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ARROW 2 CONTROL BOXES

DEVELOPMENT PROGRAM PROGRESS REPORT

National Research Council Canada
Canada Institute for Scientific and Technical Information
J.H. Parkin Branch

Conseil national de recherches Canada
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By: (Name) .....

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AVRO AIRCRAFT LIMITED

ARROW 2 CONTROL BOXES

DEVELOPMENT PROGRAM PROGRESS REPORT

Prepared by Arrow Project Office

DATE: January 28th 1959

Prepared By: A.R. Buley
Project Designer ARROW

Approved By: C.V. Lindow - Engineering
Project Manager ARROW

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INTRODUCTION

As referred in Report # 72/PROJ 7/3, Part 5, the Control Boxes on the Arrow aircraft are being developed to provide a 200 hr. min. life or 1 year whichever is the lesser.

Progress to date relative to the original plan referred above has been effected by accidents to 25201 and 25202 and by a delay in finalizing the Flying Control System and thus releasing the B.1 rig for duty cycle testing. However, other factors and planned tests have produced data indicating that the present design is gener--ally satisfactory.

The schedule included previously is now incorrect due to these changes and also by the overall program change made recently, however the predicted improvement rate remains unchanged.

1.0 Inspection of 25202:

An inspection was made on 25202 due to it's grounding for repair and incorporation of XMA-1C.

This inspection would not have been made other than for the fact that time was available. The aircraft would normally have been cleared for a further 25 hours.

For report made by Service Department see Appendix I.

2.0 Specimen tests:

Fatigue and strength testings has been carried out on numerous detail joint specimens. Test results are available as indicated, and have been or are currently being analysed.

A full technical report covering these test results will be forthcoming on or before July 1st 1959.

2.1 Fatigue tests are currently being carried out at Krouse Testing Machines, Inc., Columbus, Ohio, on representative sections of the four major attachments on the elevator and aileron control boxes, ie:

continued/

2.1 Continued/

A) Attachment of hinge spar to skin and main rib of aileron control box - Ref. RT 08-1055 Job # 3171.

B) Attachment of aileron control box skin to main torque box at rear spar Ref. RT 08-1001 Job # 3128.

C) Attachment of Trailing Edge hinge to top skin and hinge spar of elevator control box. Ref. RT 08-1028 Job # 3163.

D) Attachment of elevator control box skin to main torque box at rear spar. Ref. RT 08-1047 Job # 3170.

Static tests have been carried out at AVRO on each type of specimen used for the above tests to determine their yield and ultimate strengths.

The following is a report on the progress of each of the above tests to date together with a brief outline of available results.

A. Fatigue Test. Attachment of Hinge Spar to Skin and Main Rib of Aileron Control Box.

Sixteen specimens have been manufactured. One was loaded to failure at 30,900 lb. The remaining fifteen specimens have been delivered to Krouse Testing Machines, Inc., and testing is just beginning.

Testing will be carried out on three specimens at each of the following levels ± 80% ± 70% ± 50% and ± 30% of ultimate load.

No fatigue test results are yet available.

B. Fatigue Test. Attachment of Aileron Control Skin to Main Torque Box at Rear Spar

Thirty-two (32) specimens have been manufactured as described in RT 08-1001: sixteen with standard bolt holes (.250 dia) (.252 and 16 with oversize bolt holes (.255 dia) (.257). An additional three specimens have been manufactured with the bonded doubler on the .102" skin extended 1.0" longer and attached with one row of NAS 426 AD 4 rivets at 1.25 in pitch.

continued/

B. Continued/

Two specimens have been static tested (one with standard holes and one with oversize holes). and both failed at 22,000 lb thru' the thin skin at the line of bolts.

The remaining 33 specimens are at Krouse Testing Machines Inc. The results for 29 of these have been received.

Figure 1 is a plot of the results received to date (all loads are plus and minus unless noted). It has been noted that the majority of failures in these specimens were due to bolt failures. The failures recorded in Figure 1 are the first failures of bolts or skins.

C. Fatigue Test. Attachment of Trailing Edge Hinge to Top Skin and Hinge Spar of Elevator Control Box.

Four specimens were manufactured as described in RT.08-1028. One was tested to static failure at 22,800 lb., and the remaining three were fatigue tested by Krouse Testing Machines at + 12,750 lb and - 3,825 lb. Due to the early failure (2000 to 3000 cycles) on the elevator side of these specimens, that half was replaced with one made of steel and the test continued until failure occurred in the control box half at 11,000 to 23,000 cycles. These results are reported in ATR 3163/1.

