July 1958 71/FAR/30

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ARROW 1
FLIGHT TEST PROGRAMME
AIRCRAFT 25201, 25202 AND 25203

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Issue 1

AVRO AIRCRAFT

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Aircraft: 25201, 25202 and 25203

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FLIGHT TEST PROGRAM

AIRCRAFT 25201, 25202 AND 25203

See page 8

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FLIGHT TEST PROGRAMME ARROW 1

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1. INTRODUCTION

The following report is a more detailed breakdown of the Flight Test programme than possible at the time when FAR/C105/2 was prepared.

The objects of this programme is to determine the airworthiness and systems functioning of the aircraft, to obtain a preliminary assessment of the aircraft performance and handling characteristics, and to establish in stages a series of flight envelope boundaries for safe operation of the aircraft. It is anticipated this will eventually cover the entire flight envelope as far as speed is concerned, and up to 80% of limit structural loads. The performance programme is to be conducted jointly by Avro & C.E.P.E.

The Weapon Pack Flight Test programme to be carried out on A/C 25203 will be covered in a separate report.

This programme has been discussed at a joint meeting of C.E.P.E. and Avro and found acceptable to both parties. Consistent with the request in R.C.A.F. letter ref. S36-38-105-15 (APO-1), this document has been reviewed and agreed to by the resident C.E.P.E. representative.

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2. ALLOCATION OF AIRCRAFT FOR TESTING

2.1 A/C 25201 - This aircraft will be used primarily for systems testing.

2.2 A/C 25202 - This aircraft will be used for aerodynamic testing, namely stability and control, flying controls, and C.E.P.E. handling, the latter being incorporated in the Avro program.

2.3 A/C 25203 - This aircraft will be used for performance testing prior to starting the weapons system testing.

3. STABILITY AND CONTROL AND STRUCTURAL INTEGRITY TESTING

3.1 Introduction

This chapter presents objectives, requirements, method and sequence of flight testing of the Arrow aircraft.

3.1.1 Subjects to be considered

3.1.1.1 Development of control system.

3.1.1.2 Stability and Control - including assessment of handling qualities.

3.1.1.3 Damper development (excluding AFCS).

3.1.1.4 Structural integrity

Each of above topics will be discussed separately and the method in which they will combine into one program will be indicated.

3.1.2 The reasons for combining the above topics are as follows:

3.1.2.1 Economic execution of the whole program. Flight test information is required simultaneously on above subjects in order to proceed with development program in a most efficient manner.

3.1.2.2 To explore certain parts of the flight envelope, it is necessary to have damping system not only in working order but checked out in a quantitiative manner. ?

3.1.2.3 Structural integrity due to controllability problems in certain areas must be combined with damper and associated limiting devices development.

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The overall objective of this flight test programme is to demonstrate that an acceptable pilot-controls-aircraft combination has been achieved.

3.1.3 Detailed objectives are as follows:-

3.1.3.1 To demonstrate that control system is satisfactory from the mechanical point of view.

3.1.3.2 To demonstrate that feel and trim characteristics are acceptable in all control modes.

3.1.3.3 To show that damping system hardware generally performs satisfactorily e.g. is free from oscillations, spurious signals etc.

3.1.3.4 To demonstrate that all required manoeuvres can be performed safely from control stand point.

3.1.3.5 To demonstrate that damper action results in proper co-ordination and damping during manoeuvres.

3.1.3.6 To demonstrate performance of limiting devices where practical.

3.1.3.7 To investigate in flight effects of partial failures in control or damper system (e.g. engine failures, partial hydraulic and electrical failures).

3.1.3.8 Demonstrate compliance with MIL Spec. on aircraft handling. 8785

3.1.3.9 Investigation of structural integrity.

3.2 Method of Flight Testing

Generally it is planned that flight testing will confirm ground test, simulator and theoretical analysis predictions. Most of the development has or is to be carried out on the ground in steps requiring flight test confirmation..

3.2.1 The following major steps are at present planned in sequences as shown.

3.2.1.1 To demonstrate acceptability of flying control system from mechanical point of view. This includes feel and trim characteristics in various control modes and flight conditions.

3.2.1.2 Measure stability and control derivatives of the free aircraft in parts of the flight envelope where this is possible.

3.2.1.3 Test damping system in all modes within this established flight envelope. Evaluate it's shortcomings, undertake design modifications on the basis of ground test and simulator work into which initial flight test data have been fed.

NOTE:- The above design and development tools will be utilized simultaneously whenever possible within the flight envelope initially limited to approx. M = 1.75, 500 knots EAS., 3"g's", 120°/sec. of roll rate.

3.2.1.4 Verify in flights the effectiveness of any changes introduced on the basis of data obtained from items 3.2.1.1 to 3.2.1.3 until an acceptable but not necessarily optimum performance is obtained e.g. free from seriously objectionable characteristics.

3.2.1.5 Extend flight envelope into the region where flight without dampers may result in controllability problems. Measure pertinent damper characteristics in this area.

It is not possible to predict at this time what will be the exact flight envelope for these tests. Approximate expected limits are: M = 2.0, 630 kts EAS, 3 "g's".

3.2.1.6 Perform structural integrity testing to an equivalent of 80% (or less where restricted by other aspects) of limit loads or to command limits of the damping systems whichever is less.

3.2.1.7 Extend the flight envelope to max. EAS, by probing technique in steps not larger than 50 kts EAS preferably using chase plane of equal capability.

3.2.1.8 Perform preliminary evaluation of damping system limiting devices by adjusting their limit levels to lie within structural integrity limits established in item 3.2.1.6.

3.2.1.9 Perform damper optimization tests where required. This test will consist mainly of measurements of damper parameters over the full speed and altitude range in the configuration as close as possible to final.

3.2.1.10 Perform further structural integrity demonstrations to limits as agreed mutually by RCAF and Company. This test to be combined with those required for development of damping system limiting devices.

3.2.1.11 Incorporate all design changes resulting from earlier tests particularly items requiring long lead times in production. Perform all tests necessary in conjunction with these changes.

3.2.1.12 Consider extension of the flight envelope to full speed cabilities of Arrow 1 aircraft.

3.2.1.13 Demonstrate handling qualities in accordance with MIL. Spec.

3.2.1.14 Perform flight tests in addition to handling or structural integrity MIL Spec. requirements as required by the Company.

3.2.2. The above sequence is justified as follows:-

3.2.2.1 In development of the damping system it is of particular importance to verify the aerodynamic parameters which were used in it's design. Should these be significantly different in detail, a number of damper parameters would have to be adjusted. If aerodynamic parameters are available from flight the damper parameters can be adjusted on the ground based on simulator and ground rig work, thus saving a substantial amount of flight time and eliminating the time consuming trial and error method.

3.2.2.2 Measurements of stability and control characteristics in the early part of the program will permit accurate safety monitoring and will permit exact evaluation of aerodynamic phenomena that are known to have slowed down a number of development programs on other aircraft particularly the various forms of aerodynamic crosscoupling effects.

3.2.2.3 These measurements will permit also numerical evaluation of various aerodynamic effect usually required to be demonstrated in flight by specifications and may lead to substantial saving in these flight demonstrations e.g. structural integrity specifications require demonstration of a number of manoeuvres which according to predictions result in relatively insignificant load levels. These requirement could be precluded by predictions based on flight measurements of aerodynamic parameters.

3.2.2.4 Air loads and structural analysis will greatly be assisted by exact knowledge of aerodynamic parameters permitting e.g. elimination or reduction of arbitrary increments (defined by spec) used in loads evaluation and resulting often in un-necessarily severe penalties.

3.2.2.5 Initial damper development can, and should for safety reasons be carried out prior to full structural integrity test.

3.2.2.6 Difficulties arise in trying to separate structural integrity testing from demonstrations of various limiting devices which are part of the damper. These devices were designed to protect the airframe against inadvertent applications of large loads by the pilot and also for protection against failures. Full structural integrity testing cannot therefore be carried out until these devices are fully assessed.

3.2.2.7 For test safety reasons it is not advisable to extend the flight envelope to max. EAS prior to development of the damper to a point where firm predictions can be made as to its behaviour. Obviously both emergency and normal dampers are required prior to entering of the max. EAS region.

The detailed requirements of test sequences listed under items 3.2.1.1 to 3.2.1.14 are given in following sections which for convience have been arranged by subject rather than by sequence of test, e.g. all tests required for stability and control are listed in section 4 irrespectively of their sequence in the overall program.

In this manner a lot of repetition will be avoided since similar manoeuvres are required in each flight testing stage, the difference being in flight conditions and/or severity of the manoeuvre.

3.3 Development of Flying Control Tests

Specific flight tests are not necessary. Evaluation of pertinent control system characteristics can be carried out simultaneously with stability and control tests described in the next chapter. Some special instrumentation will be necessary to evaluate important parameters. General flying in different flight conditions will supply all the information required.

3.4 Stability and Control

The main object of these tests is to evaluate stability derivatives. This program will present the required number of test points necessary to establish these parameters over the full flight envelope which could however be substantially reduced, if results agree well with predictions. To evaluate stability derivatives a number of specific manoeuvres are required. Generally a similar type of manoeuvre is required at each selected Mach number and altitude. To describe in detail the whole flight envelope approx. 17 flight conditions are required. These could be subdivided as follows:

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3.4 Cont'd

3 low speed conditions with U/C up and down.

3 subsonic flight conditions at different altitude

5 transonic flight conditions .95 $<$ M $<$ 1.2 including one at high EAS at low altitude.

3 supersonic conditions at relatively low EAS

3 supersonic conditions at high EAS

At each of the above flight conditions the following tests are required.

3.4.1 With emergency dampers engaged.

3.4.1.1 Abrupt stick motion in pitch and return to neutral in order to excite pitching oscillation from which pitch stability and damping can be evaluated.

3.4.1.2 Abrupt stick motion in roll to produce roll rates of the order of 40°/sec. to evaluate aileron effectiveness. Rolls not to exceed 90° of bank angle.

3.4.1.3 Steady turns and pull-outs to evaluate elevator angle per "g".

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3.4.2 In dampers off configuration (all speeds).

3.4.2.1 Rudder deflections to produce dutch rolling oscillations with maximum sideslip not exceeding approx. 40% of limit fin load. Static stability in yaw, dihedral effect and damping derivatives can be evaluated from these tests.

3.4.2.2 Repeat the above whole pulling steady "g's" to obtain variation of derivatives with angle of attack.

3.4.2.3 Mild rolls to approx. ± 30° of bank angle to evaluate damping in roll and aileron yaw.

3.4.2.4 Evaluate asymmetric power effects.

3.4.3 In dampers off configuration - low speeds.

3.4.3.1 Steady sideslip investigation.

3.4.3.2 Handling in gear down configuration.

3.4.3.3 Evaluation of minimum safe flying speed and buffeting characteristics.

3.4.4 Check handling with one engine shut-off.

In addition to flight conditions listed at the beginning of section 3.4 it may be necessary to probe some areas in small increments and to perform additional manoeuvres and measurements in these areas.

3.5 Damper Development Tests

3.5.1 For the purpose of damper development the flight envelope of the Arrow will be represented by 10 flight conditions agreed to by AVRO and Minneapolis-Honeywell. At these flight conditions the damper performance will be examined in detail and results of these tests will be projected into the remainder of the flight envelope. The ten flight conditions are the following:-

Altitude	Mach Number	
10000	.7	Low Altitude
10000	1.15	Low altitude high EAS
20000	.4	Low speed (landing mode)
20000	.7	Initial test point
20000	1.4	High EAS supersonic
30000	.95	Transonic cruise condition
30000	1.6	High EAS supersonic
40000	1.8	Highest available Mach Number (Arrow 1)
50000	1.15	Design altitude
50000	1.6	Design altitude

3.5.2 The initial damper tests will consist of handling tests in various damper modes to assess the performance and compatibility of damper hardware. Measurements will be made of damper command signals, servo motions, sensor outputs etc. The measured quantities in the form of oscillograph traces will be examined by AVRO and Minneapolis-Honeywell where necessary analog computer, and digital computer check programs will be run with data from flight test fed into the computers to establish proper functioning of the hardware. In this stage optimisation of the damper performance will be limited to whatever is necessary to obtain safe operation. Therefore adjustment of damper gain settings inflight will either be eliminated or limited to a few specific cases. Any necessary adjustments will be examined on flight simulator and introduced into the aircraft damper system on the ground.

To obtain aircraft disturbances necessary to evaluate damper performance control column and rudder motions will be utilized and in cases where more exact data are required damper step switches provided for this purpose in pilot's cockpit will be used. In the initial testing stage navigator's damper control panel will not be used in flight but will be necessary for checking purposes and adjustments on the ground. Since pertinent

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3.5.2 Cont'd

testing controls for normal damper mode are located in the navigators cockpit, only a preliminary assessment of pitch and roll damper can be obtained. Also it is not expected that full damper instrumentation will be available for this phase. – Flight conditions for these tests will be selected from the ten listed in para. 3.5.1 and the usual starting point will be M = .7 at 20000 ft. Manoeuvres required for this evaluation will be the usual handling checks: e.g. commands in roll and pitch generally restricted to relatively small amplitudes. Symmetric and asymmetric power effects will be evaluated and appropriate tests will be carried out in landing mode at altitude. The general procedure will be that aerodynamic data obtained from flight (see section 4) will be fed into the flight simulator to check damper performance and where necessary appropriate adjustments will be made to the damper parameters.

