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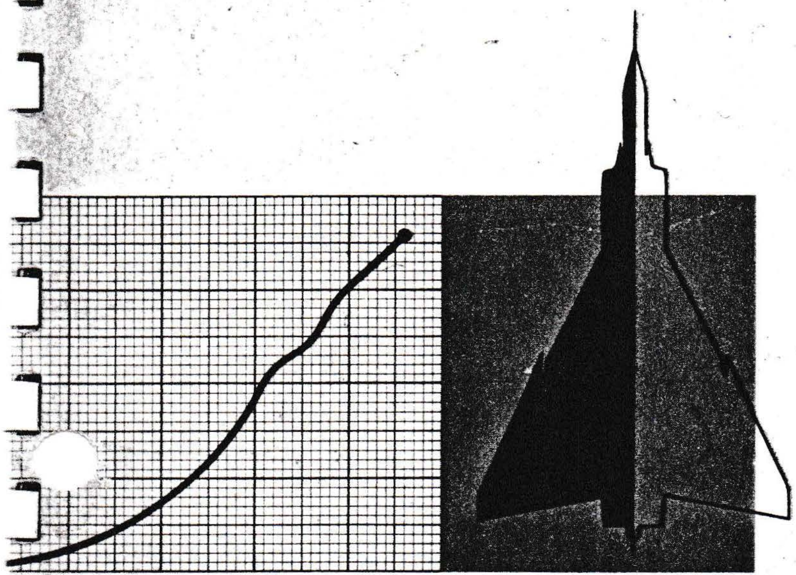

AVRO ARROW
quarterly technical report

FOR THE PERIOD ENDING

30 Sept. 1958

AVRO AIRCRAFT LIMITED

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ARROW

QUARTERLY TECHNICAL REPORT

70/ENG PUB/11

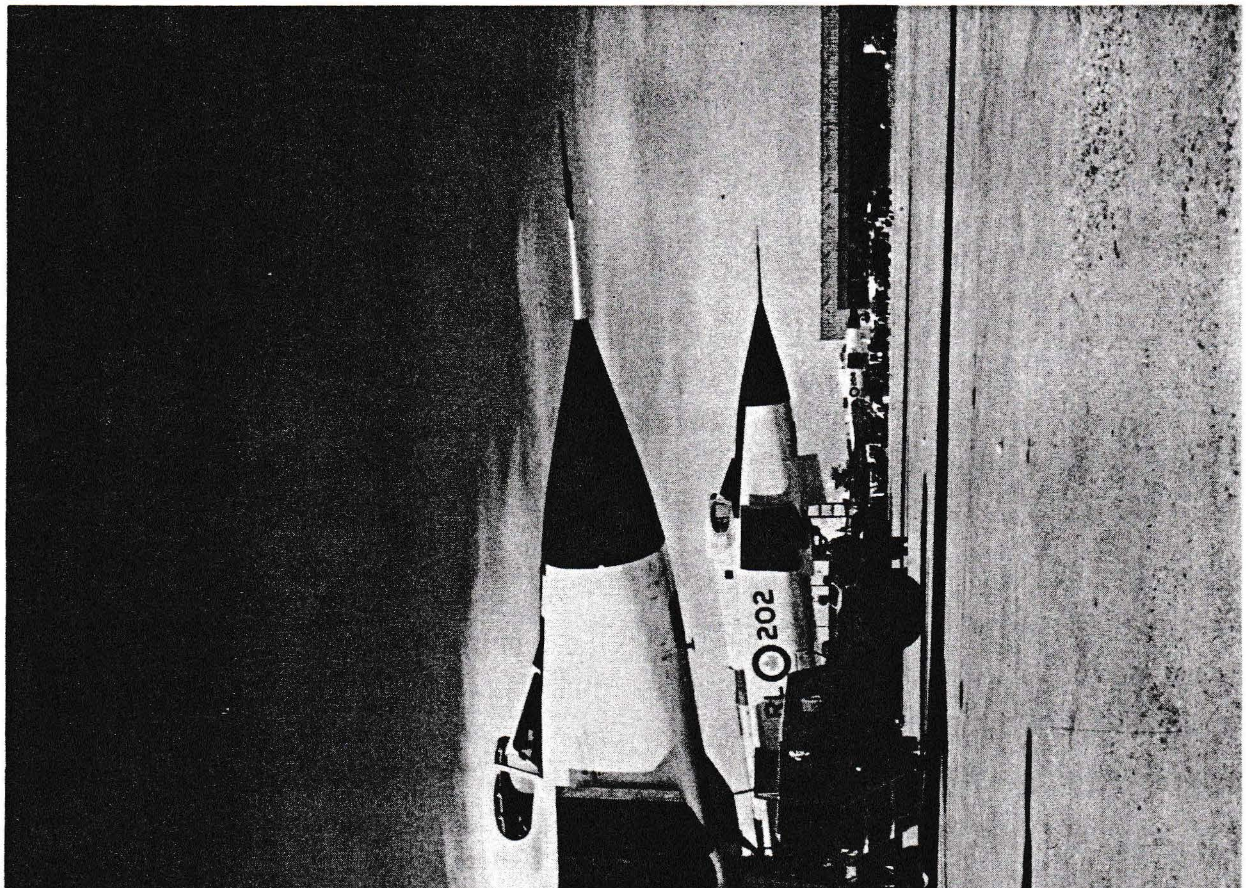
FOR PERIOD ENDING 30 SEPTEMBER 1958

Prepared by: **PROJECT MANAGEMENT SERVICES**

ENGINEERING DIVISION

AVRO AIRCRAFT LIMITED

MALTON - ONTARIO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PART 1

GENERAL INFORMATION

NOTE

On 23 September 1958, the Government cancelled the ASTRA I electronic system and the Sparrow 2D missile programs. The Company has therefore stopped work on any parts affected by this cancellation. The period covered by this report is from 1 July to 30 September, and as a great deal of the report was written prior to the cancellation date, it reflects the progress made on the ASTRA and Sparrow installations prior to their cancellation.

1.0 INTRODUCTION

1.1 SCOPE OF QUARTERLY TECHNICAL REPORT

This is the fifth Quarterly Technical Report on the AVRO ARROW aircraft project. The object of the report is to inform the Canadian Government of technical development of the project during the three month period ending 30 September 1958.

The report presents a description of work performed and the results obtained in the design and development activities of the project; it summarizes technical progress, changes and problems in all phases of the program during the report period. The text is divided into seven parts, and covers design, testing and development.

1.2 THE ARROW

The ARROW is a high altitude, supersonic interceptor of advanced design being developed by Avro Aircraft Limited at Malton, Ontario.

Two versions of the ARROW are being manufactured. The first five aircraft will be ARROW 1's and subsequent aircraft, ARROW 2's. The ARROW 1 has been designed to RCAF specification AIR 7-4 Issue 3, and is powered by two Pratt & Whitney J75 Turbojets. The ARROW 2 is being designed to RCAF specification WSC 1-2, and is powered by two Orenda Iroquois turbojets.

Both ARROW 1 and ARROW 2 have essentially the same basic configuration, but the more powerful engines of the ARROW 2 will give it superior performance over the ARROW 1. The ARROW 2 is designed to operate at altitudes up to 60,000 feet and speeds in excess of Mach 1.5.

1.3 BRIEF DESCRIPTION OF ARROW AIRCRAFT

1.3.1 ARROW 1

The ARROW 1 carries a two-man crew (pilot and flight observer) in a pressurized and air conditioned cockpit, which is equipped with two split clamshell type canopies and automatic upward ejection seats.

