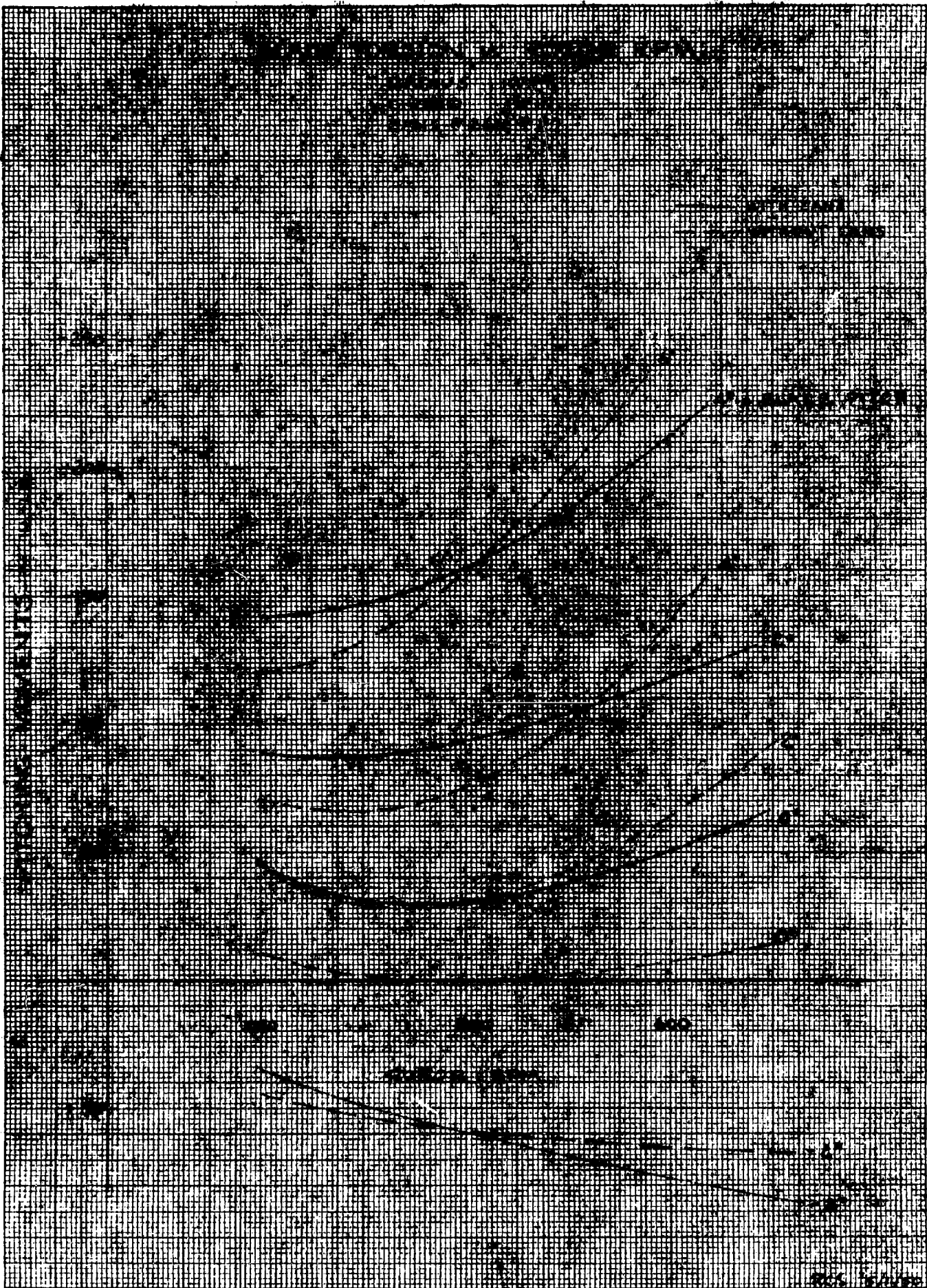
REMARKS: Tests made on runway of airport

