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6th Part of Report  
No. A4EE/911

6th Part of Report N. A4EE/911

464434



MINISTRY OF AVIATION

# AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT

BOSCOMBE DOWN

DEVON C. MK. 1 WB 531  
(2 GIPSY QUEEN 71)

SINGLE ENGINE PERFORMANCE

PRESENTED BY

T. H. J. HEFFERNAN AND MISS D. A. CALLAWAY  
PERFORMANCE DIVISION

CATALOGUED BY: DDC  
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464434

  
MINISTRY OF AVIATION

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AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT  
BOSCOMBE DOWN

23 MAR 1965

Devon C. Mk. 1 WB 531  
(2 Gipsy Queen 71)

Single Engined Performance

Presented by

T. H. J. Heffernan and Miss D. A. Callaway  
Performance Division

A. & A.E.E. Ref: AAE/2M  
Period of Test: July-September 1963.

Summary

Measurements of the single engined performance of the Devon C. Mk. 1 in I.S.A. conditions have been made at a number of weights up to 8,500 lb., with some repeats in I.S.A. +10°C conditions, and the results compared with the requirements of B.C.A.R.'s for Group A and Group C aircraft. The requirements for Group C aircraft were met completely only at 7,500 lb. in I.S.A. conditions, but provided that the undercarriage is retracted and the propeller of the failed engine is feathered the single engined performance in still air is not catastrophic even at maximum weight. Some deterioration must be expected in turbulence or in turns, particularly if speed is not held to the required values.

This Report is issued with the authority of



Air Commodore,  
Commandant, A. & A.E.E.

1. Introduction

The Dove was given a Civil Certificate of airworthiness for a maximum take-off weight of 8,500 lb. before British Civil Airworthiness requirements (B.C.A.R.'s) were issued in their present form and the R.A.F. version, the Devon C. Mk. 1, was cleared on the basis of this C. of A., without A. & A.E.E. trials, to operate at the same maximum weight. In recent years, however, some Service operators have expressed concern at the low climb performance of the Devon in the event of an engine failure, and the aircraft has been restricted unofficially to a maximum weight of 8,200 lb. In June 1963 A. & A.E.E. was requested to measure the climb performance of Devon WB 531 to provide data to determine whether a reduction in maximum permitted weight is necessary.

Preliminary results of the trial were sent to Ministry of Aviation (R.A.F./B.5(c)) by letter on 12th November, 1963. This part of the Report gives the results in a more comprehensive and permanent form.

2. Condition of aircraft

WB 531 was a standard Devon C. Mk. 1 in average external condition. At the end of the trials the airframe hours were 1478 and the engine hours were 65 (port) and 440 (starboard).

The limitations applicable to the Gipsy Queen 71 engines were

|   | <u>RPM</u> | <u>Boost lb/<br/>sq. in.</u> | <u>Cyl. temp<br/>°C.</u> | <u>Oil in-<br/>let °C.</u> |
|---|------------|------------------------------|--------------------------|----------------------------|
| Take-off and operational necessity (5 min.) | 2800       | +6                           | 280                      | 100                        |
| Climb power (1 hour)                        | 2600       | +3                           | 260                      | 90                         |
| Max. continuous (rich)                      | 2400       | +3                           | 250                      | 80                         |
| " " (weak)                                  | 2400       | +2                           | 250                      | 80                         |

3. Scope of tests

The tests were based on B.C.A.R.'s for Group A and Group C aircraft as shown in the appendix. Measurement of the rate of climb at 1,000 ft. ICAN pressure height in near I.S.A. conditions were made as follows