The airframe is an all-metal stressed skin structure and consists of the following major components: the radar nose, front, centre and rear fuselage, engine bay, duct bay, inner and outer wings, elevators, ailerons, fin, rudder and speed brakes. The elevators and ailerons are hinged to the wing trailing edge and form part of the wing area. The rudder, elevators and ailerons are split at approximately mid-span in order to alleviate control surface buckling when the surfaces are moved under deflected wing and fin conditions. An electrically-controlled, hydraulically-actuated tricycle type landing gear is installed; the main gear retracts inwards and forwards into the inner wing and the nose gear retracts forward into the front fuselage.

The landing gear, wheel brakes, nosewheel steering and speed brakes are actuated by a 4,000 psi utility hydraulic system. A compressed air system is available for emergency lowering of the landing gear. The fully powered and irreversible flying control surfaces are operated by a separate 4,000 psi hydraulic system which consists of two completely independent circuits.

Power for the electrical system is provided by two engine-driven alternators for alternating current, and two transformer-rectifiers for conversion to direct current.

Where necessary, space in the radar nose and weapon bay is utilized for test equipment and instrumentation to enable the development aircraft to carry out their designated role of flight test vehicles.

1.3.2 ARROW 2

The external configuration of the ARROW 2 is basically the same as that of the ARROW 1. However, there are major internal differences, namely; the weapon pack carrying air-to-air missiles, installation of a fully operational electronic system and the replacement of the J75 engines with Orenda Iroquois engines. The mechanical proportioner type fuel system used for centre of gravity control on the ARROW 1 is replaced by an electrically controlled sequencing system. Provisions are made for a jettisonable external fuel tank.

1.4 FIXED DIMENSIONS AND GENERAL DATA

CHARACTERISTICS:	ARROW 1 and ARROW 2
Length of aircraft (excluding probe)	(77 ft 9.65 in (See Note 1) (76 ft 9.65 in (See Note 2)
Height of aircraft over highest portion of fin	21 ft 3.0 in
Ground angle (Angle between aircraft reference line and ground static line)	4.55 degrees
Tread of main wheels	25 ft 5.6 in
Wheel base	30 ft 1.0 in
WINGS:	
Wing area (including ailerons, elevators and 390.5 sq ft of fuselage and not including 28.63 sq ft of extended leading edge)	1,225.0 sq ft

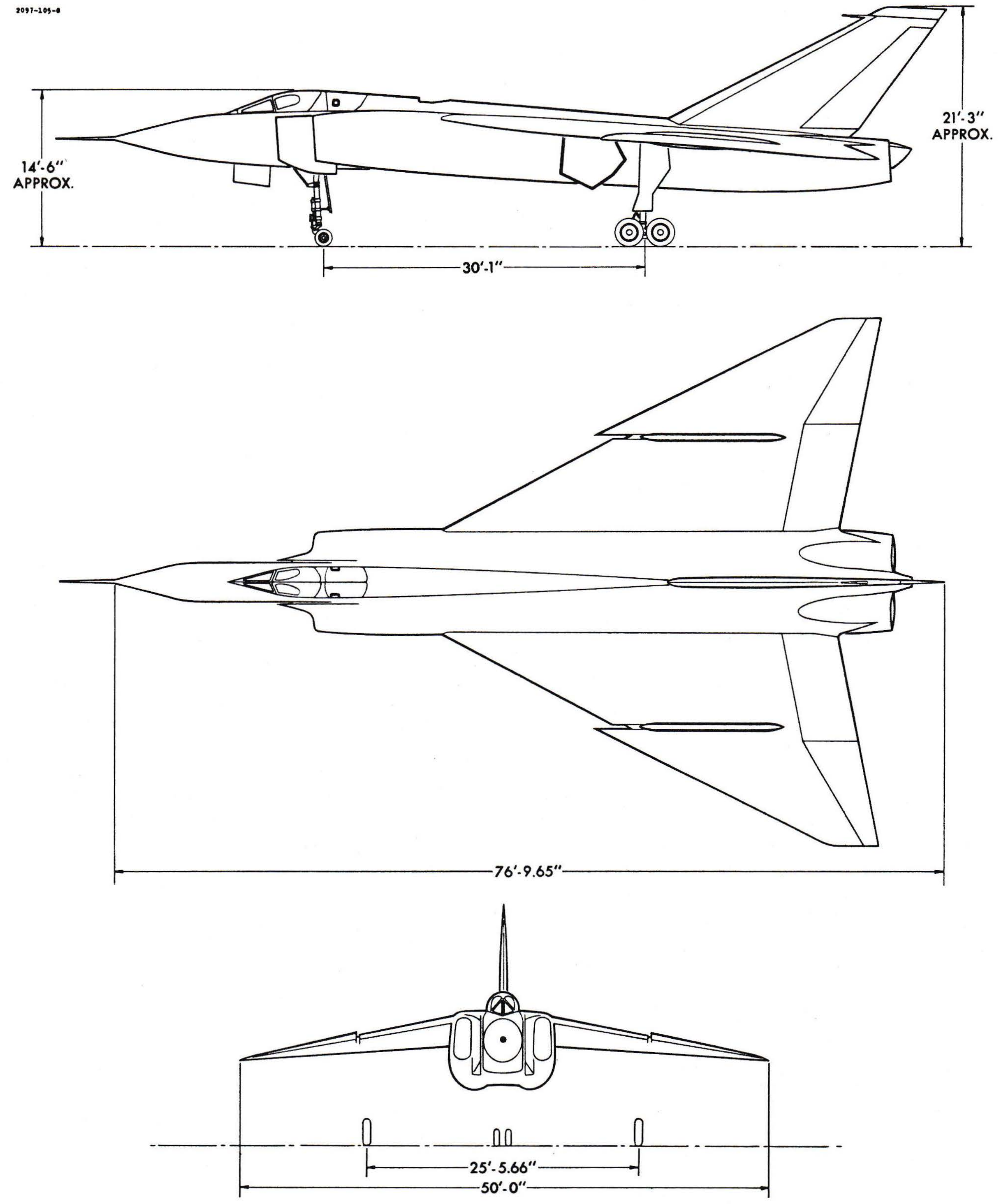

FIG. 1 THREE VIEW GENERAL ARRANGEMENT

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Tank	Location	Capacity Imp.Gal.	Litres
1	Fuselage	252	1145
2	Fuselage	254	1155
3	Wing	151 each	686
4	Wing	90 each	409
5	Wing (collector)	146 each	664
6	Wing	154 each	700
7	Wing	279 each	1268
8	Wing	173 each	787
9	External Tank (Long Range)	500	2273