Flight time for day 00:00

Running time for day 00:30

Total flight time to date 2 hours, 58 minutes

Total running time to date 19 hours, 30 minutes

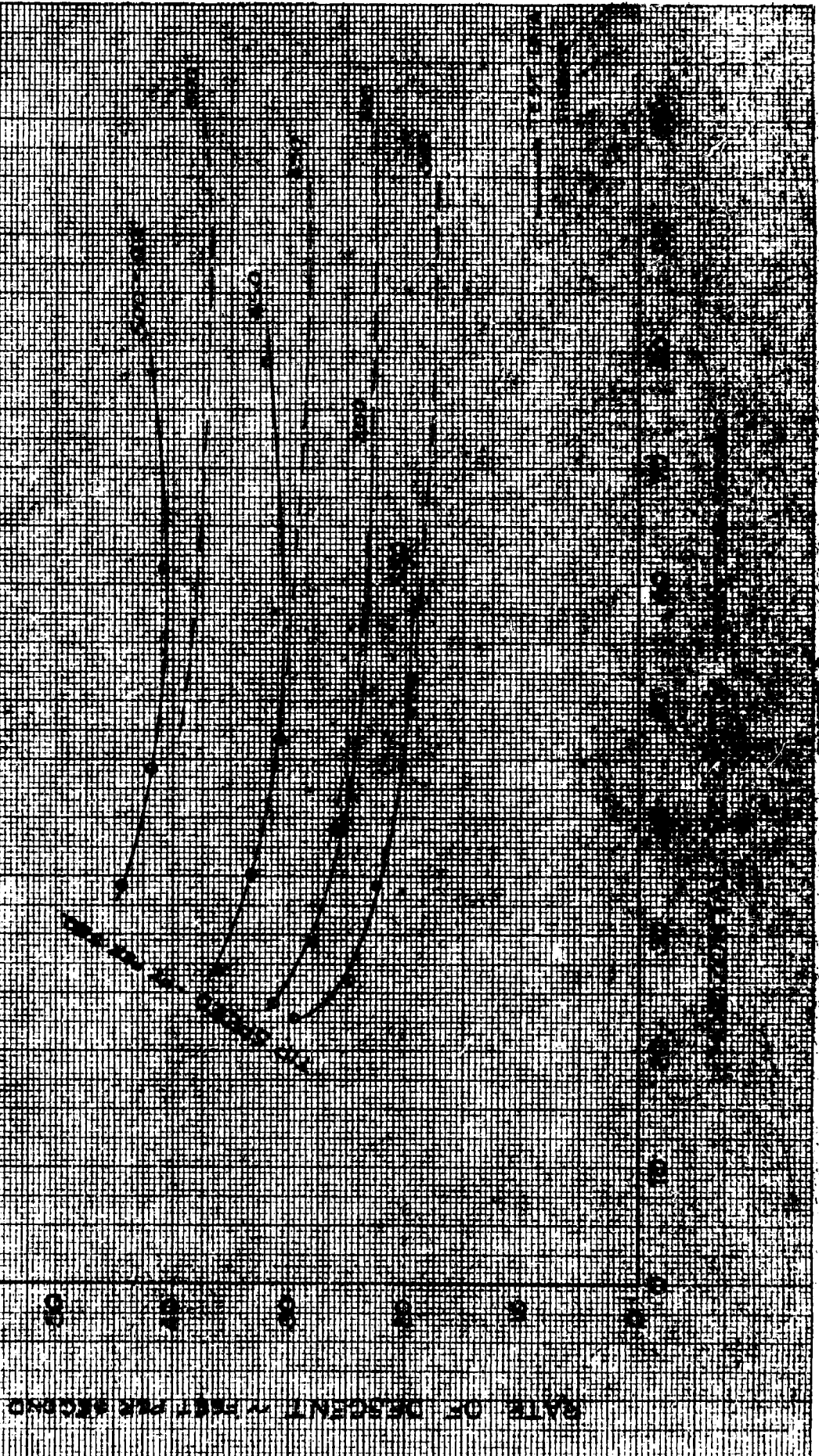


KLUPPEL & WEBER CO., N. Y. NO. 40-14
Millimeter, 5 mm. lines spaced 4 cm. lines heavy.
MADE IN U.S.A.

FIGURE 1

KEUFFEL & ESSER CO., N. Y. NO. 89-16
Millimeters, 5 mm. lines spaced, cm. lines heavy.
MADE IN U. S. A.