| <u>Test</u> | <u>RPM</u> | <u>Boost p.s.i.</u> | <u>Flap</u> | <u>U/C</u> | <u>I.A.S. Kts.</u> | <u>B.C.A.R. equivalent</u> |
|-------------|------------|---------------------|-------------|------------|--------------------|----------------------------|
| 1           | 2800       | +6                  | 20°         | Down       | 78                 | Group A 1st Segment        |
| 2           | 2800       | +6                  | 20°         | Up         | 78                 | " 2nd Segment              |
| 3           | 2600       | +3                  | 20°         | Up         | 78                 | " 3rd Segment              |
| 4           | 2600       | +3                  | Up          | Up         | 90                 | " final take-off climb     |
| 5           | 2800       | +6                  | 20°         | Up         | 82                 | " approach                 |
| 6           | 2800       | +6                  | 20°         | Down       | 78                 | Group C bailed landing     |
| 7           | 2400       | +3                  | Up          | Up         | 85                 | " en-route                 |
| 8           | 2800       | +6                  | Up          | Up         | 90                 |                            |

All the tests were made with one engine stopped and the propeller feathered except Test 1, in which the propeller of the deadengine was windmilling, and Test 6 in which both engines were operating.

Test 8 has no B.C.A.R. equivalent, but was included for comparison with results obtained in the same configuration by the firm (1) and R.A.E. (2).

Most tests were made at three take-off weights, 7,500 lb., 8,000 lb. and 8,500 lb.

/Tests

Tests 2, 6, 7 and 8 were repeated at 8,000 lb. at Idris with temperatures of about I.S.A. +10°C.

4. Results and discussion

The results are given in the Table. Those shown for ISA conditions are the averages of three runs, but time did not allow three runs at each configuration in ISA +10°C conditions.

There are two requirements in Group C, one is for a gradient of climb of 3.5% in the balked landing configuration (i.e. both engines at take-off power) and the other is for a gradient of 0.8% in the en-route configuration with one propeller feathered and the live engine at the rich cruise setting. Both were met at 7,500 lb. in I.S.A. conditions but only the balked landing requirement was met at higher weights. In Group A, only the final take-off climb requirement of 1.2% gradient was met at 7,500 lb. However, although the requirements were not met at other weights it was possible at 8,500 lb in I.S.A. conditions to maintain level flight at maximum continuous (rich) power with flaps up or a small rate of climb at take-off power with flaps at 20°. Thus provided that the propeller of the failed engine is feathered and the undercarriage is retracted the performance of the aircraft is not catastrophic in I.S.A. conditions, even at maximum weight, although it is not up to current standards.

It should be noted, however, that the results were obtained in near perfect conditions and there is some likelihood that height would not be maintained in turbulence or in turns or if speed were allowed to change appreciably. In such circumstances it would probably be necessary to use take-off power with flaps up in order to continue the circuit or even to maintain level flight in the early en-route stages.

The results of Test 8 confirm the findings of the earlier R.A.E. tests. The configuration was that for maximum single engine rate of climb i.e. flaps and undercarriage up, one engine at take-off power and the other stopped with its propeller feathered. A climbing speed of 90 kts. I.A.S. was used at a weight of 8,500 lb. The measured rate of climb is shown below with earlier results from the firm and the performance calculated by ACT(1), M. of A.

| <u>A. &amp; A.E.E.</u> | <u>R.A.E.</u> | <u>Firm</u>  | <u>Calculation</u> |
|------------------------|---------------|--------------|--------------------|
| 145 ft./min.           | 144 ft./min.  | 220 ft./min. | 201 ft./min.       |

The calculated value was based on the best guaranteed sea level static engine power of 330 b.h.p. Using the minimum guaranteed power of 315 b.h.p. the value reduces to 160 ft./min. No opportunity occurred to check the power during the A. & A.E.E. tests, and the power of the engines fitted to the R.A.E. Devon is not known. It is possible, of course, that the aircraft used in the firm's test was "as new" but regular checks made on a Dove at the College of Aeronautics (3) show no marked change in performance with time.

The measured rates of climb have been used to produce graphs showing the variation in rate of climb with weight for a range of temperature in each test configuration except Group A 1st Segment (Test 1), in which the performance was so poor as to warrant no further consideration, and the special case of Test 8. Of the three B.C.A.R. cases repeated in I.S.A. +10°C conditions there was good agreement between the measured and predicted performance in two cases, but a difference of 30 ft./min. in the Group C en-route case. This difference was between a small (5 ft./min.) predicted rate of climb and a numerically slightly larger (25 ft./min.) measured rate of descent from one test only and may not therefore be significant.