3.5.3 Second stage of damper testing will begin as soon as the damper and flying control system hardware shows satisfactory performance from mechanical, hydraulic and electrical point of view. This will consist of further damper measurements in manoeuvres where higher "g's" and rates of roll are used at the flight conditions as described previously. More extensive damper instrumentation will be required and on some flight observers will be

3.5.3 Cont'd

carried. The object of these tests will be what is generally known as damper "optimisation". Each of the ten flight conditions will be examined in more detail in order to predict the optimum damper settings resulting in smooth commands with minimum overshoots, coordination of manoeuvres to a minimum of sideslip etc. Again the same method will be followed by predicting the correct settings on the simulator, however it is expected that some gain adjustments in the air will be necessary.

3.5.4 Preliminary assessment of damper limiting devices.

The exact test procedures depend on the initial experience with the damper. It is expected that several flights will have to be devoted to this purpose. Generally these will consist of manoeuvres resulting in action of the limiting and/or switching circuitry of the damper within specified structural integrity flight envelope. It will not be necessary to check these functions at all of the ten flight conditions. A few will be selected for this purpose.

3.5.5 Final assessment of damper limiting devices. The method of testing has not been established yet but it is expected that preliminary evaluation may introduce changes and tests in addition to para. 3.5.4 will be necessary. These tests will involve the following:-

3.5.5.1 Checking that the system switches from normal to emergency if the sideslip angle reaches 10° at the lower speeds when the damper is in gear up mode.

3.5.5.2 Checking that the system switches from normal to emergency if the lateral acceleration 40' ahead of the centre of gravity exceeds 0.4 at the higher speeds (or whatever criterion is finally established for the lateral monitoring circuit).

3.5.5.3 Observing that "g" limiter is restricting the normal acceleration commands at the correct value.

3.5.5.4 Confirming that the "g" limiter behaves correctly in the case of damper failure.

3.5.5.5 Checking that the maximum rate of roll is limited in the presence of lateral acceleration.

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3.5.6 Final Damper Assessment

Final Damper assessment will be carried out as part of demonstration testing described in section 7. In addition a relatively small number of checks will be required to demonstrate the compliance of damper equipment with it's specification. One of the most important checks to this effect will consist of gentle manoeuvres with damper gain settings different by 50% from its nominal settings established on basis of previous tests. One parameter at a time will be checked at a few selected flight conditions. Gain adjustments will be performed in the air from navigators control panel.

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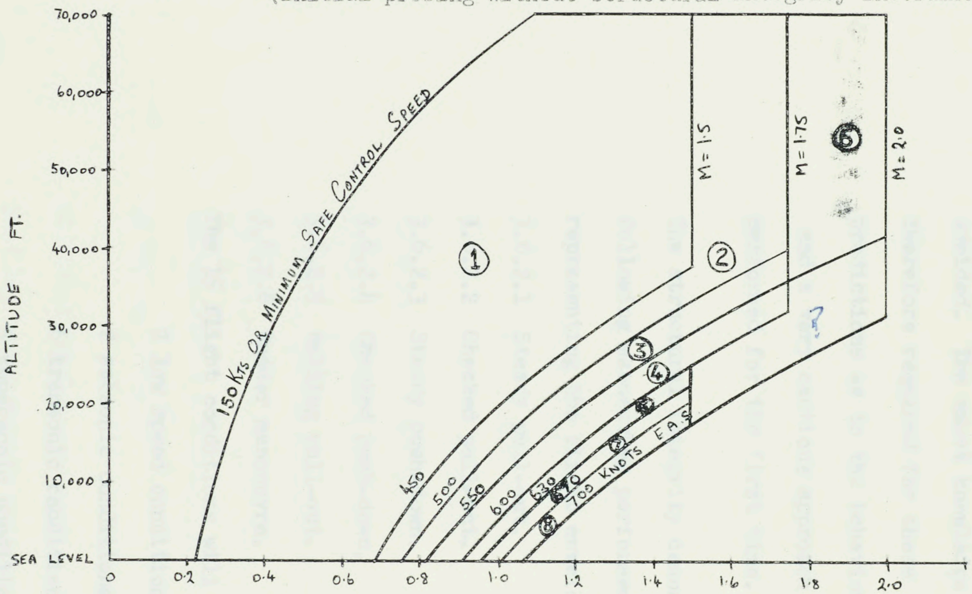
3.6 Structural Integrity Demonstration

3.6.1 The initial probing flights with non-instrumentated structural aircraft will be done in steps of approx. 50 knots as shown on the following page. Approximately 70% of limit loads will be reached in subsonic cases and less at supersonic speeds. The maximum EAS runs will be further restricted in load factors. The approximate limitations are shown on the following page. The table indicates the approximate maximum values of normal load factors in each region. The exact flight conditions at which these load factors will be applied will be selected in such a manner as not to exceed 70% of design hinge moment.

3.6.2 Demonstration with partial structural integrity instrumentation. In this phase only limited amount of structural integrity instrumentation will be available and therefore it will not be possible to extend the demonstration to full design limits. Due to controllability conditions each manoeuvre prior to it's execution will be investigated in detail on the flight simulator based on flight test aerodynamic data previously obtained. A step by step method will be applied where the results from first step will analytically be extrapolated to provide exact predictions for the next step. Particular attention will be paid to the rolling pull-out type of manoeuvre which due to cross-

Approximate Steps Extending The Flight Envelope Of The Arrow 1 In Phase I and II
(Initial probing without structural integrity instrumentation)



MAXIMUM LOAD FACTOR IN EACH STEP - A.U.W. = 60,000 LBS

REGION	1	2	3	4	5	6	7	8
MAX. "nW"	240,000	200,000	200,000	200,000	160,000	120,000	120,000	120,000
STEP 1	2.0							
" 2	3.0	2.0						
" 3	4.0	2.7	2.0					
" 4	4.0	3.4	2.7	2.0				
" 5	4.0	3.4	3.4	2.7	2.0			
" 6	4.0	3.4	3.4	3.4	2.7	2.0		
" 7	4.0	3.4	3.4	3.4	2.7	2.0	2.0	
" 8	4.0	3.4	3.4	3.4	2.7	2.0	2.0	2.0

3.6.2 Cont'd

coupling effects tends to produce large structural loads in the majority of flight conditions in damper- off configuration. The normal damper mode will be used in these tests and therefore excessively large loads will be avoided. The exact knowledge of damper performance is therefore required for these tests together with firm predictions as to the behaviour of it's limiting devices and a very cautious approach is mandatory for all tests performed for the first time.

The structural integrity demonstration will consist of the following manoeuvres performed at 15 flight conditions representing the flight envelope:

3.6.2.1 Steady pull-out.

3.6.2.2 Checked pull-out.

3.6.2.3 Steady push-down.

3.6.2.4 Checked push-down.

3.6.2.5 Rolling pull-out.

3.6.2.6 Rudder manoeuvre.

The 15 flight conditions will be selected as follows:-

2 low speed conditions

2 subsonic conditions

6 transonic conditions

5 supersonic conditions

3.6.2 Cont'd

The test will be carried out in steps of approx. 20% in load level beginning at 40% and not exceeding 80% of design loads or such lower limit as defined by the damper system command limits. It is not intended to perform all of the manoeuvres listed at each of the flight conditions shown. Appropriate selection will be made on the basis of the knowledge of more critical loadings cases. In the first priority this program will endeavour to demonstrate structural integrity within the flight envelope limited by:-

A minimum safe control speed (to be determined in flight).

Maximum altitude of 50,000 ft.

Mach number 1.5 or 600 kts EAS whichever is less.

80% of design limit loads or such lower limit as defined by normal damper protective devices.

It is expected that before this formal program will be started that the aircraft will be cleared to values in excess of 70% by non-instrumented demonstration flying , see 3.6.1. Repetition of the lower loading cases will only be used to collect data for extrapolation and therefore full coverage is not required.

Additional manoeuvres may be introduced into the program if handling tests show that important loading cases may be realised in manoeuvres not specified above.

3.7 Demonstration Program

The object of this part of the program is to demonstrate compliance with Specification MIL-F-8785 "Handling qualities of piloted airplanes". For these tests the flying control system and the damping system must be fully developed and the program will consist of demonstration flights covering a number of specific manoeuvres.

By this time a number of flights required by this specification will be completed in the course of the development. As much as possible of this information will be used to demonstrate the compliance with the specification. Therefore a full coverage will not be necessary and only manoeuvres and flight conditions not tested previously will be included in this program.

The aircraft will be tested in normal and emergency control modes.

The following in the full list of manoeuvres to be performed at flight conditions as required by the specification.

3.7.1 Augmented stability, level flight.

3.7.1.1 Abrupt control deflections to produce approx. Δn of 1 g, Δp of 30°/sec. and 60°/sec. and side acceleration not exceeding 40% of limiting side-slip.

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3.7.1.2 To determine trimmability, trimmers to be operated on all three controls to achieve: ± 1g, ± 30°/sec. of roll rate, ± 40% of limiting sideslip.

3.7.1.3 Application of step inputs into the damping system:

(a) step input to rudder differential servo.

(b) step input of roll rate command

(c) step input of normal acceleration command.

(d) step input of combined roll rate and normal acceleration command.

These tests are identical with tests required for damper optimization (section 5) and therefore the majority of them will be available prior to demonstration program. Only additional flight conditions as required by specification will be tested in this program.

3.7.2 Augmented stability in 2 g turning flight.

3.7.2.1 While trimmed into a steady 2 g trim descending if necessary to maintain Mach No., and at as near to constant altitude as power allows, pilot to determine response of aircraft to gentle control motion, and repeat items 3.7.1.1 - 3.7.1.3.

3.7.3 Further level flight tests at a few selected conditions:-

3.7.3.1 With normal damper

(a) Apply elevator step to produce 2 incremental "g's".

(b) Apply aileron to produce 70°/sec of roll rate.

(c) Apply rudder movement to produce 80% of fin load or 180 lb at the bar.

(d) Evaluate effects of airbrakes in pitch.

3.7.3.2 With emergency damper

Repeat 3.7.3.1 items (a), (c) and (d).

3.7.4 Determination of manoeuvre "g" envelope in normal damping mode.

3.7.4.1 Perform pull-ups and push downs within the command limits of the damping system.

3.7.4.2 Rolling pull-outs.

3.7.4.3 Perform "g" limiter demonstration test. This test to be defined on the basis of "g" limiter development testing.

3.7.4.4 Check roll rate limiter and lateral acceleration limiter.

3.7.5 Control mode transfer demonstration

3.7.5.1 Demonstrate manual and automatic switching from normal to emergency control mode in trimmed level flight and in gentle manoeuvres.

3.7.6 Demonstrate sideslipping capability at low speeds at altitude.

3.7.7 Demonstrate effect of symmetric and asymmetric power in normal and emergency damper mode, including after-burner effects.

3.7.8 Low speed tests

3.7.8.1 Demonstrate minimum safe flying speed in both damper configurations with undercarriage up and down and with different power settings.

3.7.8.2 Demonstrate performance of timmers on all three controls.

3.7.8.3 Determine stability in pitch at low speed by performing a number of accelerating and decelerating runs with constant trim setting.

3.7.9 Demonstrate long period longitudinal oscillation (phugoid) in both damper modes.

3.7.10 Spins and recovery

Sufficient information is not available yet to establish that spins are possible, and that recovery is satisfactory from established spins. Further tests and evaluations will be necessary to establish the extent of spin demonstrations.

3.7.11 Forward critical loading

It is assumed that most of the tests described above will be performed at c.g. positions near or at the aft limit. A number of tests will be done at the forward critical loading conditions bearing in mind air loads limitations, particularly the hinge moment limits. Since design forward limit is not going to be achieved on production aircraft this demonstration could be limited to a minimum acceptable to the RCAF and Company.

4.0 Systems Testing

Considerable amount of systems testing is planned for A/C 25201 in particular, as stated under allocation of aircraft. During systems testing the aircraft flying time can best be utilized by recording data from a number of systems on any given flight rather than investigating a particular system in its entirety.

All systems testing on the Arrow 1 will in general be restricted to that testing necessary to demonstrate safe and satisfactory functioning. The only exceptions to this are those cases where the Arrow 1 and Arrow 2 systems are for all practical purposes identical. This is intended to keep duplication of testing on the Arrow 1 and Arrow 2 to a minimum. The actual systems to be tested and the test procedures are covered in section 4.1 to 4.7.

4.1 Flying Controls

The operation of the flying control system will be investigated on Aircraft 25202 in conjunction with the Stability and Control Testing. The reason for this decision is the impracticability of attempting to divorce the flying control system from the damper.

Extensive work has been carried out on the ground rig. This will continue to act as a back-up for the inflight testing. As outlined in FAR/C105/2 the following major points are scheduled for investigation as shown below.

(a) Pilots Controls

Breakout forces.

Emergency mode feel system

Normal mode feel system

Adequacy of damper schedules and damper modes.

Suitability of trimming devices.

(b) Control Surfaces

Operation of damper and command systems hardware.

Power controls actuator performance.

The actual test procedures and estimated of flying time are covered in conjunction with Stability & Control testing, see section 3.

Flying Control centering and trimming test will be carried out on the ground. For details of quantities to be recorded during these tests see R.F.T. 5046.

4.2 Engine Handling and Structural Cooling

The engine testing is divided into two main quantities engine handling and engine and airframe cooling. The actual tests are covered in R.F.T. 5037 and 5031 respectively. Examination of the quantities to be measured shows that many of them are common to both tests.

4.2.1 Engine Handling

The engine handling tests are to demonstrate that the installation is satisfactory and to determine the engine behaviour and characteristics for various flight conditions. Engine relight will be carried out at a series of altitudes in order to establish a relight envelope for the J75 P5 engine installed in the Arrow. At the same time engine windmilling rotor speeds will be observed.

During the engine acceleration and deceleration tests the presence of any intake buzz or vibration will be noted. Estimates indicate that buzz should not occur below 1.8 M.N. It is not intended at this time to install any special instrumentation for this investigation.

Fixed throttle climb from sea level to altitude will be carried out in order to detect any RPM or JPT creep that may exist.