It was felt that a more representative joint would be obt--ained by using complete sections of spars so a total of 49 specimens were manufactured as described in RT 08-1028, Addendum 1. To ensure that the joints tested were entirely representative three of these specimens were manufactured with a section of rib attached as described in RT 08-1028, Addendum 3. One specimen was static tested to failure at 22,300 lb and the remaining 48 were shipped to Krouse for fatigue testing.

The results of 32 of the fatigue specimens including the 3 with ribs have been received and are reported in ATR 3163/2. Various methods of supporting the specimens were used during these tests involving combinations of skin edge support and lateral hinge pin support.

Results of these tests show that no marked improvement was obtained with the more elaborate specimens. Fifteen untested specimens are still at Krouse. In an attempt to improve the yield strength of the joint three static specimens were manufactured with (a) a dimpled steel doubler (b) a machined aluminum doubler and (c) both a dimpled steel and a machined aluminum doubler as described in RT08-1028, Addendum 4. As a result of these tests additional fatigue specimens are now being manufactured with machined aluminum doublers similar to (b) above.

Continued/

D. Fatigue Test. Attachment of Elevator Control Box Top Skin to Main Torque Box At Rear Spar

Forty-six (46) specimens were manufactured as described in RT 08-1047 and one was static tested to failure at 25,125 lb. In review of the results of the above test a second specimen was tested statically with repeated loading runs to determine when the bolt holes ceased to elongate. After ten runs to 10,000 lb load the permanent set across the joint remained unchanged at .020". In order to check the ultimate bolt strength of this joint one specimen was manufactured with heat treated steel skins. It was tested to failure at 29,200 lb using Phillips head bolts. These were replaced with 'Hi-Torque' recessed bolts and the specimen was again tested to failure at 31,800 lb. Forty-four (44) specimens were shipped to Krouse Testing Machines for fatigue testing as instructed in RT 08-1047. Results of 40 of these specimens have been received and are reported in detail in ATR.3170/2. At the higher load levels occasional failures were reported in the skin just at the beginning of the reduced section and one across the middle of the dimpled steel doubler.

An additional static specimen similar to original specimens above, but with a bonded steel strip in place of the bonded aluminum strip, has been manufactured and tested. It showed improvement in yield strength (15,000 lb as compared to original 12,000 lb to produce .024" permanent set) and approximately the same ultimate strength (24,000 to 25,000 lb).

3.0 Manufacture:

The manufacture of components to date indicates that oversized holes are still required in some instances, these being cleared by opening up 1/64 and using special bolts. To reduce the effect of this problem, Engineering are proposing to increase the reserve factor at the joint by a thickness change. The effectivity of this change will be established through the C.C.B. channel.

Hole tolerances have been relaxed recently permitting holes to be .255/250 as compared with .252/250.

4.0 Greasing:

Refer to 5.3 and 5.4 of Appendix.

Continued/

ARROW 1

INSPECTION OF RH AILERON CONTROL BOX LINKAGE ON AIRCRAFT 25202

REPORT NO. 71/MAINT 00/6

JANUARY 1959

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TABLE OF CONTENTS

1. INTRODUCTION

1.1 The RH aileron control box (Part No. 7-1064-6, Serial No. 64 C 2), was removed from aircraft 25202 after 23:40 flying hours, for a special inspection of the flying control linkage and bearings.

1.2 The purpose of this report is to indicate the condition of the bearings and bearing pivot bolts, together with the degree of lubrication noted on the various components as they were dis-assembled.

1.3 The reference drawings used during dis-assembly were:

7-1564-637 & 638, Shts 1 & 2 - General Arrangement, Flying Controls Outer Wing

7-1064-5 & 6, Shts 1,2 and 3 - General Arrangement, Trailing Edge Outer Wing

7-1564-541 & 542 - Assembly, Lever No. 3, Aileron Controls, Outer Wing

2. SEQUENCE OF DIS-ASSEMBLY

The following sequence was established as the quickest method of removing the control rod, bell cranks and links from the control box:

2.1 Remove the link attachment bolts Nos. 1 & 7.

2.2 Remove the links Nos. 1 to 7.

2.3 Remove the bell crank lever pivot bolts and lock washers Nos. 1 to 7.

2.4 Gently drive out the inner journals from the bell cranks.

2.5 Remove the anchor nut plates from the forward ends of ribs #3A to #7A at the upper and lower surfaces.

2.6 Remove the attachment bolt, #7 lever/control rod and disengage the lever.

2.7 Remove the attachment bolt, #6 lever/control rod and disengage the lever.

2.8 Pull the control rod outwards and towards the root end of the control box to withdraw the end of the control rod through the casting at the forward end of rib #7. The control rod is withdrawn complete with levers Nos. 1 to 5.