5. Conclusions

Tests show that the single engine performance of the Devon C. Mk. 1 is not up to current B.C.A.R. standards for new types, as was expected. However I.S.A. conditions at the maximum weight of 8,500 lb. level flight can be main-

/tained

tained at maximum continuous (rich) power with flaps up, and a small rate of climb can be achieved at take-off power with flaps at 20°. This performance applies in still air and some deterioration must be expected in turbulence or in turns.

| <u>Reference No.</u> | <u>Title, etc.</u>   |
|----------------------|--|
| 1                    | Dove 7 and 8 Crew Notes. de Havilland Division, Hawker Siddeley Aviation.                            |
| 2                    | S.M.E. Flight Report dated 26th November, 1962.  |
| 3                    | College of Aeronautics, Cranfield. Routine annual performance measurements by Students, unpublished. |

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TABLE

Results corrected to the weights shown and to I.S.A. or I.S.A. +10°C as appropriate.

Test height 1,000 ft. I.C.A.N.

All tests were with one engine stopped and propeller feathered except:-

Condition 1 - propeller windmilling  
Condition 6 - both engines operating

| Condition                          | Power setting<br>r.p.m. and boost           | Flap | U/C  | I.S.A.<br>kts. | Required<br>B.C.A.R.<br>Gradient<br>% | 7,500 lb.     |               | 8,000 lb.     |               | 8,500 lb.     |               | 8,000 lb. at<br>I.S.A. +10°C |               |
|------------------------------------|---|------|------|----------------|---------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|------------------------------|---------------|
|                                    |   |      |      |                |                                       | I/C<br>f.p.m. | Gradient<br>% | R/C<br>f.p.m. | Gradient<br>% | R/C<br>f.p.m. | Gradient<br>% | R/C<br>f.p.m.                | Gradient<br>% |
| 1. Group A<br>1st segment          | Take-off<br>2,800, + 6 p.s.i.               | 20°  | Down | 78             | 0                                     | -10           | -1.2          |               |               |               |               |                              |               |
| 2. Group A<br>2nd Segment          | Take-off<br>2,800, + 6 p.s.i.               | 20°  | Up   | 78             | 2.4                                   | 165           | 2.1           | 95            | 1.2           | 45            | 0.5           | 60                           | 0.7           |
| 3. Group A<br>3rd Segment          | Climb<br>2,600, + 3 p.s.i.                  | 20°  | Up   | 78             | 1.2                                   | 10            | 0.1           | -30           | -0.4          | No test       | No test       | No test                      | No test       |
| 4. Group A<br>Final take-off climb | Climb<br>2,600, + 3 p.s.i.                  | Up   | Up   | 90             | 1.2                                   | 130           | 1.4           | 50            | 0.5           | 5             | 0.05          | No test                      | No test       |
| 5. Group A<br>Approach             | Take-off<br>2,800, + 6 p.s.i.               | 20°  | Up   | 82             | 2.1                                   | No test       | No test       | 105           | 1.2           | 60            | 0.7           | No test                      | No test       |
| 6. Group C<br>Balked landing       | Take-off (2 engines)<br>2,800, + 6 p.s.i.   | 20°  | Down | 78             | 3.5                                   | 1,000         | 12.4          | 850           | 10.1          | 765           | 9.5           | 735                          | 9.1           |
| 7. Group C<br>En-route             | Max. continuous (rich)<br>2,400, + 3 p.s.i. | Up   | Up   | 85             | 0.8                                   | 85            | 1.0           | 30            | 0.3           | 5             | 0.05          | -25                          | -0.3          |
| 8.                                 | Take-off<br>2,800, + 6 p.s.i.               | Up   | Up   | 90             | -                                     | No test       | No test       | 235           | 2.5           | 145           | 1.6           | 160                          | 1.7           |

Extracts from British Civil Airworthiness Requirements

## SUB SECTION D2-FLIGHT

## CHAPTER D2-4 PERFORMANCE-CLIMB

(Revised 16th March, 1959)

Group A"2.2 First Segment Climb Performance (landplanes and skiplanes).