The effect on engine stability of aircraft attitude and yaw will be investigated, together with the behaviour during descent at idling conditions.

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4.2.1 Cont'd

For more detailed list of quantities to be measured and conditions of test see R.F.T. 5037.

4.2.2 Engine and Airframe Cooling

The objective of these tests is to measure and check both structural and systems temperatures associated with the engine installation for safety monitoring, and in order to verify estimates for the Arrow 2.

Both stabilized level flight and transient conditions are to be investigated. The former covers the pertinent subsonic and supersonic cruise and max. speed cases, whilst the latter are descents and decelerations. The recordings obtained during these tests will be examined and checked against estimated values. The degree of agreement between predicted and measured values will determine any region that may require further investigation.

For a detailed list of quantities to be measured and actual test conditions see FAR/C105/1 Issue 7, and R.F.T. 5031.

The engine handling and structural cooling tests involve the measurement of approximately seventy parameters.

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4.3 Air Conditioning

The objective of this test is to prove the operation of the Arrow 1 air conditioning system. An extensive ground test programme has been carried out on this system, which eliminates the necessity for an exhaustive in-flight program.

The key parameters will be recorded during test, these will establish whether the air conditioning system is working efficiently or not. These tests will cover the extreme aircraft operating conditions, namely high altitude at high speed, high altitude at low speed and low altitude at low speed, together with the pertinent cruise conditions, descent, acceleration and deceleration. This data will then be checked against theoretical calculations, and the amounts of testing necessary will largely be dictated by the agreement between estimate and measured values. A detailed list of the quantities to be measured and flight conditions are given in R.F.T. 5045.

4.4 Telecommunications and Antennae

Testing under the above heading covers calibration checks for navigation aids, range determination on both navigation aids and communications sets and antenna range patterns for a single plane.

4.4.1 Calibration Checks

Air swings will be carried out to check calibration and to compensate the AN/ARN-6 Radio Compass, to check calibration of AN/ARA-25 UHF Homer and J-4 Compass. Station passage characteristics of the AN/ARN-6 Radio Compass and the AN/ARA-25 UHF Homer will also be determined.

The test procedure is as follows. With the AN/ARN-6 tuned in to a Broadcast station and the AN/ARA-25 tuned in to a UHF station, runs will be made from a number of directions over a known checkpoint. The true course of the aircraft being obtained from photographs of the checkpoint and compared with the readings photographed by the recording camera to check out the navigation aids. Station passage characteristics and the complete test procedure are given in Technical Information Bulletin 7-13-2.

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4.4.2 Radio Range Checks

Flight checks are required to determine the ranges of the AN/ARN-6 Radio Compass, the AN/ARN-25 UHF Homer, the AN/ARC-34 UHF communications set and the AN/APX-6A IFF set. Test on the AN/ARC-34 UHF will be made with both the fin and belly antennae. An auto-observer will be used to record the AN/ARN-6 and AN/ARA-25 displays as in the calibration checks. It is proposed that range checks be carried out with the cooperation of the nearest RCAF GCI facility, which can be used to check the range of the IFF and UHF sets. Strength and readability will be recorded for various ranges.

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4.4.3 Antenna Evaluation Tests

The purpose of these tests will be to establish verification of model range patterns for a single plane. It is assumed that if close correlation between flight test and model range data can be established for one plane, then model range patterns for complete 360° coverage will be highly representative of inflight performance of a full scale aircraft.

It is proposed to select a location about 25 miles from the ground station, having a sufficiently good land mark that the pilot may fly over it and consistently pin point a fixed position. The pilot would then perform straight and level flights at a fixed altitude for several headings and field strength measurements would be recorded at the ground station. The flight test results would then be compared with the model range data. For a more detailed discussion of the antenna evaluation program see Report No. 71/SYSTEMS-13/3.

Test requirements for telecommunications and antenna evaluation are covered in RFT's 5028, 5029 and 5044.

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4.5 Fuel System

The object of this test is to prove the satisfactory functioning of the Arrow 1 fuel system on a complete aircraft.

Fuel contents of all fourteen tanks will be measured together with temperatures and pressures of certain critical tanks. Fuel temperature pressure and flow to the engines will also be measured. For detailed list and location of actual quantities see FAR/C105/1, Issue 7.

Testing will consist of measuring the above quantities during various flight conditions within the flight envelope. These will include take-off and acceleration at low altitude with and without afterburner, subsonic and supersonic climb with and without after-burner, straight and level flight at cruise and high altitude, and during dive. This is intended to cover the operating speed and altitude range, and variations in aircraft attitude.

The actual test conditions are given in detail in R.F.T. 5040 plus Add. 1.

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4.6 Landing Gear, Speed Brake and Hydraulic System

The object of these tests is to obtain a qualitative assessment of landing gear and speed brake operation and to record hydraulic system pressures and temperatures in order to determine safe and satisfactory operation of the hydraulic system.

In addition to this the energy absorbed by the landing gear will be investigated. In the design of the landing gear the energy absorbed by wing deflection during landing was ignored, by measuring the actual energy absorbed by the landing gear it is hoped to increase the maximum permissible landing weight.

Landing gear extension and retraction times, utility hydraulics pressures and temperatures will be measured during take-off and landing. Similarly for the speed brakes, continuous traces of systems pressures and temperatures will be recorded for a series of speeds at a selected altitude. Speed will then be increased with speed brakes down until they blow back, the pressure in the utility hydraulic system being recorded.

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4.6 (Cont'd)

Utility hydraulic system temperatures will be recorded during a number of pertinent flight conditions covering critical subsonic and supersonic cruise, together with certain transient conditions. The conditions for these tests are in general identical to those for Engine and Airframe Cooling Tests, for details of quantities to be measured and test conditions see R.F.T. 5039.

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4.7 Electrical Power System

The in-flight testing on the electrical system for the Arrow 1 is confined to that testing necessary to demonstrate safe operation. Hence temperature measurements are the predominant parameters that will be measured. The main objectives are to check that the cooling air flow through the A.C. generator is adequate for all conditions of electrical loading and that the maximum operating temperature of the A.C. generator rear bearing is within safe operating limits. To check temperatures in different zones where electrical equipment is mounted to ensure operating ambients are satisfactory. This will be done for a series of flight conditions ranging from low speed at low altitude to high speed at high altitude. For more detailed list of actual conditions and parameters to be measured see R.F.T. 5041 Add. 1.

5. PERFORMANCE

5.1 Introduction

After completion of the initial flights on Arrow 1 Aircraft 25203 it will be made available for the execution of an integrated R.C.A.F. (C.E.P.E)/Avro Performance Programme.

The tests will be carried out from Avro with the resident C.E.P.E. pilot doing most of the flying.

Flight test data will be made available to the C.E.P.E. personnel and will also be analysed by Avro using a digital computer program.

5.2 Object of Programme.

5.2.1 To demonstrate the performance capabilities of the aircraft with particular reference to time to height, manoeuvrability and radius of action.

5.2.2 To determine aircraft drag over a wide range of speed and altitude within the limitations of the test techniques and the methods used to measure in-flight thrust.

5.3 Aircraft Configuration

Arrow 1

Pratt & Whitney J75-P5 engines.

1A Ejector. (45" divergent).

5.4 Scope of Tests

5.4.1 Thrust Measurement

An attempt will be made to determine in-flight net thrust using a combination of manufacturer's engine data and flight test measurements of engine operating conditions. Basic engine gross thrust will be obtained from measurements of intake total pressure, L.P. and H.P. compressor R.P.M., turbine outlet total pressure and temperature and P & W engine data. Engine mass flow for net engine thrust information will be determined from flight test measurements of L.P. compressor R.P.M. & P.& W data. By-pass mass flow and thrust will be obtained from measurements of total pressure and temperature and static pressure in the exit plane of the final nozzle. In addition the ejector thrust contribution will be determined from a static pressure survey.

5.4.2 Position Error Measurement

Dependent on circumstances and facilities available at the time of the tests, position error over as wide a speed range as possible will be measured using the aneroid and/or pacing techniques.

5.4.3 Take-Off Performance

Take-off performance will be measured using military power and max. augmented power at the max. AUW of the aircraft. In addition, two take-offs will be recorded using military power only at an AUW of 55000 lb.

5.4.4 Landing Performance

Due to the lack of anti-skid brake system on the aircraft at this stage, optimum landing performance cannot be determined. However, landing performance will be measured using the best pilot techniques established at the time of test will regard to touchdown speeds, chute operation and braking effort.

5.4.5 Level Speed Performance

A limited number of level speed and fuel consumption tests will be made using the stabilized level technique mainly in the subsonic region for both symmetric and asymmetric power. One check will be made at M = 1.5 and 45,000' and partial climbs from 45,000' at various supersonic Mach number will be used to establish the ceiling of the aircraft.

5.4.6 Accelerated and Decelerated Levels

Data from accelerated levels with and without A/B and decelerated levels at idling power over an altitude range 1,000' to 45,000' will be used as the main source of level flight drag information. Effect of air brakes will be assessed from one decelerated level at 40,000' with air brakes open.

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5.4.7 Manoeuvring Performance

The thrust boundary at maximum power with A/B will be established at M = 1.5, 45,000' and 40,000' using a stabilized level turn technique. Also, an attempt will be made to establish 'buffet' or 'control hinge moment' boundary in a decelerated level turn at 40,000'.

5.4.8 Climb Performance

Three or four demonstration climbs will be made to establish minimum time from brakes off to 45,000' with A/B using optimum procedure.

5.4.9 Descent Performance

Descent performance will be measured using various techniques and starting speeds at altitude.

NOTE For detailed list of parameters to be recorded and test conditions see R.F.T. 5059.

6. NOTES ON PROGRAM

6.1 Engine and Airframe Time

Estimates of engine and airframe time presented in the test schedule (compiled to determine occurrence of inspection grounding periods) are based on an assumed average chock to chock period of 1 $\frac{1}{4}$ hrs.

6.2 Flying Hours

6.2.1 Total Hours

The chart of Estimated Total Flying Hours vs Time in Section 7.1 of the report is based on an assumed average flight duration of 55 mins.

6.2.2 Useful Test Time

Of the 55 mins. assumed average flight duration, 45 mins. is considered to be useful test time. Tests/flight have been scheduled in accordance with this and the further considerations detailed in 6.3 below.

6.3 Flight Tests

6.3.1 System Tests

As the instrumentation loads on these flight is high, almost 100 parameters per flight, flight and time allocation is based on 66% data gathering efficiency and 2 flights per week.

6.3.2 Telecom and Navigation Aids Tests

As the instrumentation pack is not required for these tests, flight and time allocation is based on 75% data gathering efficiency and 3 flights per week.

6.3.3 Handling Tests

Flight and time allocation is based on 66% data gathering efficiency and 2 flights per week in view of high instrumentation load.

6.3.4 Performance

Flight and time allocation is based on 66% data gathering efficiency and 10 flights per four weeks. Instrumentation is relatively uncomplicated and of low content.

6.4 Aircraft Groundings

It will be noted from the bar charts that major groundings have been scheduled to coincide with the periodic engine and airframe inspections. Existing L.F.A. requirements against miscellaneous aircraft equipment would necessitate frequent short grounding periods, however, an investigation is currently underway with a view to incorporation of the majority of these requirements with the periodic engine and airframe inspections. L.F.A. requirements which cannot be incorporated will be carried out during the flying program.

The duration of the grounding periods for each aircraft is based upon the presently known work content.