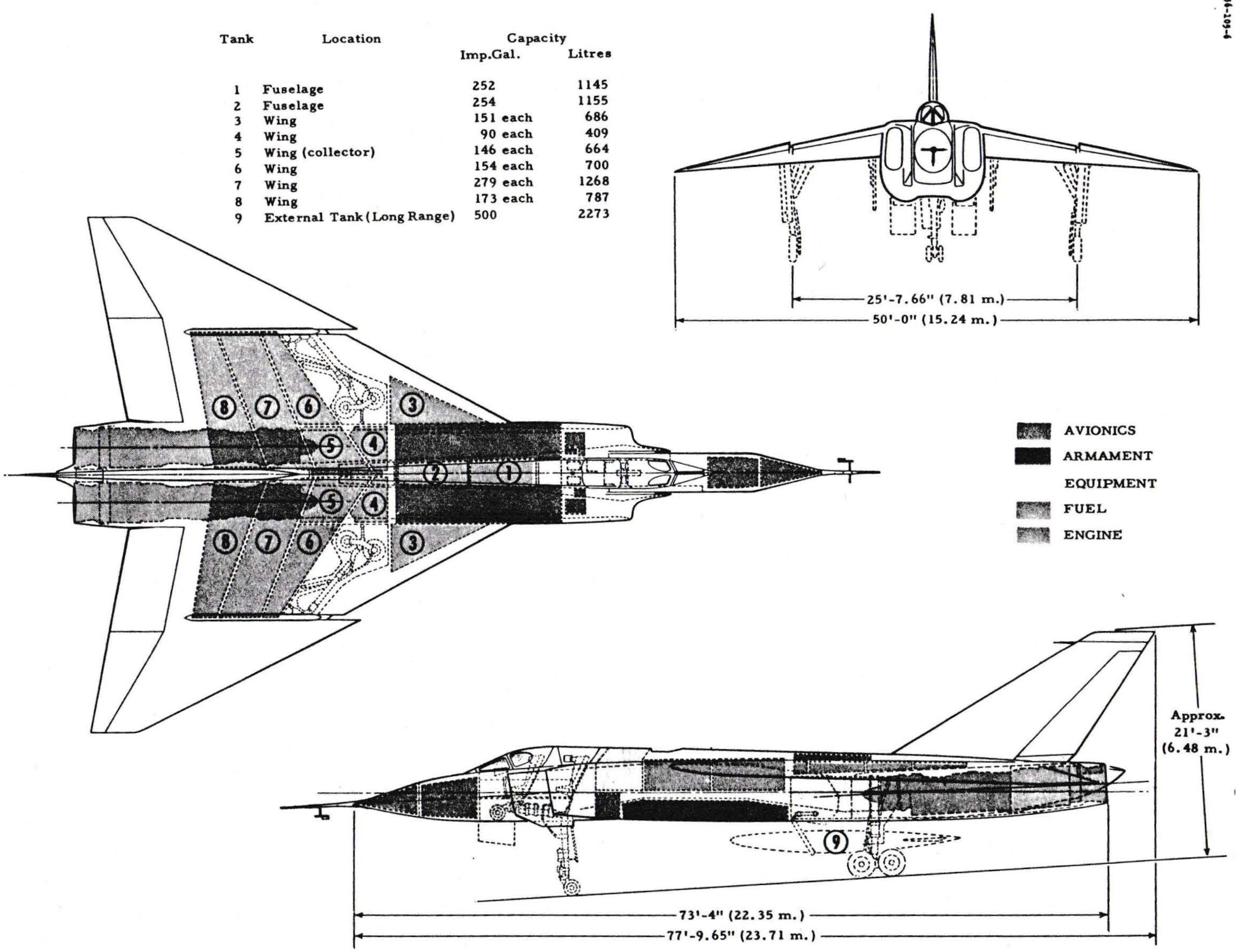

FIG. 2 EQUIPMENT ZONES

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CHARACTERISTICS:	ARROW 1 and ARROW 2
Span	50 ft 0.0 in
Chord - Root	45 ft 0.0 in
- Construction tip	4 ft 4.98 in
Mean Aerodynamic Chord	30 ft 2.61 in
Airfoil section - Inner wing profile	NACA - 0003.5-6-3.7 (Modified)
- Outer wing profile	NACA - 0003.5-6-3.7 (Modified) NACA - 0003.8-6-3.7 (Modified)
Camber	.0075 (Modified)
Incidence - At root	Zero degrees
- At construction tip	Zero degrees
Anhedral of chord plane	4.0 degrees
Aspect ratio	2.04
Taper ratio	0.0889
Thickness ratio - parallel to ℄ of aircraft	3.5 and 3.8%
Sweepback at 25% chord	55 degrees

AILERONS:

Aileron area (aft of hinge line) - Total	66.55 sq ft
Span	10 ft 0.0 in
Chord (average percent of wing chord) - Root	25.735
- Tip	35.0

ELEVATORS:

Elevator area (aft of hinge line) - Total	106.90 sq ft
Span	10 ft 2.0 in
Chord (average percent of wing chord) - Root	14.109
- Tip	25.735

VERTICAL TAIL:

Area (including rudder)	158.79 sq ft
Span	12 ft 10.5 in
Chord Root	19 ft 0.0 in
Construction tip	5 ft 8.0 in
Mean aerodynamic chord	13 ft 6.41 in
Airfoil section	NACA - 0004-6-3.7 (Modified)
Sweep Back - Leading edge	59.34 degrees
- Trailing edge	33.08 degrees
- 1/4 chord	55.0 degrees
Aspect ratio	1.04
Taper ratio	0.2982

CHARACTERISTICS:	ARROW 1 and ARROW 2
Thickness ratio (parallell to aircraft datum)	4.0%
Rudder area (aft of hinge line)	38.17 sq ft
Rudder - Span (average)	9 ft 11.0 in
- Chord (average percent vertical fin chord)	30.0

SPEED BRAKES:

Speed brake area (2) - Projected	14.37 sq ft
Span (each)	2 ft 1.08 in
Chord	4 ft 1.0 in

CONTROL SURFACES AND CORRESPONDING CONTROL MOVEMENTS

CHARACTERISTICS:		ARROW 1 and ARROW 2	
		Surface Movement	Control Movement
Ailerons:	Up and Down	19°	4.98 in
Elevators:	Up	30°	Aft. 6.63 in
	Down	20°	Fwd. 4.37 in
Rudder:	Left	30°	Fwd. 3.28 in
	Right	30°	Aft. 3.03 in
Speed Brakes		60°	-

Note 1. Aircraft 25201, 25202, 25203

Note 2. Aircraft 25204 and subsequent aircraft.

PART 2

TECHNICAL DESIGN

2.0 WEIGHT AND CENTRE OF GRAVITY

2.1 ARROW 2 WEIGHT

The ARROW 2 weight history is shown in Figure 3. A summary of current weights is given in Table 1, along with foot-notes to explain the weight changes which have occurred during this quarter. Weight accounting, as used in the foot-notes, refers to recorded weight changes arising from minor design changes, revised weights obtained from production drawings, and the incorporation of actual weights or vendor-quoted weights. Significant weight changes which have occurred for reasons other than normal weight accounting are explained by more detailed foot-notes.

2.2 ARROW 2 BALANCE

The extreme points of C.G. travel, corresponding to the weight summary in Table 1, are as follows:

Extreme forward C.G.	26.65% MAC
Extreme Aft C.B.	29.35% MAC

TABLE 1 - STATEMENT OF WEIGHT

ARROW 2 - OPERATIONAL AIRCRAFT

	Weight - Pounds			
	Present	Previous	Change	Notes
Structure	19228	19163	+65	(a) +65
Landing Gear	2698	2658	+40	(b) +40
Power plant and services	10771	10814	-43	(a) -69 (c) +26
Flying controls group	1966	1932	+34	(d) +34
Fixed and removable equipment	9082	9094	-12	(a) -12
Trapped fuel	214	-	+214	(e) +214
Basic Weight	43959	43661	+298	-
Useful load (less fuel)	2687	2799	-112	(a) -5 (e) -214 (f) +84 (g) +23
Operational weight empty	46646	46460	+186	-
Normal combat mission fuel	17684	17605	+79	(h) +79
Normal combat weight	64330	64065	+265	-

NOTE:
- (a) Weight accounting.
- (b) Redesign of main landing gear wheels and legs to meet strength requirements. (Interim only).
- (c) Fuel system modifications to reclaim residual fuel.
- (d) Change to higher strength tubing in flying control hydraulic system.
- (e) Accounting change - trapped fuel now included in aircraft basic weight in accordance with chapter 30 of RCAF Spec. CAP 479.
- (f) Addition of missile cocoons.
- (g) Accounting change to include oil in constant speed drive separate oil system.
- (h) Fuel weight change due to change in operational weight empty.