At the altitude of the Take-off surface, the gross gradient of climb in free air with the aeroplane in the configuration and at the power appropriate to the start of transition to climbing flight, at Take-off Safety Speed  $V_2$ , with the Critical Power-unit inoperative and its propeller in the condition it rapidly and automatically assumes, shall be not less than:-

- 0% for aeroplanes with two power-units.
- 0.3% for aeroplanes with three power-units.
- 0.5% for aeroplanes with four power-units.

NOTE: This requirement is intended to ensure that sufficient acceleration is available from the Power-unit Failure Point up to and including the transition to climbing flight to ensure that the Take-off Field Length data is adequate."

"2.4 Second Segment Climb Performance. The gross gradient of climb in free air with one power-unit inoperative, and the aeroplane in the configuration existing at the point on the flight path where the landing gear is fully retracted, with the power of the operating power-units appropriate to this point, unless subsequently a more critical power condition exists before a gross height of 400 feet above the Take-off Surface is reached, shall be not less than:-

- 2.4% for aeroplanes with two power-units.
- 2.7% for aeroplanes with three power-units.
- 3.0% for aeroplanes with four power-units,

NOTE: A power condition more critical than that existing at the time the landing gear is fully retracted would exist for example if water methanol injection was discontinued prior to reaching a gross height of 400 feet."

"2.5 Third Segment Climb Performance. From a height of 400 feet to a height of 1,500 feet above the Take-off Surface, the Gross Performance from which the Take-off Net Flight Path data are derived shall be not less than that corresponding to a gradient of climb or horizontal acceleration, as appropriate, of:-

- 1.2% for aeroplanes with two power-units,
- 1.4% for aeroplanes with three power-units,
- 1.5% for aeroplanes with four power-units."

"2.6 Final Take-off Climb. The gross gradient of climb with the aeroplane in the en-route configuration, with one power-unit inoperative, at a speed of not less than  $1.25V_{MS1}$ , and conditions of power and weight corresponding to those which would exist on reaching a gross height of 1,500 feet when establishing the data from which the Take-off Net Flight Path are derived, shall be not less than:-

- 1.2% for aeroplanes with two power-units,
- 1.4% for aeroplanes with three power-units,
- 1.5% for aeroplanes with four power-units."

"4.2 Approach. At the altitude of the Landing Surface the gross gradient of climb with the aeroplane in the one-power-unit-inoperative approach configuration (which shall be such that  $V_{MS1}$  does not exceed  $1.1 V_{MEO}$ ) but with the landing gear retracted, with one power-unit inoperative and the remaining power-units at a power not exceeding Maximum Take-off Power and at a speed not greater than  $1.3 V_{MS1}$ , shall be not less than:-

/2.1%

- 2.1. for aeroplanes with two power-units,  
 2.3. for aeroplanes with three power-units,  
 2.4. for aeroplanes with four power-unit.

NOTE: See D2-8 concerning the conditions governing the choice of approach Wing-flap Setting."

### Group C

"5.1.2. Initial En-Route. At an altitude which exceeds that of the Take-off surface by 1,500 feet, the gross gradient of climb, in the conditions of air speed, configuration and power prescribed in 5.2.2., shall be not less than

$\left(11 \frac{D}{W}\right)\%$ , where  $\frac{D}{W}$  is the ratio  $\frac{\text{Drag}}{\text{Weight}}$  at the speed and in the configuration to

which the requirement relates, with the drag term excluding any increment of drag resulting from slipstream."

"5.2 En-Route. The following conditions apply to 5.2.2.:-

Air Speed. This may be selected by the applicant, provided that it is not less than  $1.2V_{S1}$ , and that it permits the appropriate cooling and handling (trim and stability) requirements to be met.