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TABLES & CHARTS OF PROGRAM

7.1 Summary Charts

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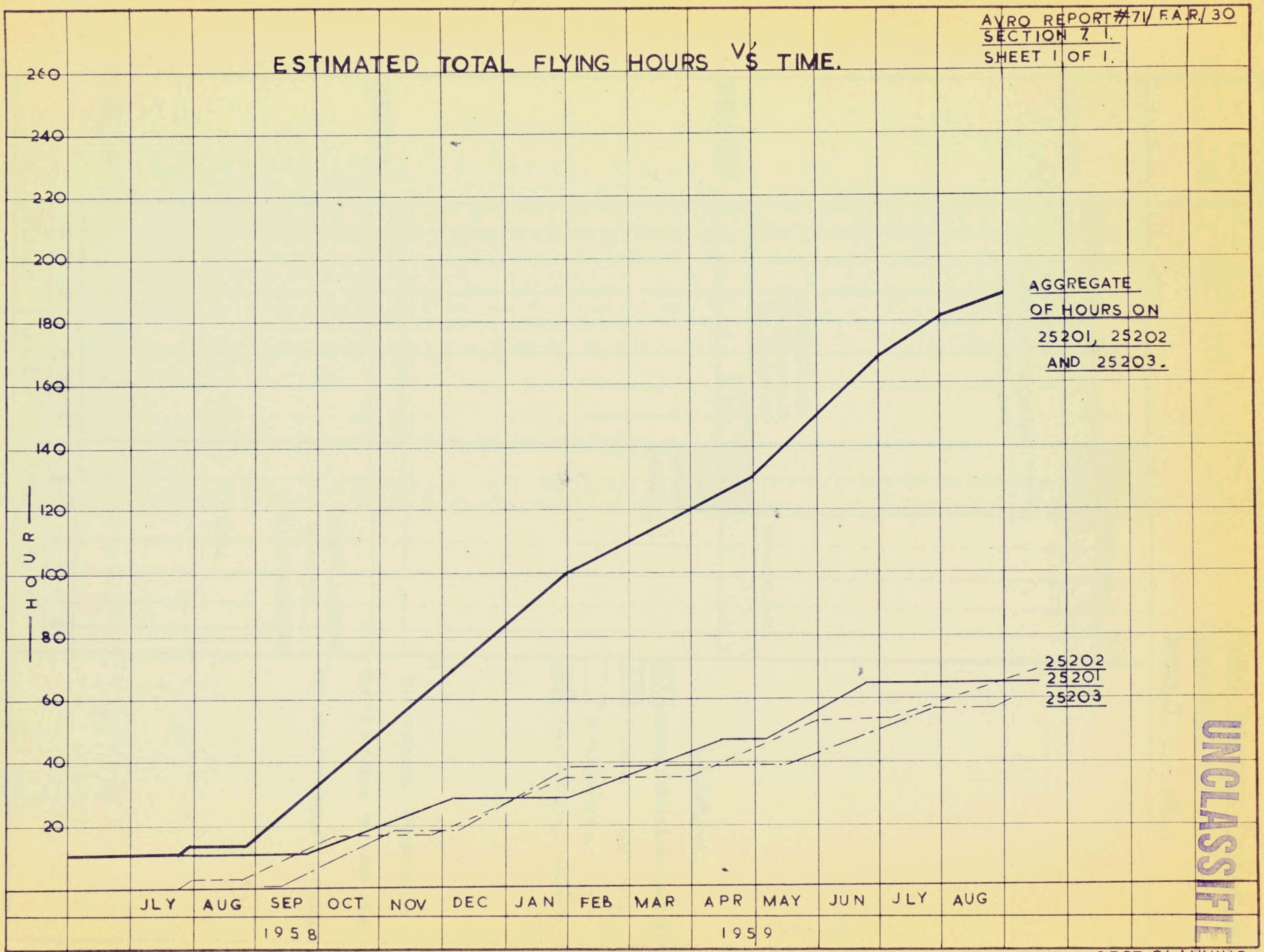
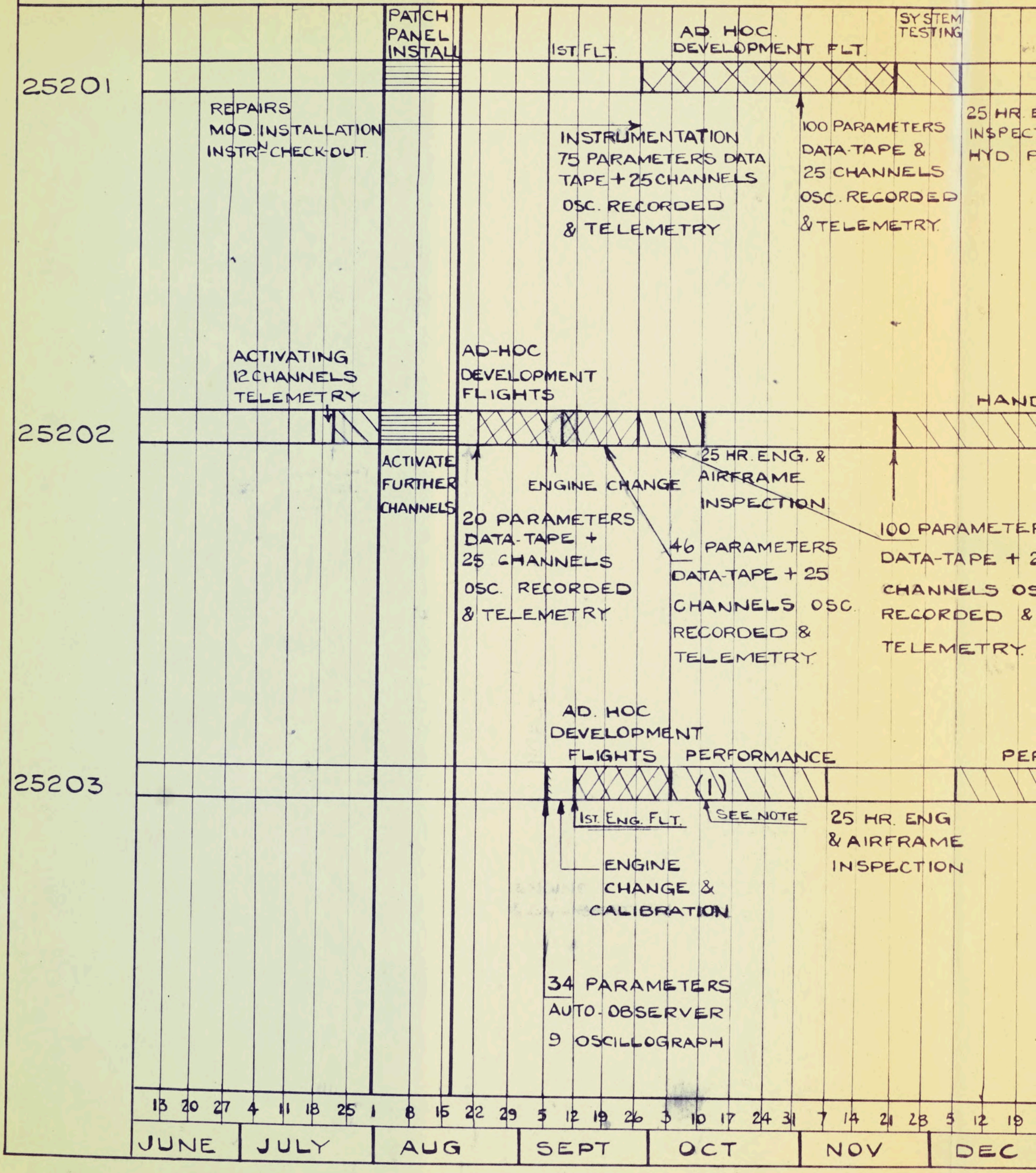
ESTIMATED TOTAL FLYING HOURS V'S TIME.



TEST DEPT PLANNING

FLIGHT & GROUND SCHEDULE



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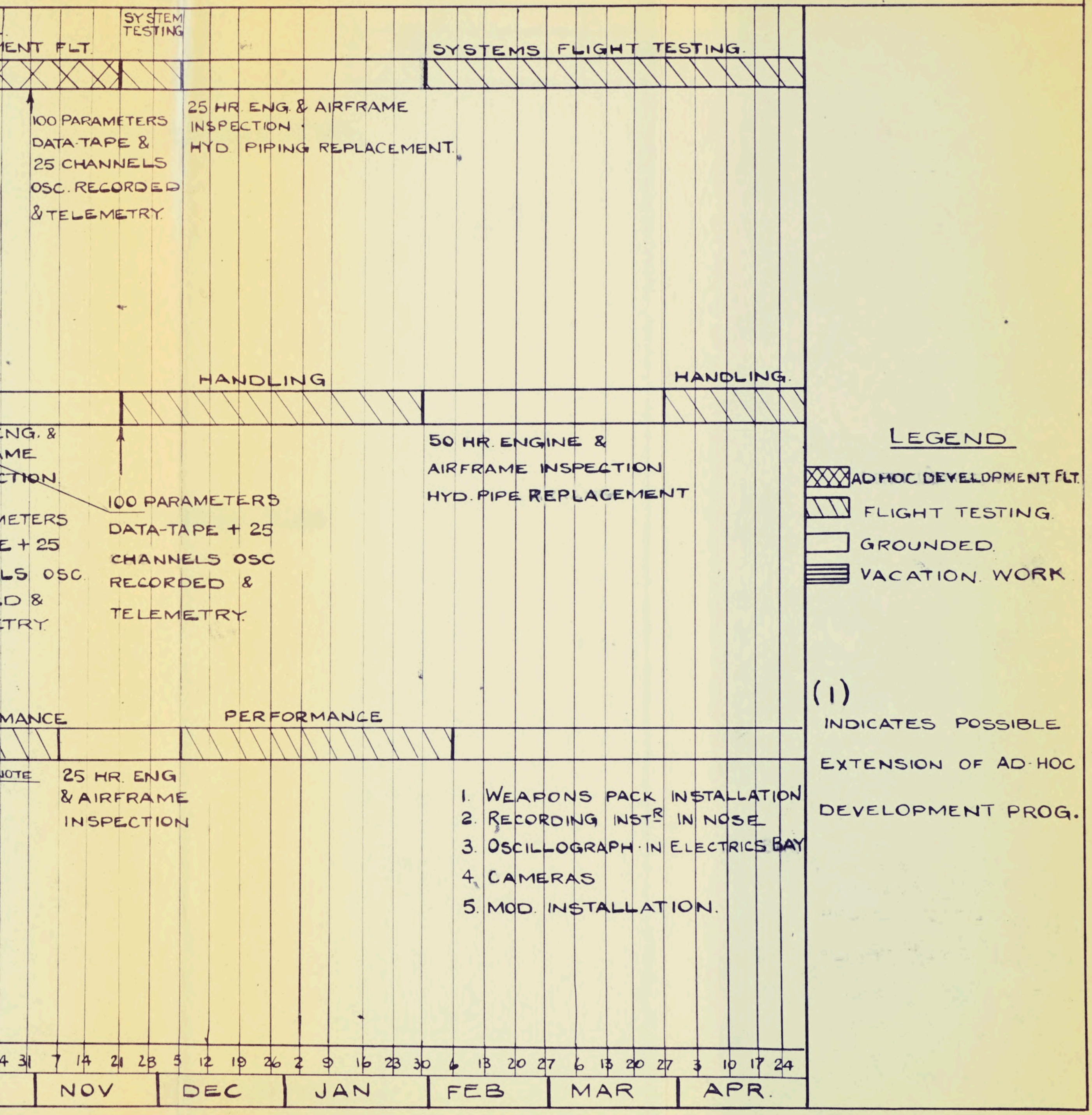
SHEET 1 OF 1.

...GROUND SCHEDULE A/C 25201-2 & 3.



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TABLES & CHARTS OF PROGRAM

7.2 Systems Testing

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A/C GROUNDING.

REPAIR & INSTALLATION OF MODS.

PREPARATION FOR SYSTEM TESTG

FLIGHT PREPARATIONS

AD HOC DEVELOPMT FLYING.

TEST CONTENT AS FOUND NECESSARY (PLUS NOSE WHEEL STEERING.)

C_L VS α INVESTIGATION

A/C GROUNDING

50 HR. ENG. & 25 HR. AIRFRAME INSP.

HYD. PIPE REPLACEMENT

FLIGHT PREPARATIONS.

FLIGHT TESTING.

SYSTEMS CHECKING.

A/C GROUNDING.

75 HR. ENG. & 50 HR. AIRFRAME INSPECTN

FLIGHT PREPARATIONS.

FLIGHT TESTING

SYSTEMS CHECKING (CONT.)

ANTENNA EVALUATION

A/C GROUNDING.

ENG. MAJOR OVERHAUL & AIRFRAME INSPN

FLIGHT PREPARATIONS

FLIGHT TESTING.

NAV AIR AIDS CALIBRATION.

TEL-COM FLT. RANGE CHECKS.

PROPOSED FURTHER TESTS & DEVT

1. ANTI-SKID SYSTEM.
2. AIR DATA COMPUTOR.
3. AUTOMATIC FLYING CONTROL.
4. FINAL SYSTEM ASSESSMENT.

LAB WORK

VACATION

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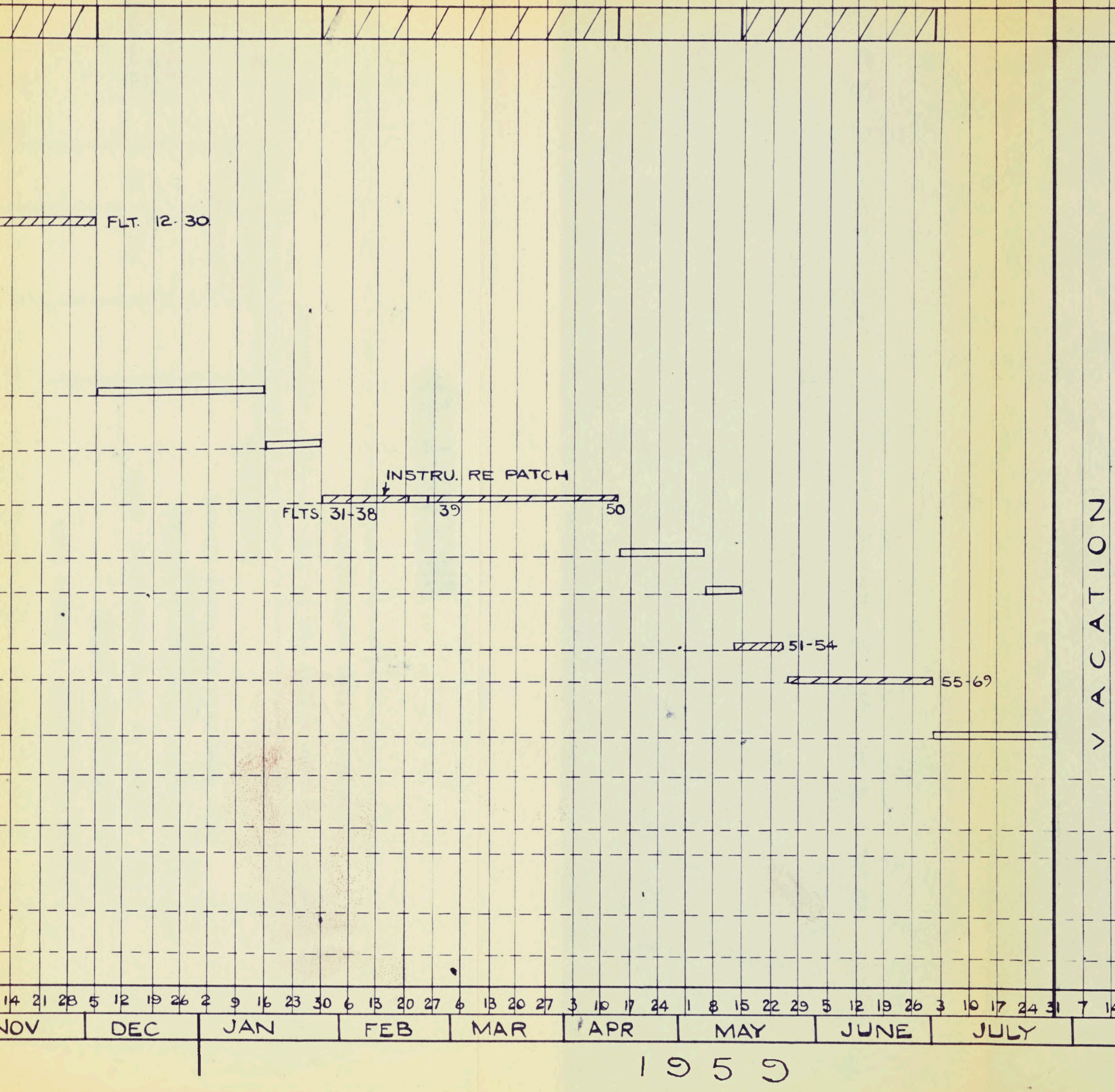
FLIGHT & GROUND PROGRAMME A/C 25201