MODEL 50 ROTOR ALONG
VARIATION OF RATE OF DESCENT WITH
FORWARD VELOCITY AND TIP SPEED
OF ROTOR



VELOCITY

RATE OF DESCENT - FEET PER SECOND

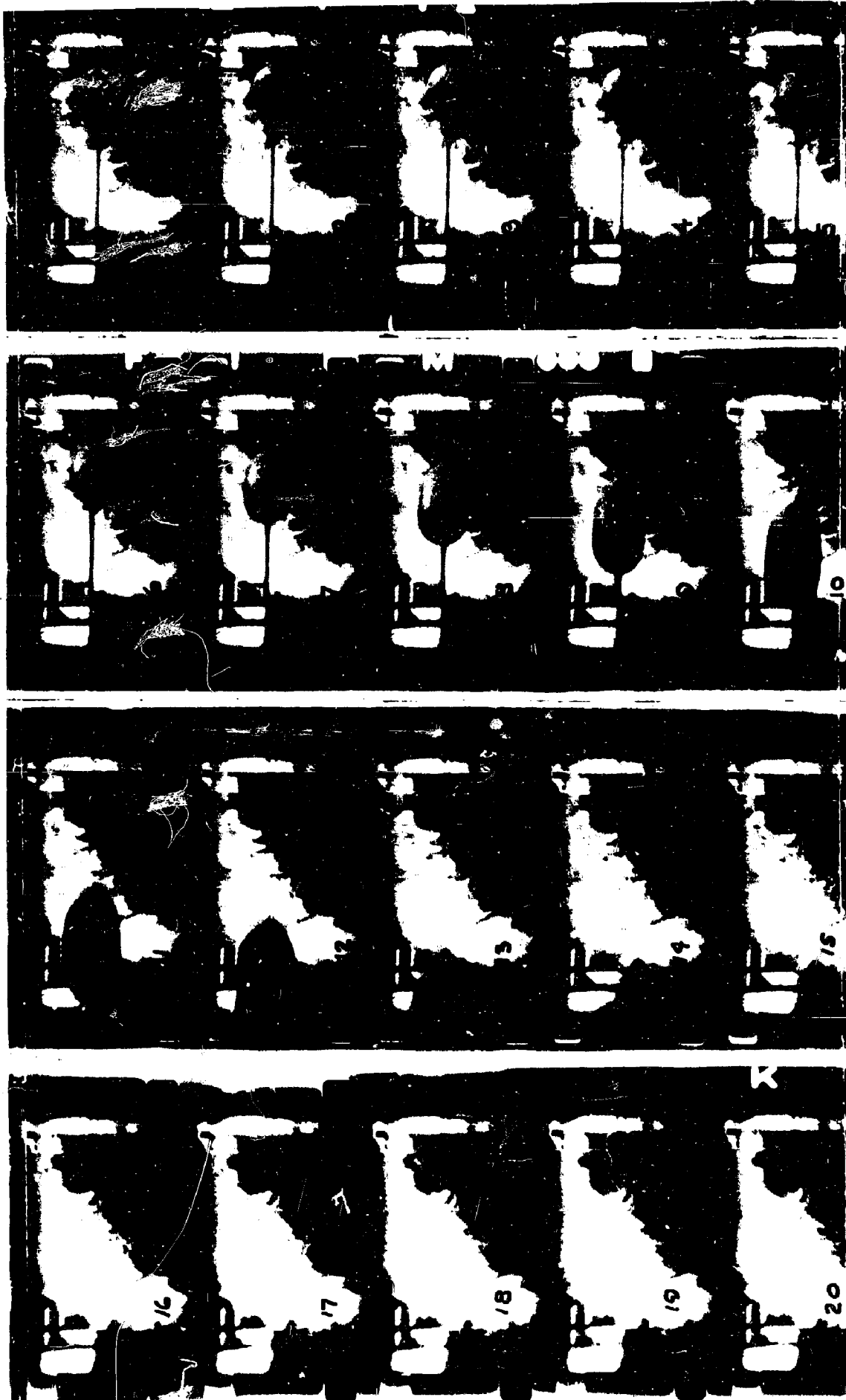