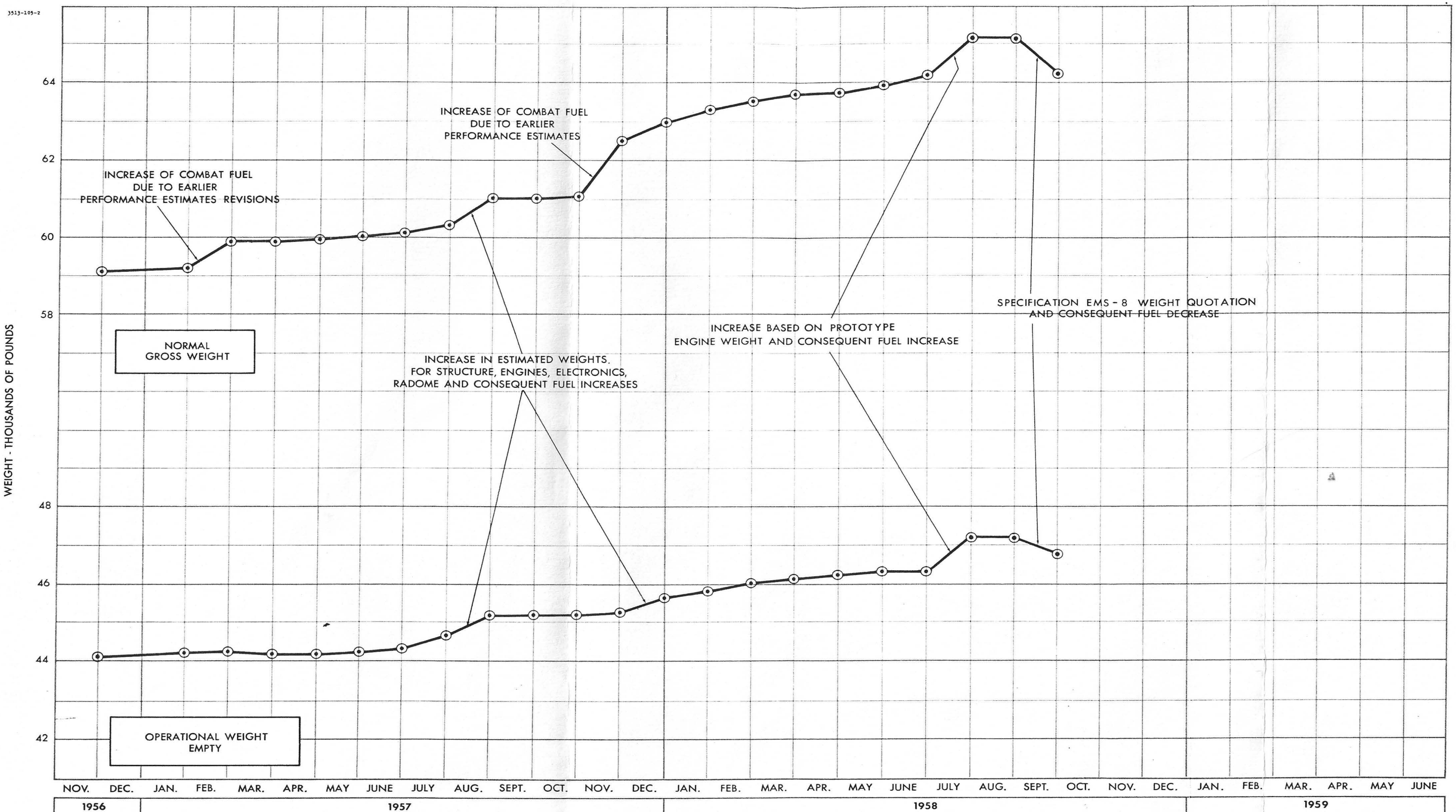

FIG. 3 WEIGHT HISTORY - ARROW 2 - OPERATIONAL AIRCRAFT

3.0 PERFORMANCE

3.1 ARROW 1

3.1.1 PROGRAMMING FOR PERFORMANCE DATA

A report has been prepared which outlines the AVRO computing program to be used during the initial RCAF performance evaluation of ARROW 1 aircraft.

Flight test data will be transformed to punch cards, from traces and auto-observer, and fed into the IBM 704 Digital Computer. The results produced will require no further computation. The computer output will be presented graphically versus time, with four outputs to one graph, except when tabulated or cross-plotted results are specifically requested. All anticipated performance parameters will be calculated, including total air miles covered in a particular manoeuvre or over a complete flight.

Reference: Report No. 71/PERF/2, Issue 4 - Programming for Performance Data from ARROW 1 Aircraft 25203 (Phase II) Flight Tests - September 1958.

3.2 ARROW 2

3.2.1 PERIODIC PERFORMANCE REPORT 14

A revision of the ARROW 2 performance estimates has been necessitated primarily as a result of the following:

(a) An increase of 1,489 pounds in operational weight empty.

(b) Revised mission profiles and combat-weight definition.

(c) Revised input data for take-off and landing distances based on flight test.

It should be noted that the operational weight empty used in this report is 557 pounds less than the figure quoted in weight report number 7-0400-34 Issue 22, August 1958. This difference is due to an increase in engine weight, which is not considered in this performance report since the revised weight is not applicable to the production engine.

The revised mission profiles and the combat weight definition are as informally agreed to but not yet approved by the RCAF. The revised mission profiles are tabulated in para. 3.2.2. The combat weight is now defined as the operational weight empty plus one-half the maximum useable internal fuel weight.

The performance data given in this report are based on the drag and propulsion data given in Periodic Performance Reports 12 and 13 and the engine performance as in EMS 8 Issue 2. These performance data represent an estimate of the ultimate performance of the ARROW 2 as presently envisaged.

Performance estimates are based on ICAO standard atmosphere conditions, clean aircraft (i. e. no ventral tank) and CG at 29.5% MAC.

3.2.2 WEIGHTS

Operational weight empty	46,650 lb.
Maximum useable internal fuel	19,443 lb.
Gross take-off weight (max. internal fuel)	66,093 lb.
Combat weight	56,372 lb.
Maximum external fuel and tank (500 gallons at 7.8 lb/gall. and drop tank)	4,242 lb.
Maximum gross take-off weight (combat mission)	70,335 lb.
* Maximum gross take-off weight (ferry mission)	68,607 lb.
Normal design landing gross weight	49,783 lb.
Maximum landing gross weight (combat mission)	66,093 lb.

* Maximum gross take-off weight (combat mission) less 1,728 lb. for missiles.