Wing-flaps Retracted.

Landing Gear Retracted

Cooling Gills

The cooling gills of the operating power-units shall be in the positions established as suitable for the maintenance of power plant temperatures within the Maximum Continuous limitations, when climbing in the appropriate Maximum Anticipated Air Temperature (see D2-2 6.7) at the air speed, configuration, and engine power associated with the climb performance established in accordance with this requirement.

Power Operative power-units operating within Maximum Continuous limitations."

"5.2.2. One Power-unit Inoperative. The gross and net gradients of climb or descent with the Critical Power-unit inoperative shall be determined for the ranges of conditions prescribed in D2-3. The net gradient of climb shall be obtained by

subtracting from the gross gradient, a gradient equal to  $\left(13 \frac{D}{W}\right)\%$ .

The conditions of rotation, cooling gills, etc., of the inoperative power-unit shall be consistent with correct action to remedy the occurrence of fire in the zone(s) related to that power-unit having been taken.

NOTE: For piston-engine aeroplanes this usually means that the inoperative power-unit is stopped."

"5.3.2. Balked Landing. The gross gradient of climb shall be not less than:

$\left(2.0 + 14 \frac{D}{W}\right)\%$  in the following conditions:-

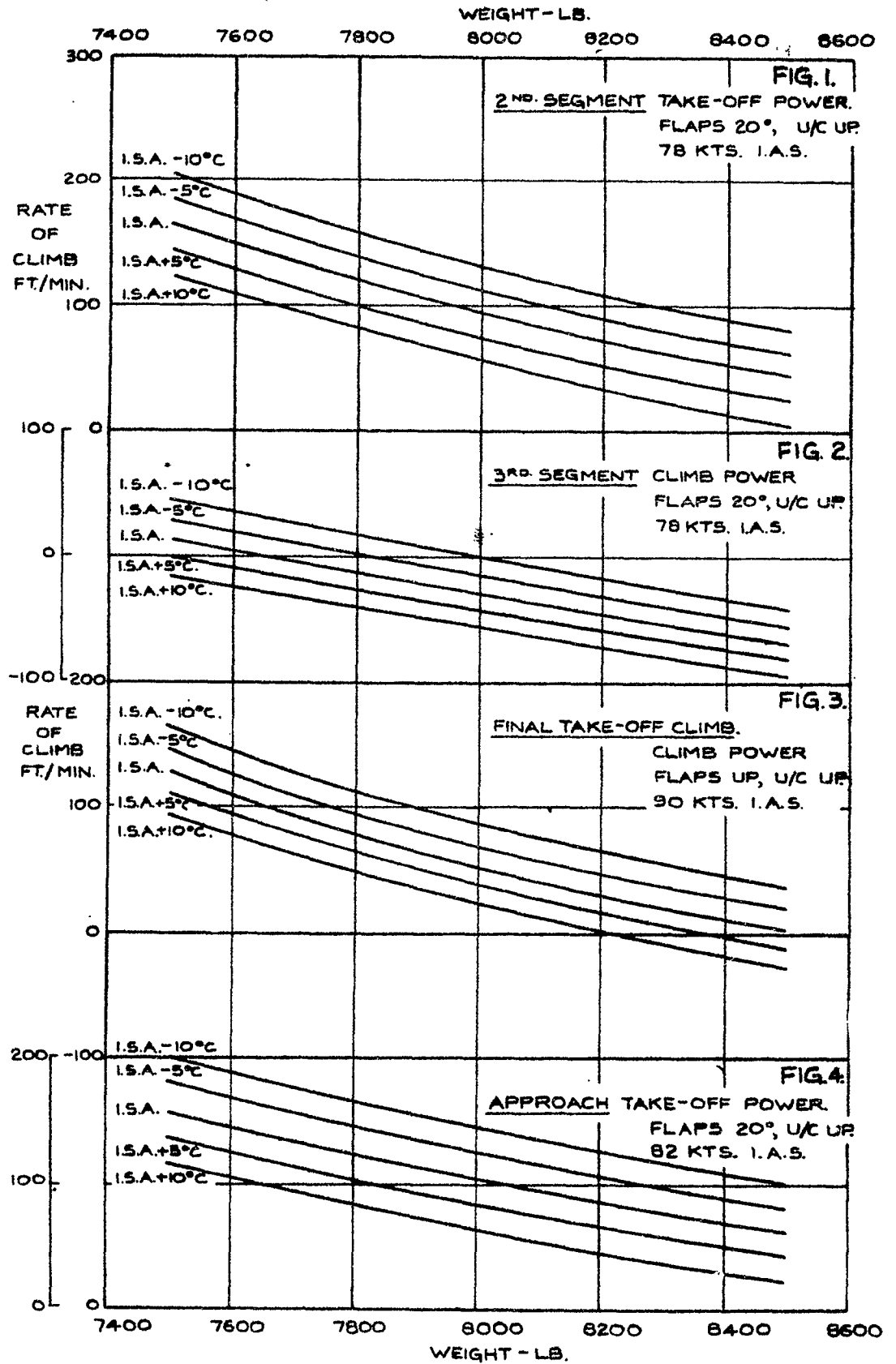
|               |   |
|---------------|---|
| Air Speed     | 1.2 V<br>S <sub>1</sub>   |
| Wing-flaps    | In the maximum Landing Setting except in so far as they may be moved in compliance with the relevant control requirements of D2-8, 5.4.4.   |
| Landing gear  | Full extended.  |
| Cooling Gills | In the positions recommended by the Applicant for use in the final approach to a landing in Maximum Anticipated Air Temperature Conditions. |
| Power         | All power-units operating within Maximum Take-off limitations.  |