2.9 Remove levers Nos. 6 & 7 from the control box.

2.10 With the control rod and levers suitably supported on a bench, remove lever attachment bolts Nos. 1,2,3,4 & 5. Remove levers Nos. 1,2, 4 and 5.

2.11 Slide the control rod through No. 3 lever towards the outboard side, to expose the control rod attachment bearing.

3. DIS-ASSEMBLY INVESTIGATION

Each pivot and attachment bolt was examined on removal for condition and evidence of lubrication, as applicable. Each bearing was checked for torque loading to the formula, "10 lb. inches per inch of bearing outer race outside diameter", and also for any binding or catching. Self-aligning bearings were also checked for evidence of grease at the joint between the outside shield and the inner journal.

3.1 Links Nos. 1 to 7

3.1.1 All .6250" reamed holes gave no indication of wear.

3.1.2 All attachment bolts were uniform on surface condition and showed no indication of scoring due to wear.

3.1.3 All eccentric aileron operation bearings appeared well lubricated and moved easily and smoothly by hand. (Operation was sufficiently smooth that a torque figure reading was impractical to obtain).

3.2 Bell crank levers Nos. 1,2,4,5,6 & 7.

3.2.1 The link attachment bearings showed evidence of grease at the edges of the inner journal and operated smoothly at 2-5 lb. inches torque.

3.2.3 The bell crank lever pivot bearings showed evidence of grease in the grease groove of the inner journals, indicating that grease had been transmitted from the lubrication nipple in the head of the pivot bolt. As these bearings are sealed and not self-aligning, very slight evidence of grease was found at the outer edges of the inner journal. It can be assumed that grease had penetrated to the interior of the bearing. The torque load of 5-10 lbs. inches obtained in all cases, together with the smooth operation, is consistent with this assumption.

3.3 Bell Crank Lever No. 3 (Master Lever)

3,3.1 The link attachment bearing (Shafer A14E) had a torque figure of 15 lb. inches (max 35 lb. inches) and gave indication of very slight catching during rotation.

3.3.2 The pivot bearing (Shafer YD 164A) had a border-line torque figure of 35-40 lb. inches (max. 40 lb. inches) and gave indication of very slight catching during rotation.

3.3.3 The aileron actuator bearing (Shafer YD 137A) had a torque figure of 15 lb. inches (max. 35 lb. inches) and gave indication of slight catching during operation. The inner journal was found to be scored. One score mark was approximately .020" wide by .010" deep and extended across the width of the journal. It was apparently caused by the pivot bolt being driven through the bearing on assembly. Other spiral scores indicated that the pivot bolt had been rotated during assembly, or screwed through the bearing. In view of the above defects, the matter was referred to Mr. J. Lassam, Product Design, who examined the defects and expressed the opinion that the bearing should be removed for strip down to check for brinelling. A new bearing was checked for comparison of torque and feel, and was found to have a lower torque figure (5 lb. inches) and to be very smooth in operation. The above defect is the subject of an inspection snag sheet and FDR 5232 has been raised.

3.4 Control Rod

The control rod attachment bearing had a torque figure of 10 lb. inches (max. 35 lb. inches) and was smooth in operation.

4. SUMMARY

4.1 The general condition of bearings, other than those on No. 3 bell crank lever, was considered satisfactory.

4.2 The 12-1/2 hr periodic lubrication of flying controls was not carried out, but the flying time of 23 hrs 40 minutes may not be truly representative of the actual period of non-lubrication. On several occasions flying control surfaces were removed for various reasons and were lubricated on re-assembly. The full extent of this lubrication cannot be determined.

5. RECOMMENDATIONS

5.1 That Shafer bearing (YD 136A) on No. 3 bell crank lever be removed for a more detailed examination and that a new bearing be installed.

5.2 That non-scheduled lubrication of flying controls linkages cease. If any non-scheduled lubrications are considered essential, then such should be recorded so that all information is available when consideration is being given to establishing the lubrication frequency of the flying controls linkages.

5.3 That lubrication of the flying controls linkages be continued at 12-1/2 flying hour periods, subject to the results of recommendation 5.4.