3.2.3 MISSIONS - (Radii of Action)

(1)	Subsonic high altitude mission - subsonic combat	442 n.m.
(2)	Subsonic high altitude mission - supersonic combat	347 n.m.
(3)	Supersonic high altitude mission - supersonic combat	238 n.m.
(4)	Combat air patrol - supersonic combat	467 n.m.
(5)	Subsonic low level mission (10,000 ft. altitude) subsonic combat	349 n.m.
(6)	Ferry mission (no armament)	
(a)	ventral tank carried throughout	1,306 n.m. range
(b)	ventral tank jettisoned when empty	1,357 n.m. range

3.2.4 GRAPHS

(a)	Maximum Level Speed	Figure 4
(b)	Maneouvrability	Figure 5

(c) Time to Height Figure 6

(d) Rate of Climb Figure 7

(e) Take-off Distance Figure 8

(f) Landing Distance Figure 9

Reference: Periodic Performance Report 14 - August 1958.

3.3 REVISED ARROW 2 PERFORMANCE ESTIMATES

As a result of the recent change in armament and electronic systems, a revision of the ARROW 2 performance estimates will be made. A Genie missile installation appears to be simple and compact, resulting in savings of weight and space.

3.4 PERFORMANCE WITH J75 P6 ENGINES

A performance comparison has been made between an ARROW powered with Iroquois engines and an ARROW powered with Pratt & Whitney JT4B-23 (P6) engines. Both versions of the aircraft were at compatible weights, with suitable allowances being made for the weight changes due to the installation of the Pratt & Whitney engines.

The results of the comparison indicate that both versions are comparable from the performance point of view, when operating subsonically with after-burners unlit. However, in addition to a superior aircraft performance at supersonic speeds with afterburners lit, it is evident that the Iroquois engine has a much lower fuel consumption than the Pratt & Whitney engine.

A comparison of missions was also made for these two aircraft. The Iroquois powered version has, with one exception, the greater radius of action and range. In the subsonic low level mission (10,000 feet altitude) with subsonic combat, the Pratt & Whitney powered version has a greater radius of action due to an apparent improvement in economy at this altitude.

Reference: Report No. 72/PERF/22 - ARROW Performance with Pratt & Whitney JT4B-23 Engines - July 1958.

Report No. 72/PERF/22/ADD 1 - Further ARROW Performance with Pratt & Whitney JT4B-23 Engines - New Missions - September 1958.

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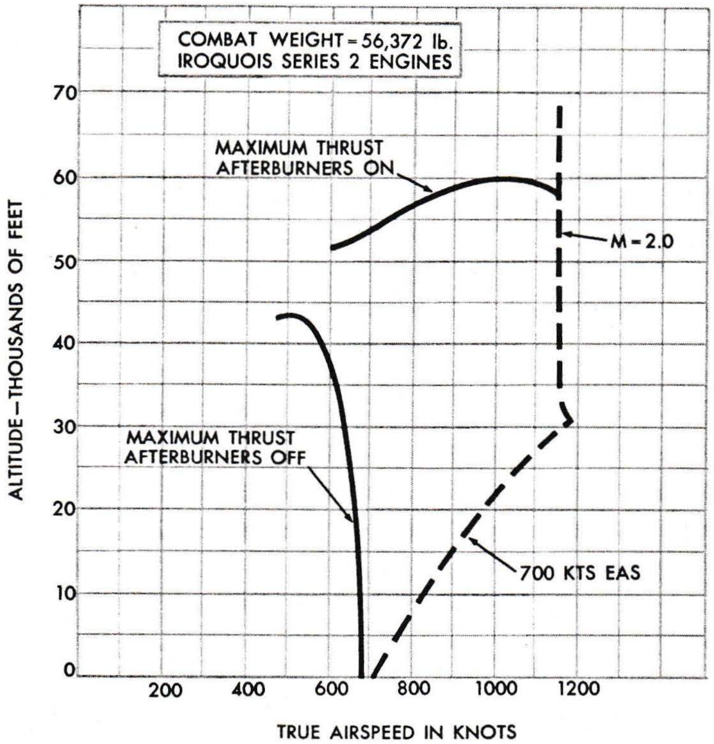

FIG. 4 ARROW 2 - MAXIMUM LEVEL SPEED

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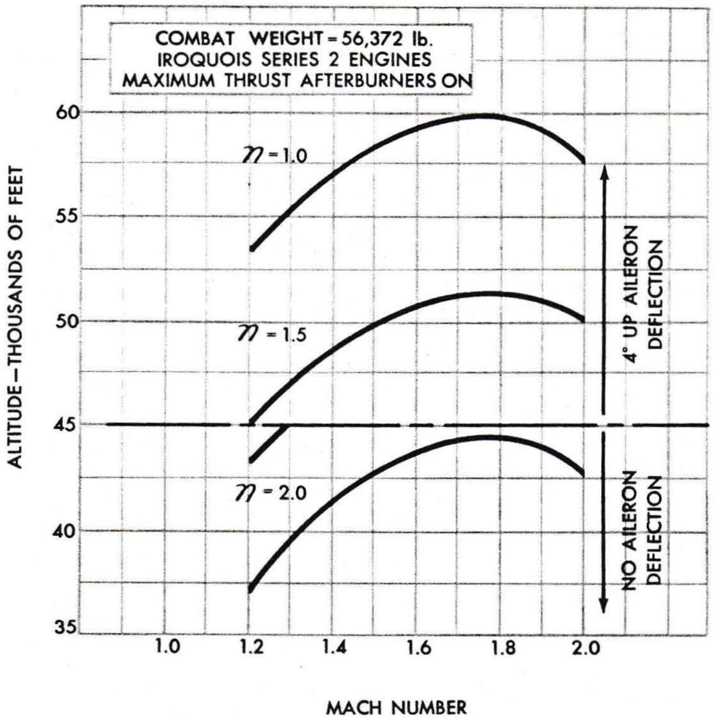

FIG. 5 ARROW 2 - MANOEUVRABILITY

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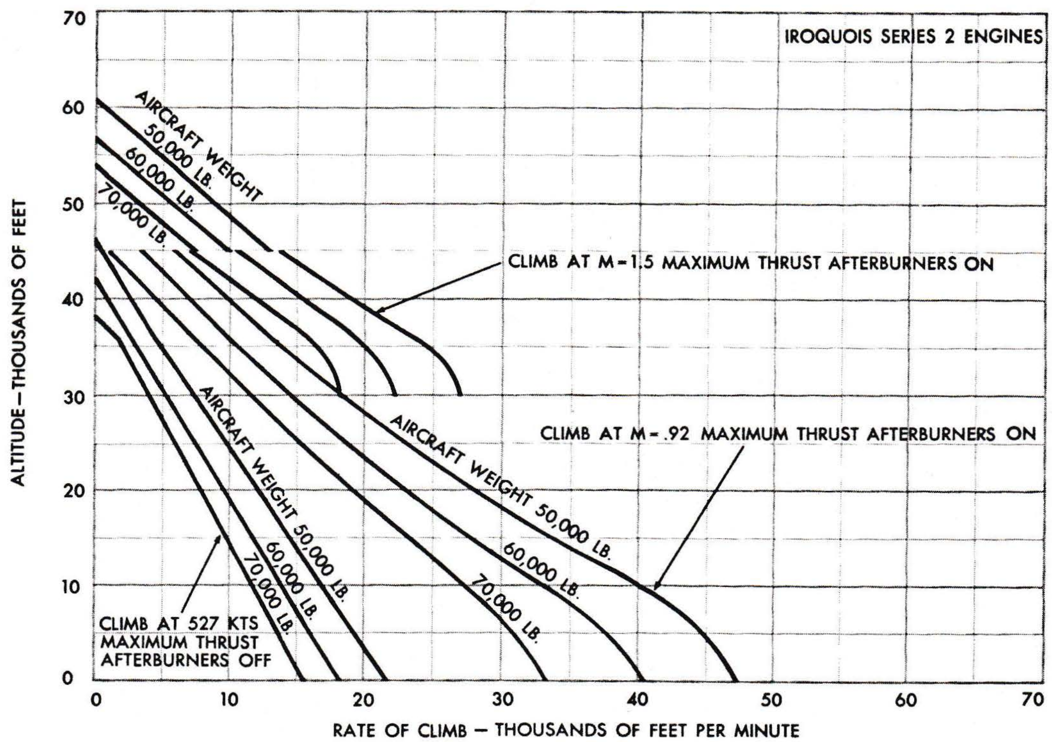