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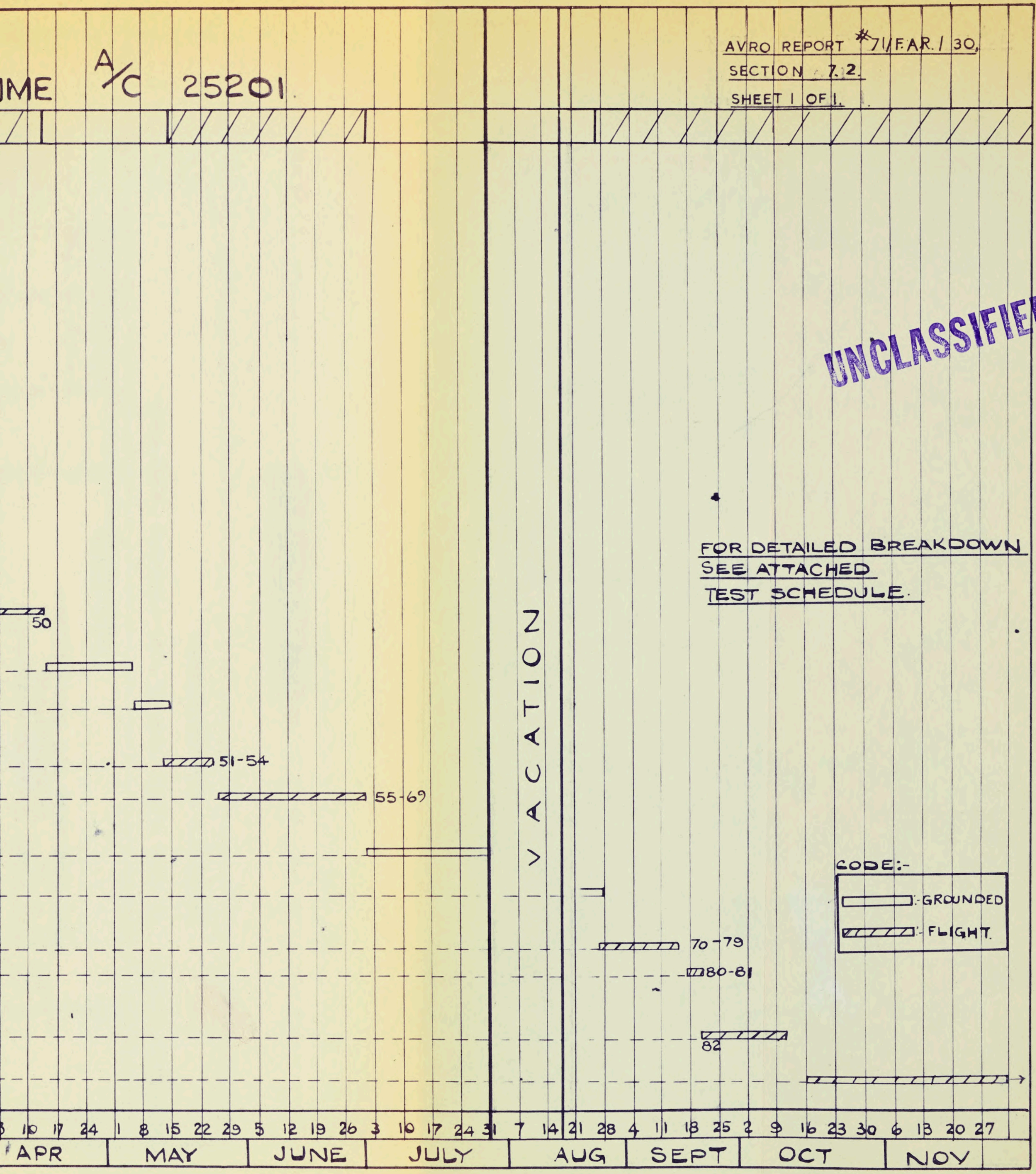

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TEST DEPT. PLANNING.

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ARROW 1
A/C 25201

TEST SCHEDULE

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SECTION 7.2
SHEET 1

FLIGHT NO.	DESCRIPTION OF TEST	R.F.T.	EST. ENG. HRS.	EST. A/C HRS.	REMARKS
-	Engine & Aircraft Hours from previous flight and Ground Tests.		24/17	$11\frac{1}{2}$	
GROUNDING PERIOD - Repair, Installation of Mods. and Preparation for Systems Tests					
PRIOR 12	FLIGHT PREPARATIONS - Engine Runs		3	-	
12 – 30	AD HOC DEVELOPMENT FLYING Test content as found necessary, plus (1) Nose Wheel Steering assessment (2) C_L v α investigation. Gear down main U/C doors closed		24	24	Instrument-ation as required.
	Total Hours		51/44	$35\frac{1}{2}$	
GROUNDING PERIOD - 50 hour engine and 25 hour airframe inspection Hydraulic Pipe replacement.					

SECRET

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FLIGHT NO.	DESCRIPTION OF TEST	R.F.T.	EST. ENG. HRS.	EST. A/C HRS.	REMARKS.
PRIOR 31	SYSTEMS FLIGHT TESTING				
	FLIGHT PREPARATIONS - Engine Runs		2	-	
31	(1) Landing Gear accelerations - Record during take-offs and landings. No Specific Test Maneouvres	5039 para. 3.5			
	(2) Engine installation temperatures Straight and level stabilized conditions and transient cases as detailed in R.F.T. para.4.	5031 para. 3.2			45" Ejectors are essential for these tests.
	(3) Utility Hydraulics System temperatures Record during the straight and level & transient flight cases of (2) above.	5039 para. 3.3.2			Instrumentat-ion require-ments are defined in the relevant RFTs. For the tests of flts 31-38, approx 89 parameters will be re-corded on data tape, 10 of which will be telemetered.
	(4) Flying Control Hydraulics (i) Record pressures detailed in the R.F.T. throughout flights. No Specific Test Maneouvres (ii) Record temperatures detailed in R.F.T. during maneouvres of (2) above.	5039 para. 3.4.1 5039 para. 3.4.2	10	10	
	(5) Air-Conditioning System. Record para-meters detailed in R.F.T. throughout flights. No Specific Test Maneouvres.	5045 para. 3.1			
38	(6) Wheel Brakes-Record fluid and pad temps. throughout landings. No Specific Test Maneouvres.	5039 para. 3.3.1			

TEST SCHEDULE

FLIGHT NO.	DESCRIPTION OF TEST	R.F.T.	EST ENG HRS.	EST A/C HRS	REMARKS
GROUND PERIOD - Instrumentation Re-Patch, Check-Out and Calibration					
39	SYSTEMS FLIGHT TESTING				
	(1) Landing Gear accelerations-Record during at least first four take-offs and landings. No Specific Test Maneouvres	5039 para. 3.5			
	(2) Engine Handling and Installation Tests	5037			
	(3) Landing Gear Tests - Record parameters specified in para. 3.1 of RFT during extension and retraction of landing gear. To be programmed with tests of (2) above.	5039 para. 3.1			
	(4) Speed Brake Tests-Record parameters specified in para. 3.2 of RFT during extension and retraction of speed brakes. To be programmed with tests of (2).	5039 para. 3.2			Instrumentation requirements are defined in the relevant RFT. For the tests of flights 39-54, approx 83 parameters will be recorded on datatape, 7 of which will be telemetered.
	(5) Electrics System Tests. To be programmed with tests of (2).	5041			
	(6) Flying Control Hydraulics-Record pressures detailed in para. 3.4.1 of RFT throughout flights. No Specific Test Maneouvres.	5039	15	15	

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TEST SCHEDULE.

AVRO REPORT 71/FAR/30
SECTION 7.2
SHEET 4

FLIGHT NO.	DESCRIPTION OF TEST	R.F.T.	EST ENG HRS	EST A/C HRS	REMARKS
↓	(7) Air Conditioning System Tests. To be programmed with tests of (2)	5045			
	(8) Fuel System Tests To be programmed with tests of (2)	5040			
50	(9) Wheel Brakes-Record fluid and pad temps throughout at least the first four landings. No Specific Test Maneouvres.	5039 para. 3.3.1			
	Total Hours.		78/71	$60\frac{1}{2}$	
GROUNDING PERIOD - 75 hour Engine and 50 hour Airframe Inspection					
PRIOR 51	FLIGHT PREPARATIONS - Engine Runs		2	-	
	SYSTEMS FLIGHT TESTING				
51 - 54	As for flights 39-50 less items 1 and 9.		5	5	

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S E C R E T

TEST SCHEDULE

FLIGHT NO.	DESCRIPTION OF TEST	R.F.T.	EST ENG. HRS	EST A/C HRS	REMARKS
55 - 69	Antenna Evaluation Tests.	5044	18.3/4	18.3/4	Pack Instrumentation is not required for any of the telecommunication or navigation aids flight tests, and in the event of a major instrumentation snag occurring during flts.31-54, these tests could be substituted at short notice. An observer will be required in the rear cockpit during all the telecommunication and navigation aids test flight.
	Total Hours		104/97	84	
GROUNDING PERIOD-Engine Major Overhaul and 75 hour Airframe Inspection.					
PRIOR 70	FLIGHT PREPARATIONS-Engine Runs		3	-	

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TEST SCHEDULE

FLIGHT NO.	DESCRIPTION OF TEST	R.F.T.	EST. ENG. HRS.	EST. A/C HRS.	REMARKS
	SYSTEMS FLIGHT TESTING.				
70 – 79	Navigation Aids Air Calibration	5028	12½	12½	
80 – 81	Telecommunication Flight Range Checks	5029	2½	2½	
	Total Hours.		122/115	99	
	PROPOSED FURTHER TESTS AND DEVELOPMENT				
82 →	(1) Anti Skid System				
	(2) Air Data Computer.				
	(3) Automatic Flying Control System.				
	(4) Final Systems Assessment.				

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AIRCRAFT:

TABLES & CHARTS OF PROGRAM

7.3 Stability and Control

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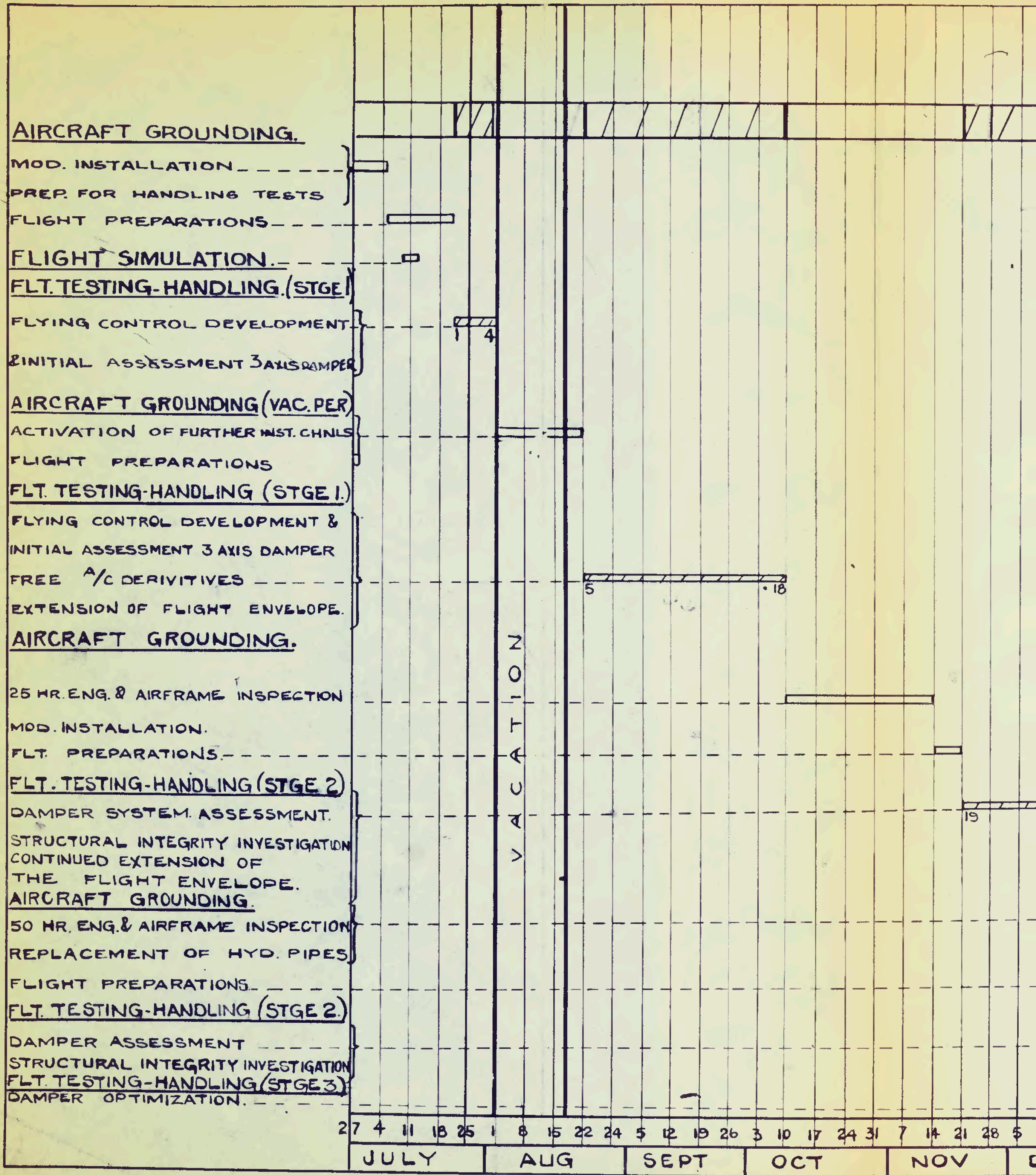