5.4 That at the next 25 hour periodic inspection carried out (on any Arrow 1 aircraft), one of the flying control boxes be removed and subjected to the inspection check outlined in this report. The results of this check will be used to consider extension of the lubrication frequency of the flying controls linkages.

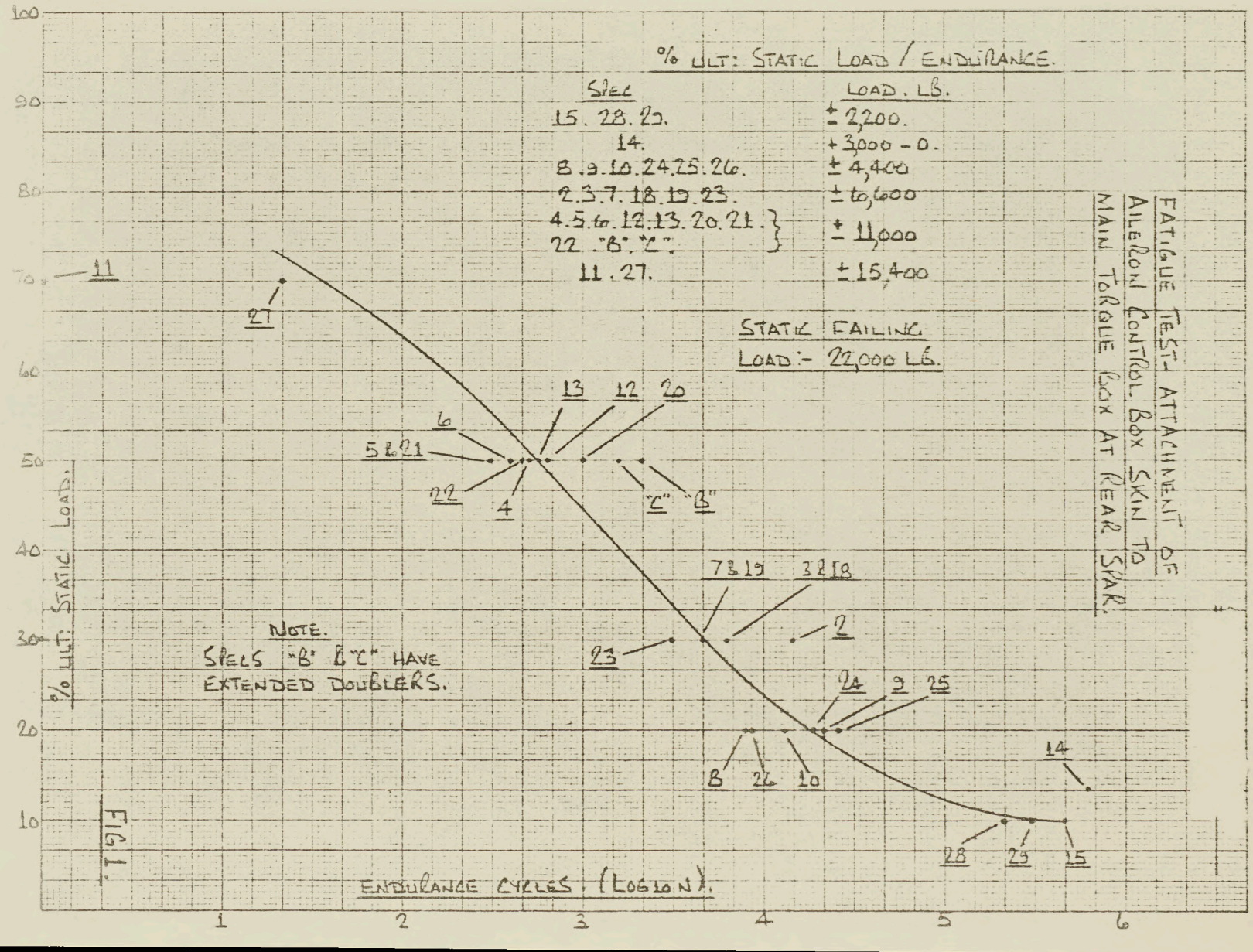
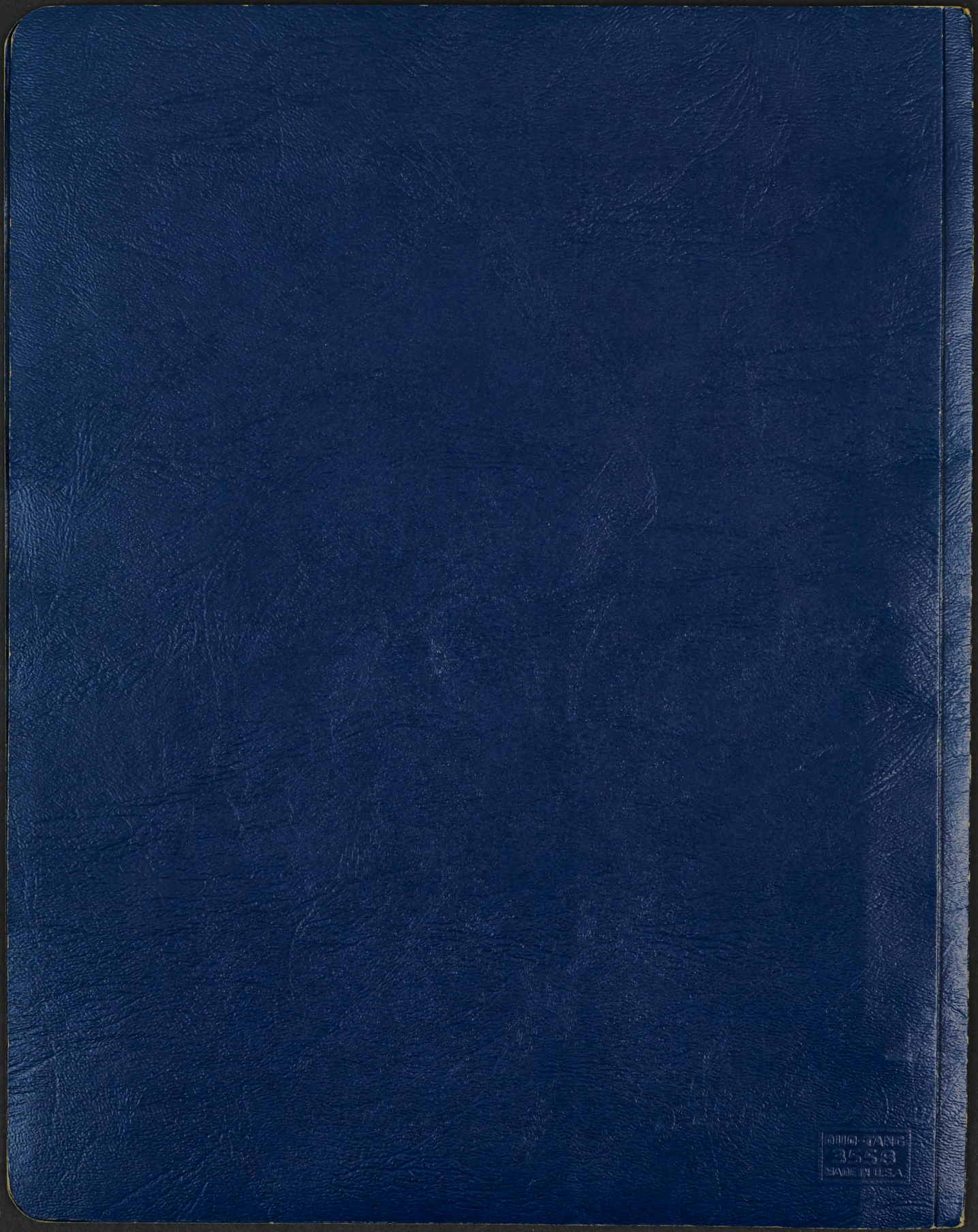

% ULT: STATIC LOAD / ENDURANCE.
SPEC
15. 28. 29.
14.
8. 9. 10. 24. 25. 26.
2. 3. 7. 18. 19. 23.
4. 5. 6. 12. 13. 20. 21.
22 "B" "C"
11. 27.
LOAD. LB.
± 2,200.
+ 3,000 - 0.
± 4,400
± 10,600
± 11,000
± 15,400
STATIC FAILING LOAD:- 22,000 LB.
FATIGUE TEST ATTACHMENT OF AILERON CONTROL BOX SKIN TO MAIN TORQUE BOX AT REAR SPAR.
NOTE.
SPECS "B" & "C" HAVE EXTENDED DOUBLERS.
% ULT: STATIC LOAD.
ENDURANCE CYCLES. (LOG10 N).
100
90
80
70
60
50
40
30
20
10
1
2
3
4
5
6
11
27
13
12
20
6
5 & 21
22
4
"C"
"B"
7 & 19
3 & 18
23
17
24
9
25
8
22
10
14
28
29
15

FIG 1.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