NOTE: In some cases, the applicant may prefer to show compliance at a reduced power."

SK.B 3097 6TH PART OF REPORT NO. A. & A.E.E./911 DEVON C. MK.II. W.B 531 TR. SPT. CH. MR. HEFFERNAN APP. 11-3-65

I.C.A.N. HEIGHT 1,000 FT.  
 ONE ENGINE STOPPED & PROPELLER FEATHERED

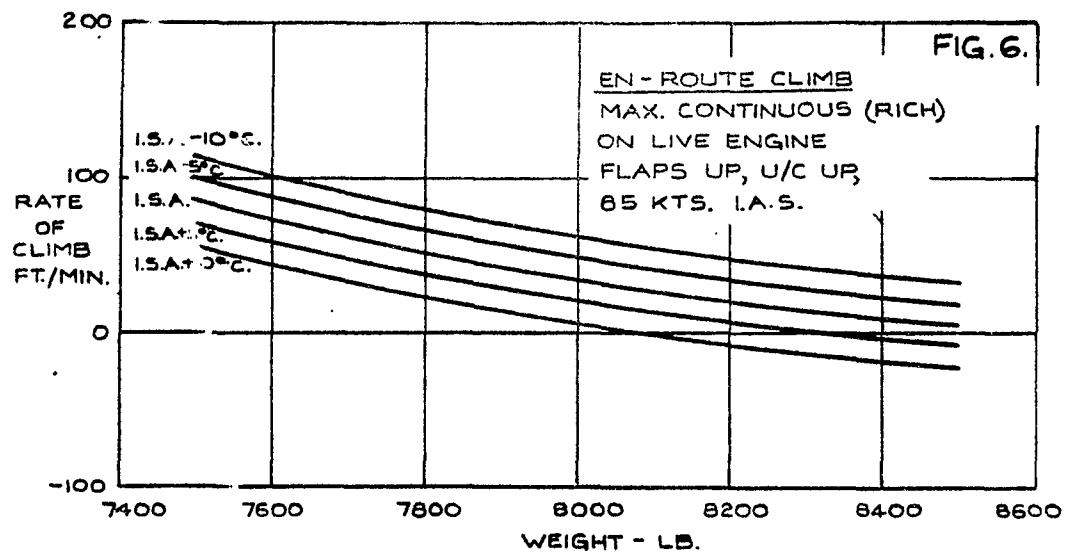