FIGURE 3 - High Speed Photographs of Rotor Induced Flow

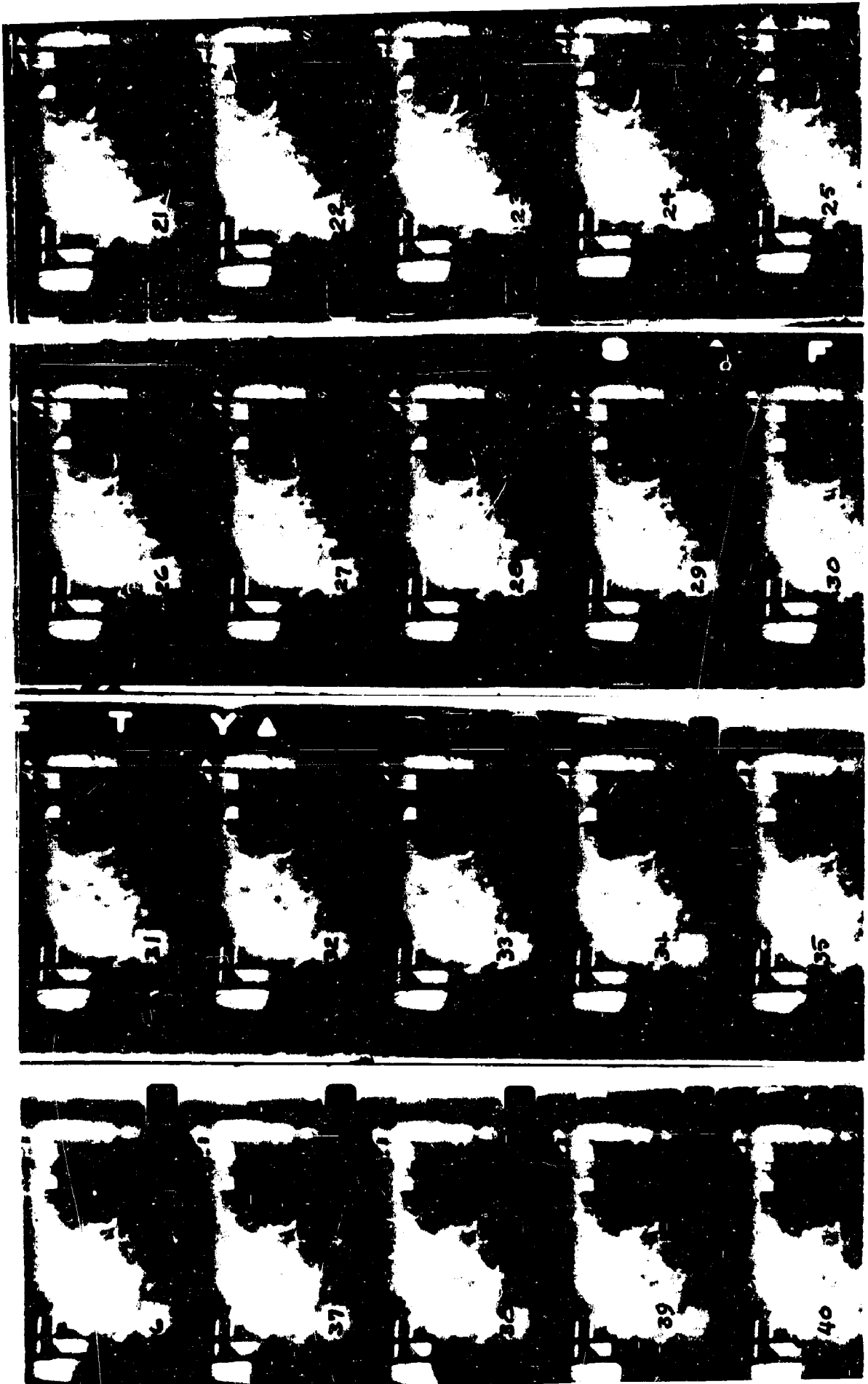


FIGURE 4 - High Speed Photograph of Rotor Induced Flow.