AIRCRAFT GROUNDING.
MOD. INSTALLATION
PREP. FOR HANDLING TESTS
FLIGHT PREPARATIONS
FLIGHT SIMULATION.
FLT. TESTING-HANDLING (STGE I)
FLYING CONTROL DEVELOPMENT
&INITIAL ASSESSMENT 3 AXIS DAMPER
1
4
AIRCRAFT GROUNDING (VAC. PER)
ACTIVATION OF FURTHER INST. CHNLS
FLIGHT PREPARATIONS
FLT. TESTING-HANDLING (STGE I.)
FLYING CONTROL DEVELOPMENT &
INITIAL ASSESSMENT 3 AXIS DAMPER
FREE A/C DERIVITIVES
EXTENSION OF FLIGHT ENVELOPE.
5
18
AIRCRAFT GROUNDING.
25 HR. ENG. & AIRFRAME INSPECTION
MOD. INSTALLATION.
FLT. PREPARATIONS.
FLT. TESTING-HANDLING (STGE 2)
DAMPER SYSTEM ASSESSMENT.
STRUCTURAL INTEGRITY INVESTIGATION
CONTINUED EXTENSION OF
THE FLIGHT ENVELOPE.
19
AIRCRAFT GROUNDING.
50 HR. ENG. & AIRFRAME INSPECTION
REPLACEMENT OF HYD. PIPES
FLIGHT PREPARATIONS
FLT. TESTING-HANDLING (STGE 2)
DAMPER ASSESSMENT
STRUCTURAL INTEGRITY INVESTIGATION
FLT. TESTING-HANDLING (STGE 3)
DAMPER OPTIMIZATION.
VACATION
27 4 11 18 25 1 8 15 22 24 5 12 19 26 3 10 17 24 31 7 14 21 28 5
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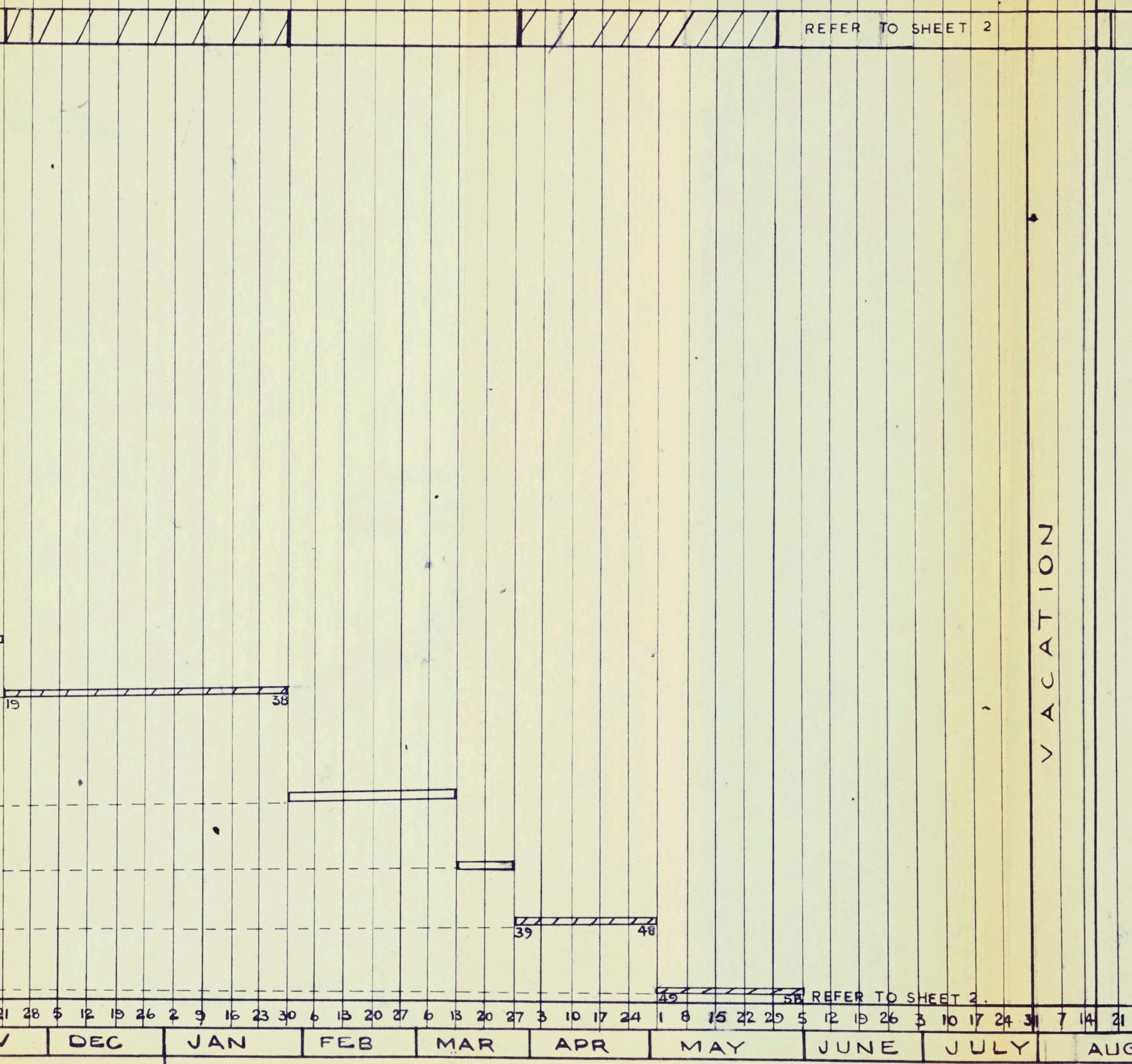
FLIGHT & GROUND PROGRAMME A/C 25202.



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SECTION 7.3.
SHEET 1 OF 2.

REFER TO SHEET 2

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45 58 REFER TO SHEET 2.

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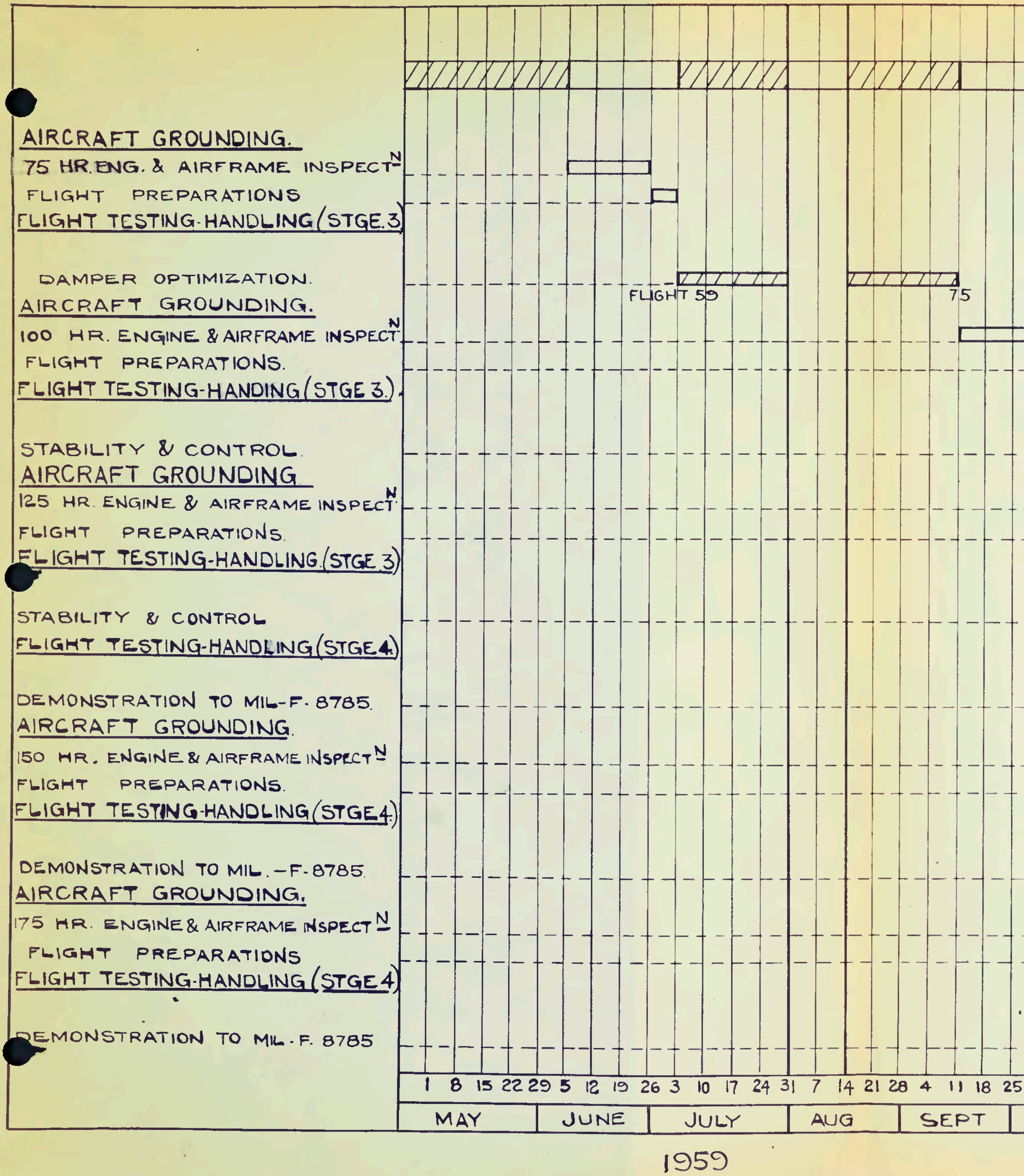
TEST DEPT. PLANNING