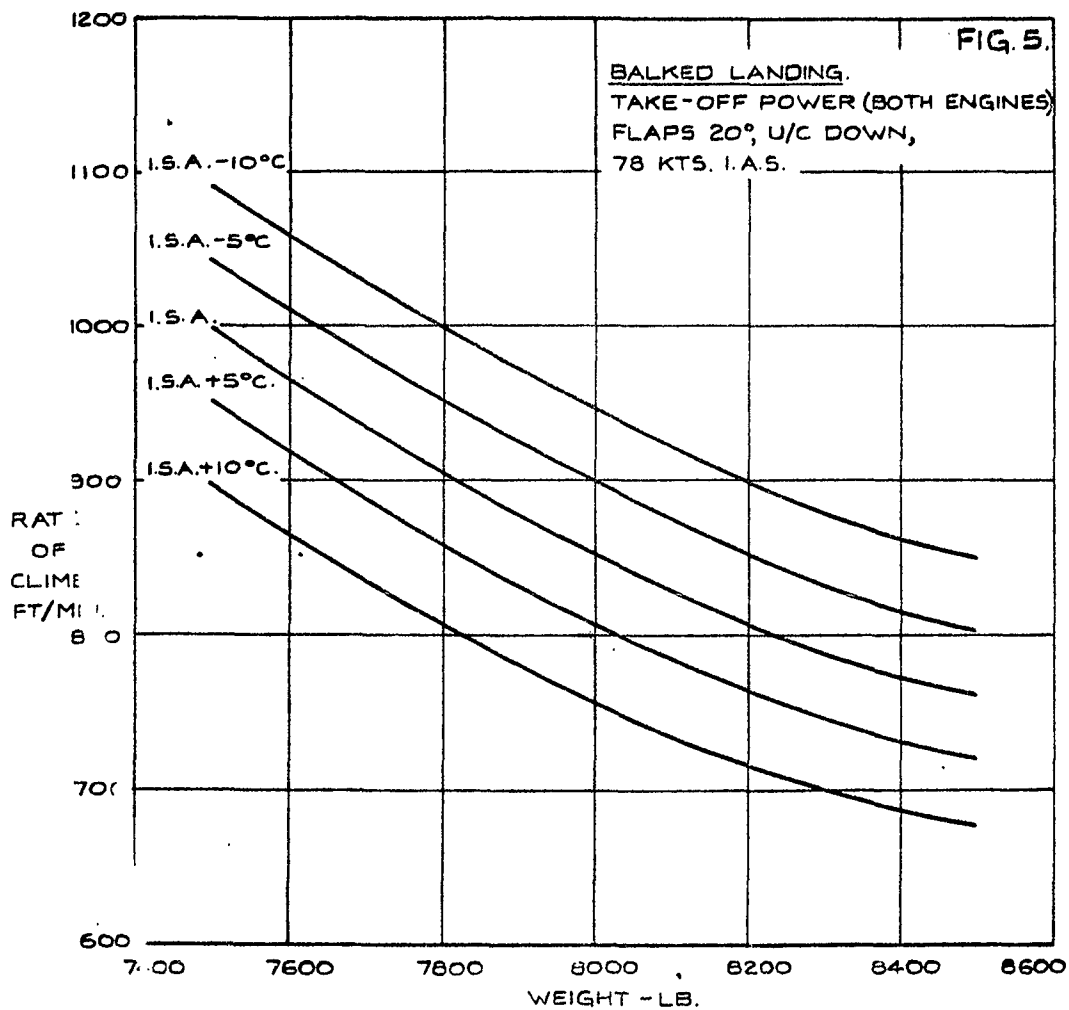
FIGS 1 - 4.



CLIMB PERFORMANCE -  
 B.C.A.R.s. GROUP A.

I.C.A.N. HEIGHT 1,000 FT.

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**CLIMB PERFORMANCE -  
 B.C.A.R.'s GROUP C.**



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