FIG. 6 ARROW 2 - TIME TO HEIGHT

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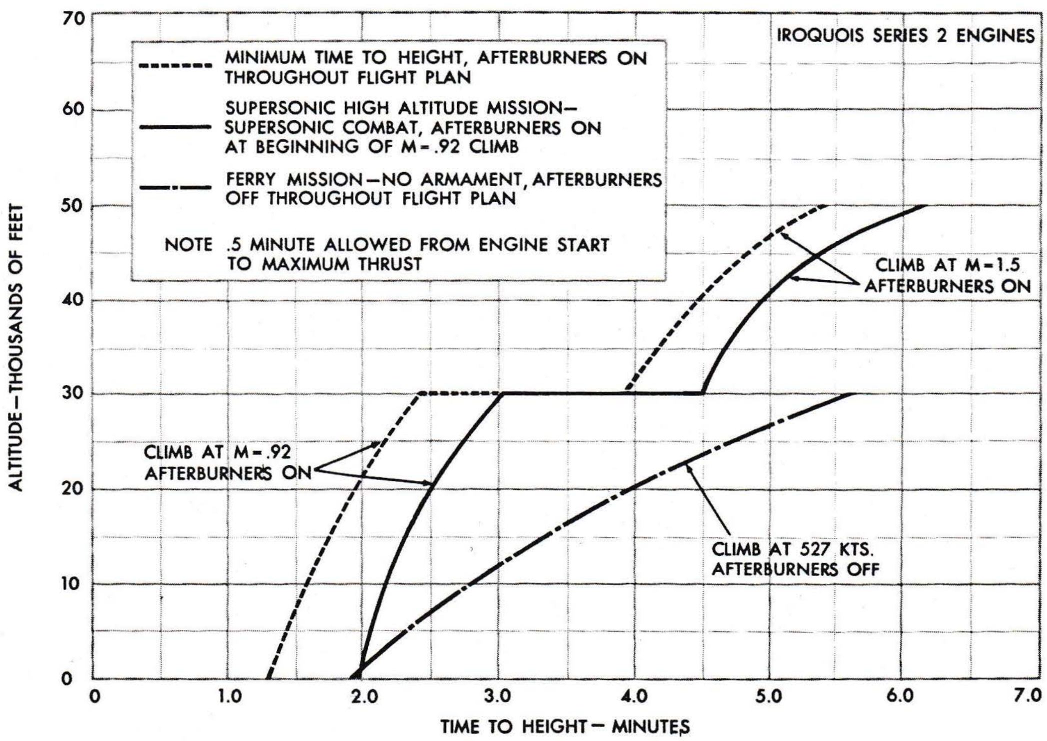