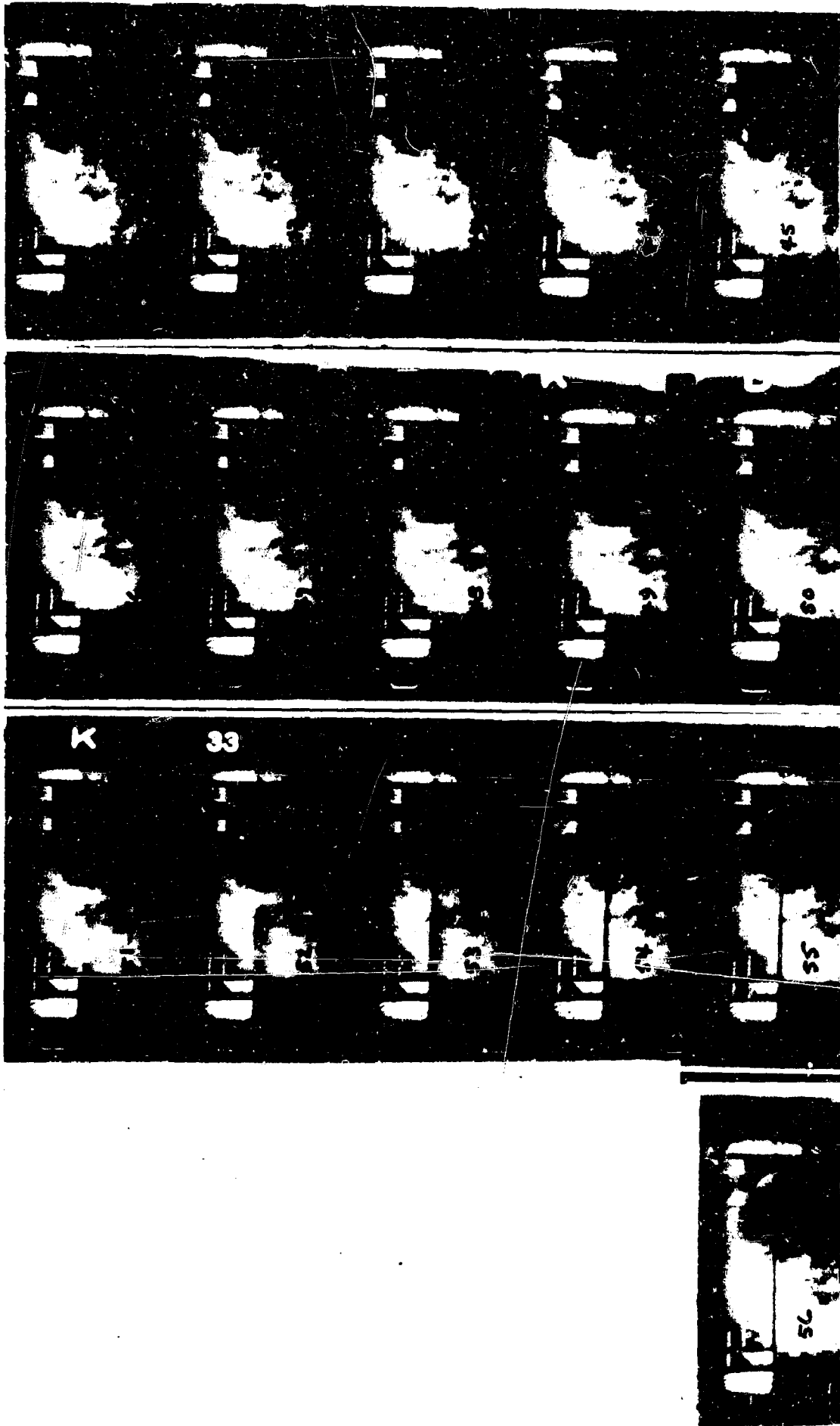


FIGURE 5 - High Speed Photographs of Rotor Induced Flow

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P113

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- 2. Engines, Ramjet
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- 4. H-20
 - I. Ballauer, A.C.
 - II. USAF Contr. No.
 AF 33(038)-9845

(Not abstracted) *mDC-*

~~AD-A800 041~~

**Jet Helicopter Rotors
Ramjet Engines*



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