AIRCRAFT GROUNDING.
75 HR. ENG. & AIRFRAME INSPECTN
FLIGHT PREPARATIONS
FLIGHT TESTING-HANDLING (STGE.3)
DAMPER OPTIMIZATION.
AIRCRAFT GROUNDING.
100 HR. ENGINE & AIRFRAME INSPECTN
FLIGHT PREPARATIONS.
FLIGHT TESTING-HANDING (STGE 3).
STABILITY & CONTROL.
AIRCRAFT GROUNDING
125 HR. ENGINE & AIRFRAME INSPECTN
FLIGHT PREPARATIONS.
FLIGHT TESTING-HANDLING (STGE 3)
STABILITY & CONTROL
FLIGHT TESTING-HANDLING (STGE 4)
DEMONSTRATION TO MIL-F-8785.
AIRCRAFT GROUNDING.
150 HR. ENGINE & AIRFRAME INSPECTN
FLIGHT PREPARATIONS.
FLIGHT TESTING-HANDLING (STGE 4)
DEMONSTRATION TO MIL.-F-8785.
AIRCRAFT GROUNDING.
175 HR. ENGINE & AIRFRAME INSPECTN
FLIGHT PREPARATIONS
FLIGHT TESTING-HANDLING (STGE 4)
DEMONSTRATION TO MIL-F. 8785
FLIGHT 59
75
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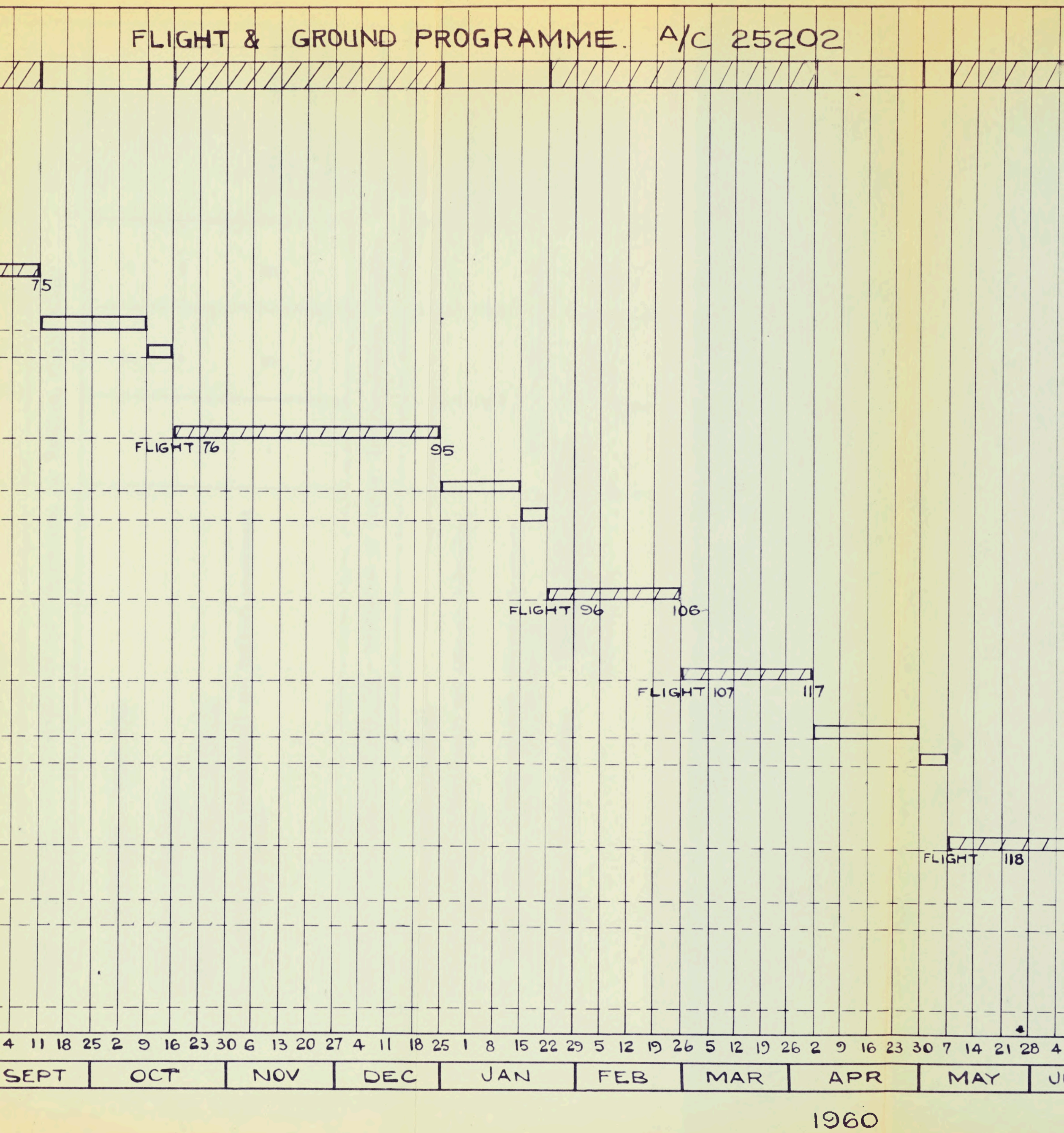
FLIGHT & GROUND PROGRAMME. A/C 25202
75
FLIGHT 76
95
FLIGHT 96
106
FLIGHT 107
117
FLIGHT 118
4 11 18 25 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 5 12 19 26 5 12 19 26 2 9 16 23 30 7 14 21 28 4
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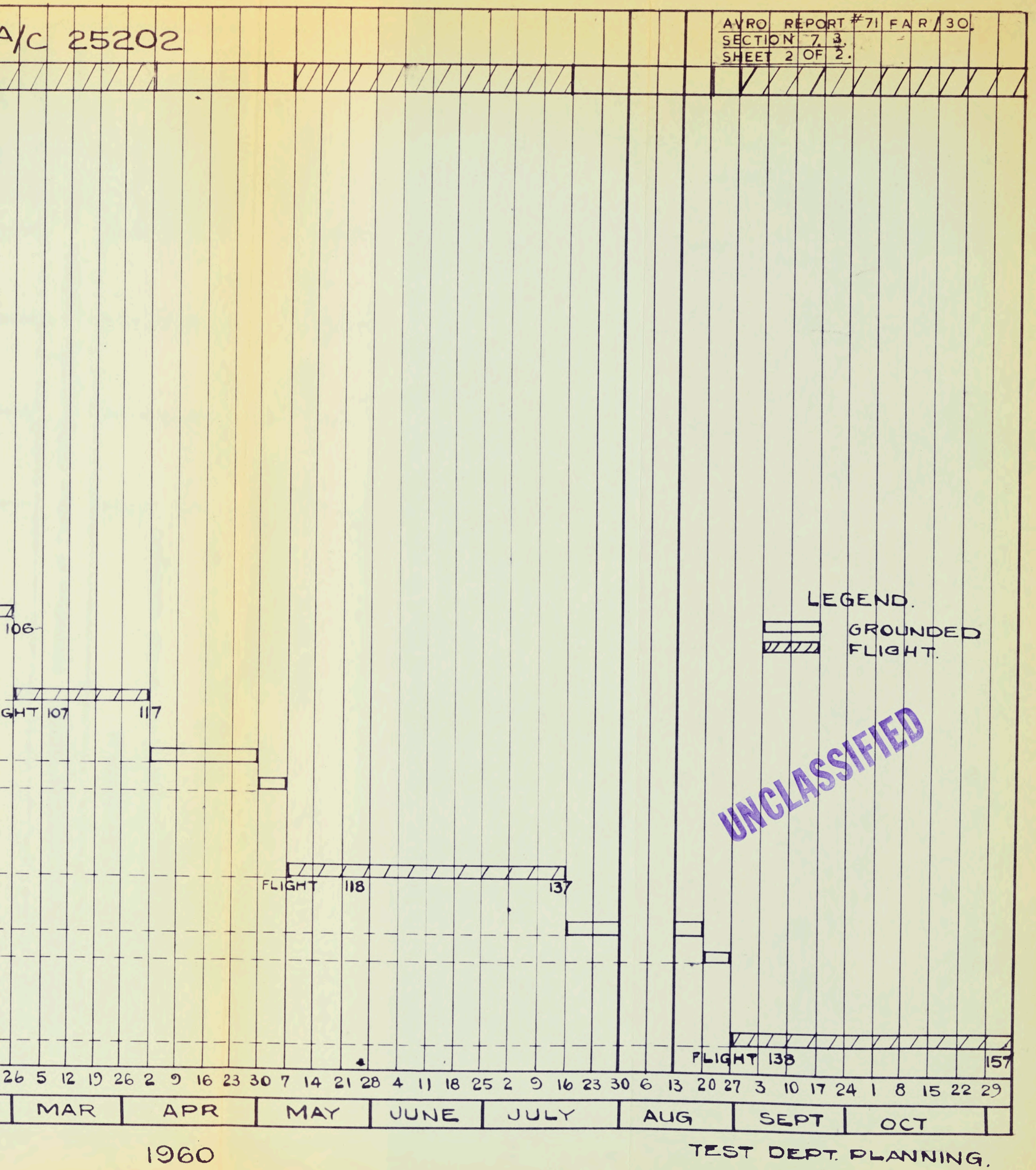

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TEST DEPT. PLANNING.

ARROW 1
A/C 25202

TEST SCHEDULE

AVRO REPORT #71/FAR/30
Section 7.3
Sheet 1

FLIGHT	DESCRIPTION OF TEST	R.F.T.	EST. ENG. HRS.	EST. A/C HRS.	REMARKS
	ENGINE HOURS FROM PREVIOUS GROUND TESTS		3		
	AIRCRAFT GROUNDING - Mod. Installation and Preparations for Handling Flight Tests				
PRIOR 1	FLIGHT PREPARATIONS - Engine runs		2	-	
PRIOR 1	FLIGHT SIMULATION TESTS		-	-	
	HANDLING FLIGHT TESTING (STAGE 1)				
1 – 4	(1) Flying Controls development and initial assessment of 3 axis damper.	-	5	5	Choice of test parameters as required for development. 12 telemetry channels will be available.
	AIRCRAFT GROUNDING (VACATION PERIOD) - Activation of further instrumentation channels. Flight preparations				
5 –	HANDLING FLIGHT TESTING (STAGE 1)				
	(1) Flying controls development and initial assessment of 3 axis damper.				Instrumentation requirements are defined in Memo No. 1354/02A/J. However, it should be noted that final choice of parameters will be dependant on
	(2) Determination of free aircraft derivatives within Flight limits: M=1.75, EAS 500 kts, 3g.	5051	17½	17½	
	(3) Extension of flight envelope				
	TOTAL HOURS		27½	22½	

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FLIGHT NO	DESCRIPTION OF TEST	R.F.T.	EST. ENG. HRS.	EST. A/C HRS.	REMARKS
18					development requirements. Instrumentation will be activated progressively as permitted by development flying, towards the ultimate target of 100 channels.
	AIRCRAFT GROUNDING - 25 Hour engine and airframe inspection. Mod. installation.				
PRIOR 19	FLIGHT PREPARATIONS - Engine Runs	-	3	-	
19	HANDLING FLIGHT TESTING (STAGE 2)				
	(1) Damper system assessment.	71/FAR/23			Instrumentation requirements are defined in the relevant R.F.T.'s and in Avro report 71/FAR/1 Issue 7. It is expected that approx. 100 channels will be available on data tape and oscillograph with provision for telemetry.
	(2) Structural Integrity Investigation. Step 1. Subsonic and transonic manoeuvres at 40% limit load	5034	5	5	
22	(3) Extension of flight envelope				
23	(1) Damper system assessment.	71/FAR/23			
	(2) Structural Integrity Investigation. Step 2 (a) Subsonic and transonic manoeuvres at 60% limit load (b) Supersonic at 40% limit load	5034	7 ½	7 ½	
28	(3) Extension of flight envelope.				

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FLIGHT NO	DESCRIPTION OF TEST	R.F.T.	EST. ENG. HRS.	EST. A/C HRS.	REMARKS
29 – 36	(1) Damper System Assessment (2) Structural Integrity Investigation. Step 3. (a) Subsonic and transonic at 80% limit load. (b) Transonic and supersonic at 60% limit load (c) Supersonic at 40% limit load. (3) Extensions of flight envelope.	71/FAR/23 5034	10	10	
37 – 38	(1) Damper system Assessment (2) Structural Integrity Investigation. Step 4 Transonic and Supersonic at 80% limit load (3) Extension of flight envelope	71/FAR/23 5034	2 ½	2 ½	
	TOTAL HOURS		55 ½	47½	
	AIRCRAFT GROUNDING - 50 Hour Engine and Airframe Grounding. Replacement of hydraulic pipes.				
PRIOR 39	FLIGHT PREPARATIONS - HANDLING FLIGHT TESTING (STAGE 2) CONT'D		2	-	
39 – 41	(1) Damper system assessment (2) Structural Integrity Investigation. Step 4 cont'd Supersonic at 60% limit load	71/FAR/23 5034	3 3/4	3 3/4	

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TEST SCHEDULE

FLIGHT NO	DESCRIPTION OF TEST	R.F.T.	EST. ENG. HRS.	EST. A/C HRS.	REMARKS
42 – 45	(1) Damper System Assessment	71/FAR/23			
	(2) Structural Integrity Investigation. Step 5 Supersonic at 80% limit load.	5034	5	5	
46 – 48	(1) Stability and Control - Extension of Flight envelope to maximum EAS in stages	71/FAR/23			
	(2) Flutter checks.		3 3/4	3 3/4	
	HANDLING FLIGHT TESTING (STAGE 3)				
49 – 58	Damper system optimization and final assessment of limit devices. Checks at following test points with normal gain ± 50% :- 10,070 (i.e. 10,000' M=0.70) 10,115, 20,040, 20,070, 40,140, 30,095, 30,160, 40,180, 50,115, and 50,160.	71/FAR/23	12 ½	12 ½	An observer will be required in the rear cockpit for the tests of flts. 49-75.
	TOTAL HOURS		82½	72½	

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TEST SCHEDULE

FLIGHT NO	DESCRIPTION OF TEST	R.F.T.	EST. ENG. HRS.	EST. A/C HRS.	REMARKS
	AIRCRAFT GROUNDING - 75 Hour Engine and airframe inspection				
PRIOR 59	FLIGHT PREPARATIONS		2	-	
	HANDLING FLIGHT TESTING (STAGE 3) CONT'D				
59 – 75	Damper optimization - Continuation of program of flights 49 -58	71/FAR/23	21¼	21¼	
	TOTAL HOURS		105 3/4	93 3/4	
	AIRCRAFT GROUNDING - 100 Hour Engine and Airframe Inspection.				
PRIOR 76	FLIGHT PREPARATIONS.		2	-	
	HANDLING FLIGHT TESTING (STAGE 3) CONT'D				
76 – 95	Stability & Control Tests (1) Free Aircraft Derivatives (2) Rolls (3) Cross wind landings (4) Free Stability, 2g flight (5) Low speed stability (6) Asymmetric power	71/FAR/23	25	25	
	TOTAL HOURS		132 3/4	118 3/4	

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FLIGHT NO	DESCRIPTION OF TEST	R.F.T.	EST. ENG. HRS.	EST. A/C HRS.	REMARKS
	AIRCRAFT GROUNDING - 125 Hour Engine and Airframe Inspection				
PRIOR 96	FLIGHT PREPARATIONS		2	-	
96 — 106	<u>HANDLING FLIGHT TESTING (STAGE 3) CONT'D</u> (7) Free stability power effect (8) Control system failure (9) Free stability, 3g flight (10) Free stability, 4g flight	71/FAR/23	13 3/4	13 3/4	
	<u>HANDLING FLIGHT TESTING (STAGE 4)</u> The following tests are to meet the requirement of MIL-F-8785 as qualified by Avro Report 71/FAR/23. The tests completely cover the requirements of Report 71/FAR/23, within the limitations of the Mk. 1 aircraft. It should be noted, however, that it is unlikely that all of the conditions listed will have to be checked as the tests of the earlier stages of the handling program should satisfy some of the requirements. To what extent the earlier tests might reduce the program is difficult to predict, consequently, the stage 4 section of the Handling Program has been scheduled in its entirety.				
107 — 117	Augmented Stability (1) Level flight.		13 3/4	13 3/4	
	TOTAL HOURS		$162\frac{1}{4}$	$146\frac{1}{4}$	

TEST SCHEDULE

FLIGHT NO	DESCRIPTION OF TEST	R.F.T.	EST. ENG. HRS.	EST. A/C HRS.	REMARKS
	AIRCRAFT GROUNDING - 150 Hour Engine and Airframe Inspection				
PRIOR 118	FLIGHT PREPARATIONS		2	-	
	HANDLING FLIGHT TESTING (STAGE 4) CONT'D				
118–137	Augmented Stability (Cont'd) (2) Level Flight (3) 2g Flight (4) Flight envelope demonstration	71/FAR/23	25	25	
	TOTAL HOURS		189 1/4	171 1/4	
	AIRCRAFT GROUNDING - 175 Hour Engine and Airframe Inspection				
PRIOR 138	FLIGHT PREPARATIONS		2	-	
	HANDLING FLIGHT TESTING (STAGE 4) CONT'D				
138–156	Augmented Stability Cont'd (5) Rolling pull-outs (6) Limiter checks (7) Climbs and dives (8) Damper switching (9) Cross-wing landings (10) Symmetric power (11) Asymmetric power (12) Low Speed (13) Phugoid investigation (14) Hingemoment investigation (15) Forward critical loading investigation c.g. = 28% MAC	71/FAR/23	23 3/4	23 3/4	
	TOTAL HOURS		215	195	

AVRO AIRCRAFT LIMITED
MALTON – ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT:		REPORT NO. 71/FAR/30
		SHEET NO.
PREPARED BY	DATE	
CHECKED BY	DATE	

TABLES & CHARTS OF PROGRAMME

7.4 Performance

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FLIGHT & GROUND TEST

PRE-FIRST FLIGHT

- INSTALLATIONS. } PRODUCTION
- SYSTEM FUNCTION TESTS }
- MOD. INSTALLATION }
- PREPARATION OF A/C FOR PERFORMANCE PROGRAM }
- FLIGHT PREPARATIONS.