FIG. 7 ARROW 2 - RATE OF CLIMB

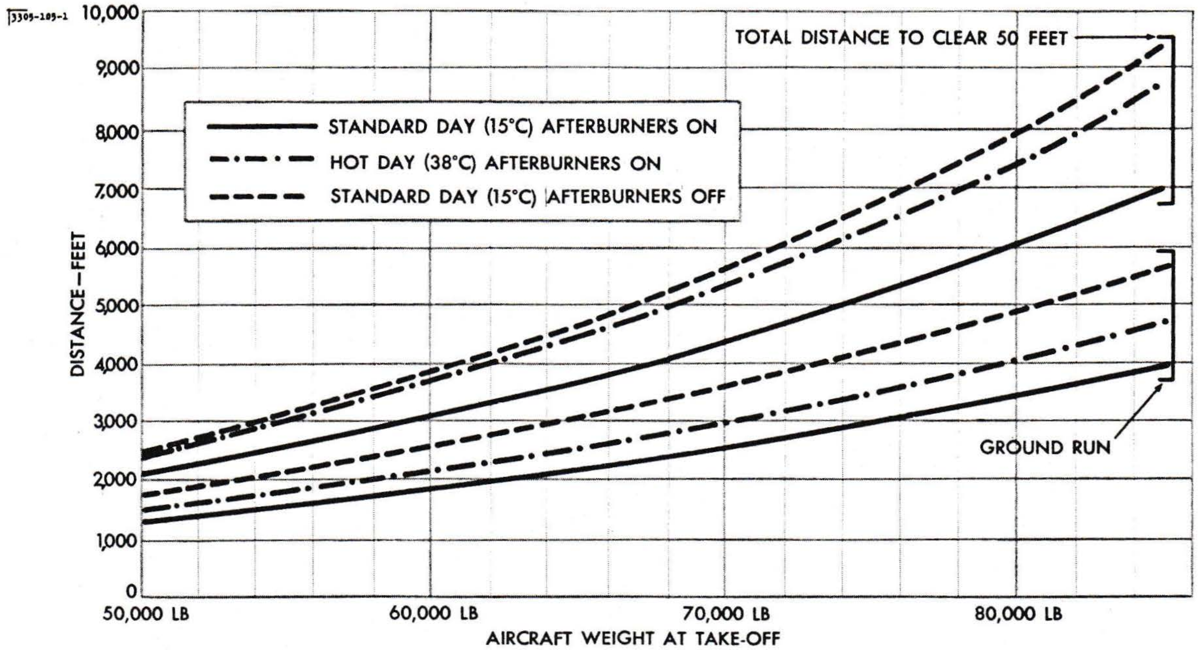

FIG. 8 ARROW 2 - TAKE-OFF DISTANCE AT SEA LEVEL

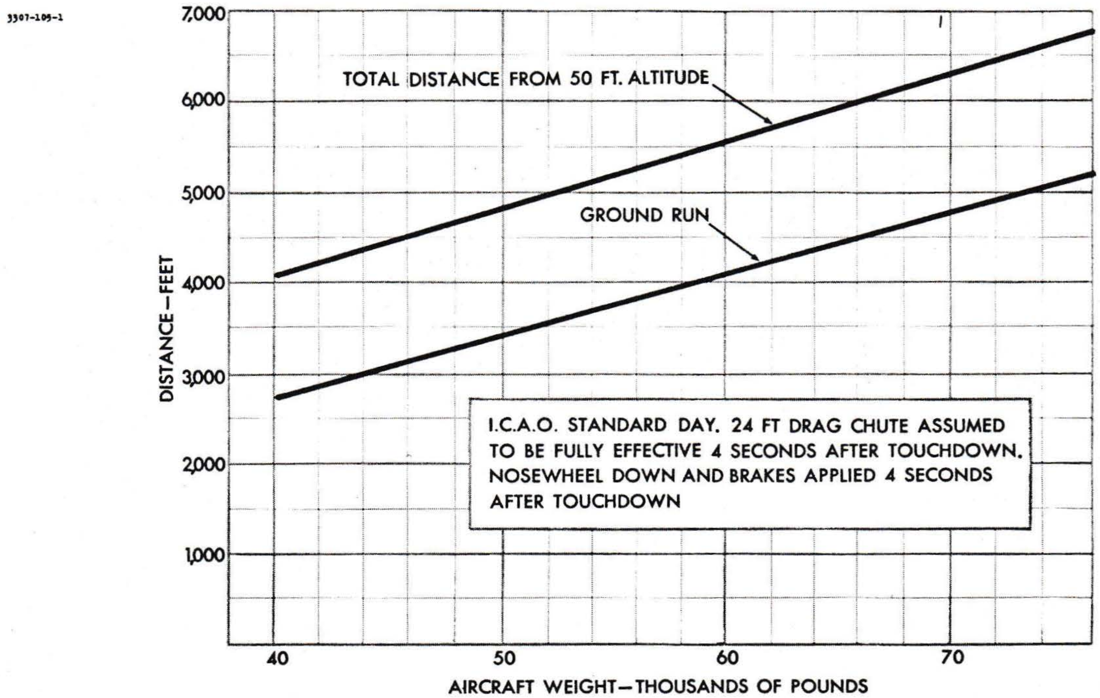

FIG. 9 ARROW 2 - LANDING DISTANCE AT SEA LEVEL

3.5 TACTICS

3.5.1 ARROW 2 MATHEMATICAL MODEL

A report has been prepared which describes a program of digital and analog simulations of the ARROW 2 weapon system capabilities. This program has been written to meet AAWS requirements for a mathematical model of the ARROW 2, for the following purposes:

(a) To determine the theoretical potential of the weapon system.

(b) To indicate suspect areas and influence the flight test program accordingly.

(c) To form a basis for evaluation of the weapon system.

The following terms of reference for the study have been laid down:

(a) A single interceptor versus a single target.

(b) The model will start at target detection by ground environment.

(c) The model will end at the completion of the missile phase.

(d) Both clear and ECM environments will be considered.

(e) The results of the model prediction and the ARROW weapon system demonstration are to show statistical agreement.

(f) The 1961 weapon system shall have priority over studies of the ultimate system.

Reference: ARROW Weapon System co-ordinating contractor.
Report No. 10 - The Mathematical Model.

3.5.2 REVISED TACTICAL STUDIES

In view of the Sparrow missile and ASTRA system cancellations, work on the tactical studies program has been temporarily suspended.

4.0 STABILITY AND CONTROL

4.1 PRELIMINARY STABILITY, CONTROL AND DAMPER ANALYSIS

The first nine flights of aircraft 25201, and the first seven flights of aircraft 25202, have been analyzed and assessed with regard to handling qualities and suitability of the control systems. Particular reference is made to aircraft 25202 because of the greater amount of data available.

4.1.1 YAW DAMPER

In all flights of aircraft 25201 to date, the normal and emergency yaw dampers have functioned satisfactorily up to Mach 1.86 with gain set at 100% of design. A slight 1-cps oscillation was present for a time but it is thought to have been exaggerated by the roll damper, which appeared to excite this mode. The relocation of the lateral accelerometers to a forward position has practically eliminated this oscillation. With this change, yaw damper operation in all modes is considered to be satisfactory and reliable. A very effective side slip minimization has been obtained under all flight conditions tested so far.

Pilot comment on the yaw damper is favourable except for operation on the runway. Some difficulty is experienced here, as was expected, since the damper tends to oppose any change of direction, whether intentional or not. This is particularly noticeable in heavy cross winds and when the drag chute is streamed. When landing under these circumstances the damper is switched off immediately the drag chute is streamed.

4.1.2 ROLL DAMPER

During the operation of the roll damper, under both subsonic and supersonic conditions, the differential servo has been too oscillatory in action. This oscillation aggravated the yaw axis 1-cps vibration described in paragraph 4.1.1. Damping has been effected in this mode but is not yet considered to be satisfactory. Flight tests are continuing in order to establish suitable gain settings.

The stick feel has been changed from 10 lb/120°/sec., which was too sensitive, to 23 lbs/120°/sec., which appears to be of the right order. In several flights, stick locking occurred with the roll damper in operation. This was subsequently traced to a faulty connection in the control stick. Experience gained so far, indicates that the present stick requires a considerable effort to keep it in serviceable condition. In addition, the stick shows some undesirable characteristics which are the cause of inconsistent test results and critical comments from the pilots. This is currently being investigated.

4.1.3 PITCH DAMPER

The pitch damper was not activated during these flight tests because of a number of problems which arose in conjunction with valve stability and linkage behaviour. These problems are being investigated. In addition, the electronic filter associated with the stick had to be relocated within the circuit in order to eliminate the excessive pickup of structural vibrations through the accelerometers.

4.1.4 VIBRATIONS IN FLIGHT

Excessive buffeting, at a frequency of approximately 35 cps, has been indicated by the transverse accelerometer sensors with landing gear extension. This is probably caused by the vibrations of the landing gear doors. An occasional 12-cps vibration in the elevator system appears to be sensitive to the configuration of the viscous dampers on the main control valves. Investigations are continuing in order to eliminate both of these problems.

4.1.5 STABILITY AND HANDLING CHARACTERISTICS

The limited amount of instrumentation available so far has permitted only an approximate evaluation of stability derivatives.

Dutch rolling characteristics agree well with prediction and show a slight improvement over the extimate of directional stability in most flight conditions.

Both aircraft (25201 and 25202) have been flown without dampers, supersonically up to Mach 1.7 and 50,000 feet and subsonically at 450 knots EAS. With the damping system inoperative, the lateral control of the aircraft appeared satisfactory, though a little heavy. In the pitch axis the aircraft experienced oscillations, of approximately 1 second periods. This indicated that pitch control is inadequate for flight in excess of approximately 430 knots EAS subsonically in the damper-off configuration. This oscillation is probably due to high sensitivity and dynamics of the stick-linkage-valve combination. An investigation of this unacceptable behaviour is being made on the simulator and flying controls test rig. The dynamics of the hydraulic system and control valves are also being checked. Supersonic handling at speeds up to 450 knots EAS is good. Flight tests are being continued to extend the supersonic effective airspeeds beyond this point.

Preliminary assessments of flight test results indicate good agreement with prediction of the following parameters:

(a) Aileron effectiveness at supersonic speeds.

(b) Elevator effectiveness at all speeds.

(c) Roll to yaw (Ø/B) ratio in most conditions.

(d) Trim angles of the elevator at supersonic speed (indicating good agreement of Cm_o, and therefore on supersonic trim drag).

(e) Elevator angle per-g at most conditions.

(f) Angles of attack in level flight.

(g) Period of the dutch rolling oscillations.

(h) Dutch roll damping at high altitudes.

Reference: Report No. 71/FAR/43 - Preliminary Stability and Damper Analysis of the First Seven Flights, ARROW 1. No. 25202 - September/58.

4.2 WIND TUNNEL TESTING

4.2.1 SPARROW MISSILE COCOON JETTISON TESTS

Preliminary tests have been made to assess the jettison characteristics of the following cocoon model configurations.

(a) 15° drooped nose - with and without aft release pin.

(b) 25° drooped nose - with aft release pin.

(c) Nose vent - with and without aft release pin.

(d) Plain nose - with and without aft release pin.

The plane nose and nose vent configurations did not separate without interference with the missiles and in some cases, the fuselage. The 15° and in particular the 25° drooped nose configuration, with the aft release pin, tended to pitch nose down and drop cleanly from the pack when released. The use of the aft release pin appeared to improve the jettison characteristics.