FIRST FLIGHT

A/C GROUNDING.

- INSTALLATION OF CALIBRATED ENGINES FROM A/C 25202
- ENG. CALIBRATION RUNS.

AD. HOC. DEVELOPMENT FLYING

FLIGHT TESTING-PERFORMANCE

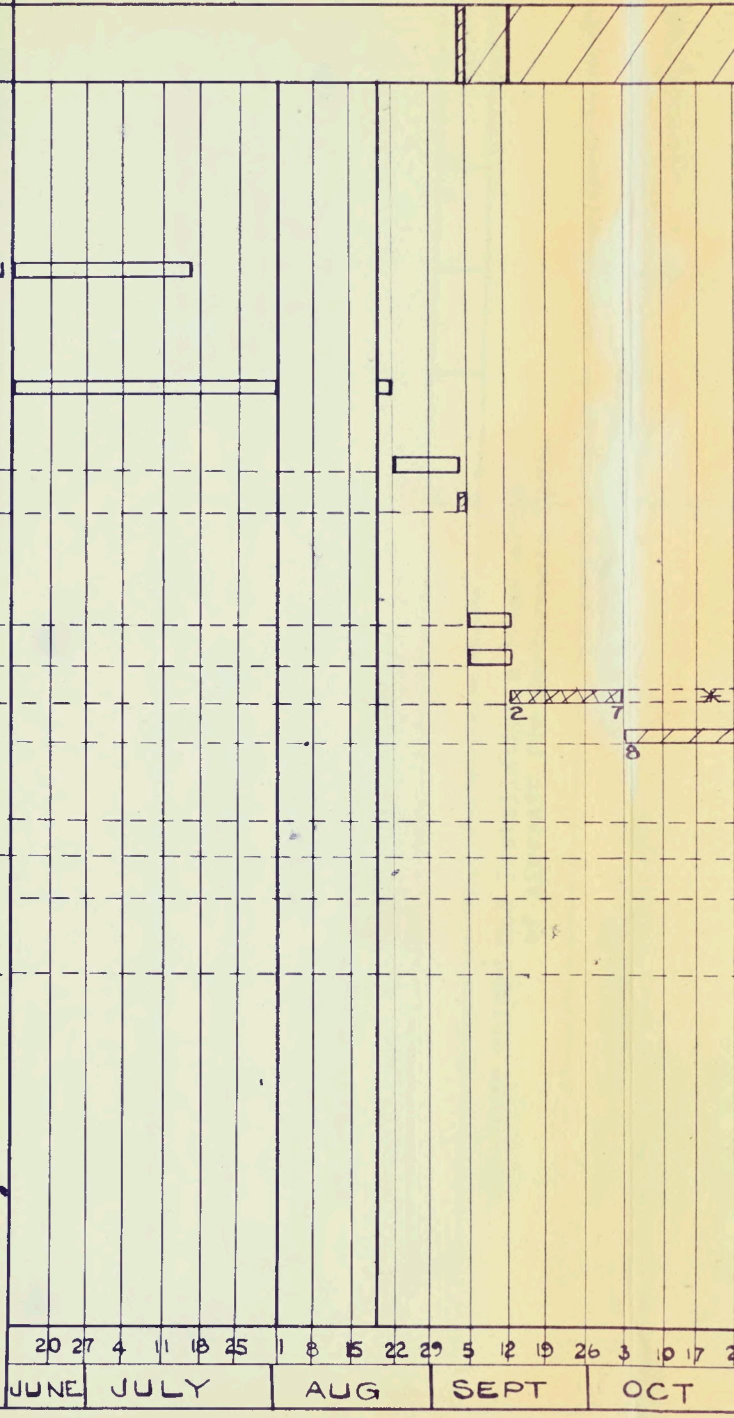
A/C GROUNDING.

- 25 HR. ENG. & AIRFRAME INSPECTION
- FLIGHT PREPARATIONS

FLIGHT TESTING-PERFORMANCE

AIRCRAFT GROUNDING.

- 50 HR. ENG. & AIRFRAME INSPECTION }
- PREPARATION FOR ARMAMENT PROGRAM. }



1958

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AVRO REPORT #71/FAR/30.

SECTION 7. 4.

SHEET 1 OF 1

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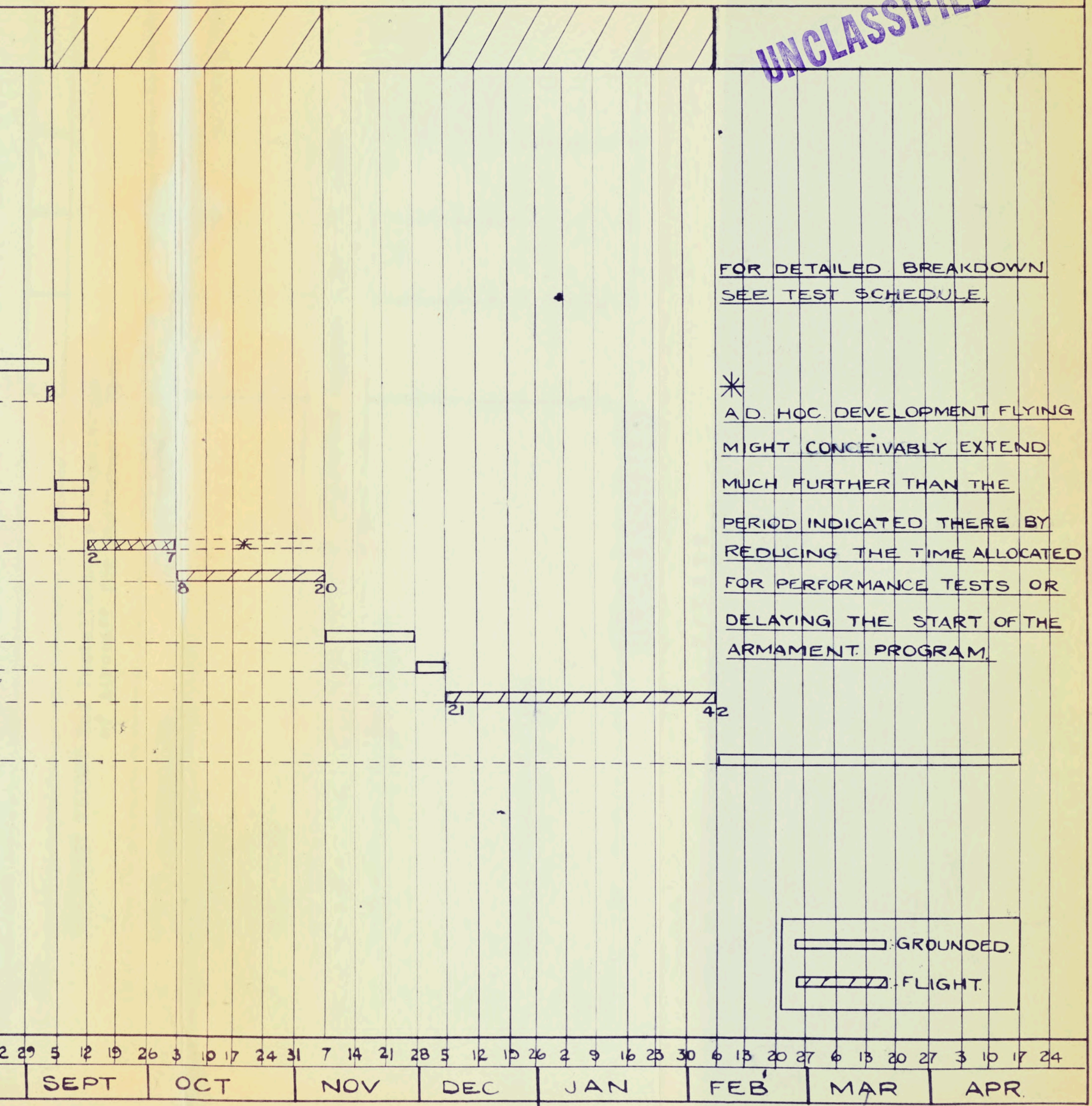
T & GROUND TEST PROGRAM – ARROW 1 25203.



1958 1959 TEST DEPT. PLANNING.

TEST SCHEDULE

FLIGHT NO.	DESCRIPTION OF TEST	R.F.T.	EST. ENG. HRS.	EST. A/C HRS.	REMARKS.
	PRE-FIRST FLIGHT-Installation & System Function Tests (Production).				
	PRE-FIRST FLIGHT-Mod Installation & Preparation of Aircraft for Performance Tests.				
PRIOR 1	FLIGHT PREPARATIONS				
	Engine Runs		2	-	
	Taxi Tests		$\frac{1}{2}$	-	
1	FIRST FLIGHT		1	1	
	AIRCRAFT GROUNDING-Installation of calibrated engines from A/C 25202				
	HOURS ON REPLACEMENT ENGINES		15		Engines to be inspected and cleared for further 25 hrs prior to installation
PRIOR 2	ENGINE CALIBRATION RUNS		2	-	

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SECRET

ARROW 1
A/C 25203.

AVRO REPORT 71/FAR/30
SECTION 7.4
SHEET 2

TEST SCHEDULE

FLIGHT NO.	DESCRIPTION OF TEST	R.F.T.	EST ENG. HRS	EST A/C HRS	REMARKS.
	AD HOC DEVELOPMENT FLYING				
2 → 7	Test content as found necessary		$7\frac{1}{2}$	$7\frac{1}{2}$	
	FLIGHT TESTING-PERFORMANCE	5059			See Note on Sheet 3
8 → 9	Take-off performance without afterburner and A.U.W. of 55,000 lb.		1	1	
10 → 12	Position error investigation-Aneroid P.E. plus pacing.		3.3/4	3.3/4	Pacing aircraft required.
13 → 20	Level Speed Performance:- 30,000' at M = .8, .85, .90, .92, .95 35,000' at M = .85, .90, .92, .95 40,000' at M = .85, .90, .92, .95		10	10	
	Total Hours		$39\frac{1}{4}$	$23\frac{1}{4}$	

AIRCRAFT GROUNDING - 25 hour Engine and Airframe Inspection.

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TEST SCHEDULE

FLIGHT NO.	DESCRIPTION OF TEST	R.F.T.	EST. ENG. HRS	EST A/C HRS	REMARKS.
PRIOR 21	FLIGHT PREPARATIONS - Engine Runs		2	-	
	FLIGHT TESTING - PERFORMANCE.	5059			
21 → 22	Level speed performance, 30,000' with one engine, at M= .80, .85, .90 and max.speed		$2\frac{1}{2}$	$2\frac{1}{2}$	
23	Level Speed performance at 45,000' M = 1.5		$1\frac{1}{4}$	$1\frac{1}{4}$	The instrumentation requirements are defined in the RFT. A total of 38 parameters will be recorded during the performance tests, 31 on an auto-observer and 7 on an oscillograph.
24 → 28	Level flight accelerations (with & without afterburners) and decelerations at 10,000', 20,000' and 30,000'		$6\frac{1}{4}$	$6\frac{1}{4}$	
29 → 31	Level flight accelerations (with afterburner) and decelerations at 35,000', 40,000' and 45,000'. Level flight decelerations at 40,000' with airbrakes out.		3.3/4	3.3/4	
32 → 34	Climbs from 45,000' to ceiling at M=1.3,1.5 and 1.7		3.3/4	3.3/4	
35 → 38	Demonstration Climbs. Minimum time to height.		5	5	

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TEST SCHEDULE

FLIGHT NO.	DESCRIPTION OF TEST	R.F.T	EST ENG. HRS.	EST A/C HRS.	REMARKS.
39 – 41	Maneouvres - Power Boundaries 45,000', M= 1.5 Three checks. 40,000', M= 1.5 One check		3.3/4	3.3/4	
42	Maneouvres - Decelerated turn to buffet boundary or limitation.		$1\frac{1}{4}$	$1\frac{1}{4}$	
	Total Hours.		68.3/4	50.3/4	
	The following additional tests are incidental to the tests detailed above and will be fitted in as convenient. 1. Take-off performance - normal take-off weight. 2. Descent 3. Landing. 4. Acceleration check, 180 kts. to limit speed at 1,000'.				

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