Some additional testing has been planned which will clarify the jettison characteristics already observed, and indicate the need for further testing.

4.2.2 IR POD INSTALLATION ON FIN

Supersonic wind tunnel tests to determine the effect of the IR seeker pod installation, have been completed in the NAE high speed tunnel. Tests were made at Mach 1.35, 1.78 and 2.03, to measure fin forces and moments and rudder hinge moments with the pod on, and fin pitot and static pressures with the pod on and off. Test results indicate that the pod has no appreciable influence on the lateral stability derivatives or rudder hinge moments. At speeds above approximately Mach 1.5 with the pod on, the fin pitot position errors were reduced. At the lower Mach numbers there was almost no effect. The fin static pressure position error throughout the Mach range covered, was also improved with the pod on. These results only indicate the trend, however, since the static pressure probe model was not exactly to scale.

4.2.3 POST STALL GYRATION TESTING

Preliminary post stall gyration tests are almost complete. A launching technique for these tests, which are made from the roof of the NAE spin tunnel, has now been developed. It has been found, however, that open air testing is impracticable due to the influence of wind and weather.

4.2.4 SPIN AND RECOVERY CHARACTERISTICS

This program is now being continued after delays necessitated by tunnel modification work. A disparity between early and later test results is being investigated. A smaller model has been built for testing at higher altitudes (30,000 feet).

5.0 AIRLOADS

5.1 LANDING GEAR

An investigation has been completed to determine the reasons for the malfunction of the landing gear extension mechanism. The results have shown that the specified aerodynamic limits for the landing gear had to be considerably reduced, due to excessive internal friction and insufficient spring load. In order to obtain a landing gear suitable for operation within the originally specified limits, internal and external load details were issued for the redesign of the ARROW 1 gear and the design of the ARROW 2 landing gear.

5.2 AIRLOADS MATRIX

Air loads matrix is being prepared in a form suitable for correlation with the structural integrity flight test program.

6.0 THERMODYNAMICS

6.1 THERMAL STRESSING

A report has been wirtten by Avro on some of the considerations which should be made in establishing temperature distributions through structure, when used in the calculation of thermal stress.

The analysis of thermal problems depends upon various physical properties, some of which are:

(a) Coefficient of heat transfer

(b) Thermal conductivity

(c) Joint conductivity

(d) Relative density

(e) Specific heat

(f) Geometry of the section

(g) Coefficient of thermal linear expansion

(h) Young's modulus

Most of these properties have a considerable influence on the final stress and temperature distribution through a structure.

In most of the structures that have been analyzed, these properties have been assumed to be constants or average values and invariable with temperature. Such an assumption is not strictly correct; investigation has shown that a large variation exists in the physical properties of materials for different batches, and for different heat levels of the materials. These variations result in unavoidable errors inherent to the input data. In addition to these, errors arising in the calculation of the restraints of the adjacent structure must be added. The latter have a significant effect on skin stresses.

Since all the variables involved are seldom considered, the "exact" thermal analysis of a structure is not usually possible. A method of analysis which approximates the structure to a simplified model, together with a simplified mission, will give results that are within the spread of results due to the variations in input data.

Ref: Report No. 70/THERMO/32 - Some Considerations in Establishing Temperature Distributions as Used for Thermal Stressing - July 1958.

7.0 ELASTICITY

7.1 THERMAL STRESS EFFECTS

An investigation has been conducted to determine the significance of thermal stresses on material stiffness in the plastic and buckled regimes. Although the cases investigated to date represent only an illustration of the problem, they are useful in determining the stiffness drop when the ARROW wing structure buckles elastically.

Thermal stresses (and altered material properties) reduce the bending and torsional stiffness. For this reason it was necessary to determine the significance of thermal stresses at various external load levels.

The problem was approached by investigating the effects of buckling and plasticity on thermal stress and ultimate strength for end-loaded bars and for a typical wing spar. Buckling and plasticity were considered separately in the simple end-loaded bars. The more complicated case of a typical wing spar, where both effects occur simultaneously, was then analysed.

The following conclusions were made:

(a) Buckling causes a redistribution of stress which decreases thermal stress in some elements and increases thermal stress in others.

(b) By defining thermal stress as the difference in stress between the cases where thermal expansion occurs and where it is zero, it was found that plasticity reduces thermal stress.

(c) The ultimate strength of the spar considered was mainly a function of the mechanical properties and was virtually unaffected by thermal stress.

(d) Since thermal stress tends to become unimportant in the plastic region, it can be concluded that exact temperature distributions are not required for ultimate strength calculations.

It should be noted that reference is made only to ultimate strength calculations. In the calculations of limit loads, however, thermal stresses may not be negligible.

Reference: Report No. 70/ELASTIC/10 - The Effect of Plasticity and Buckling on Thermal Stress and Stiffness.

PART 3

SYSTEMS AND EQUIPMENT DESIGN

8.0 ELECTRONIC SYSTEM

8.1 INSTALLATION DESIGN

8.1.1 ARROW 1

Design work has been completed for the flight test damper system modifications in aircraft 25201, 25202, and 25203. Wiring information has been issued to the Manufacturing Division for the AFCS installation in aircraft 25202 and stage 1 wiring of the air data computer installation in 25204.

ASTRA system wiring and installation design (including instrumentation) for aircraft 25204 and 25205 is complete and has been released to Manufacturing.

8.1.2 ARROW 2

Wiring modifications for introduction of the development damper and revised qc actuator system in aircraft 25206, 25207 and 25208 (Partial ASTRA aircraft) have been completed.

System wiring requirements (less AN/ARC-552) for aircraft 25209 to 25215 were received from RCA during July, but instrumentation requirements have not yet been finalized. Aircraft wiring and installation design for these aircraft is 30% complete. No information is available on the production damper or missile auxiliaries wiring. Instrumentation signal requirements have been received from RCA, but the associated wiring details are not yet available.

8.2 RADOME

Hetron 72 polyester resin has been chosen for fabrication of the ARROW 2 radome. Physical testing of radome wall laminated, constructed with this resin, has been completed by the vendor (Brunswick-Balke-Collender) and creep evaluation is currently being conducted by AVRO. Minor differences in the electrical properties of Hetron 72 and resin originally used (Bakelite Company BRSQ 142) may require a small increase of the radome wall thickness, probably in the order of 0.005 inch.

At a meeting between the RCAF, RCA and AVRO it was decided to retain the air data nose boom in its present location, since the minor improvement gained in radome performance does not justify its relocation.

AVRO is currently studying an improved radome specification formulated by RCA. This specification is not consistent with present radome development and cannot be applied to radomes currently under construction. However, it may be necessary to investigate the design of a higher performance radome for the Genie rocket.

The radome vendor will be requested to investigate the production of the radome by the filament winding technique which is considered superior to the hand lay-up method currently in use. Filament-wound radomes can be produced in quantity more readily to meet the high performance requirements than those produced by hand methods. They provide greater uniformity of wall thickness and homogeneity, with resulting improvements to electrical performance.

8.3 BORESIGHT RANGE

The automatic boresight range mentioned in paragraph 8.7 of the previous Quarterly Technical Report is now partially installed on the roof of the Engineering Building at AVRO.

The California Technical Industries (CTI) boresight range consists of a radome holding fixture, a master control console and a null-seeking boom (See Figure 10). The holding fixture provides rotation about all three axes and has attachments for the radar system antenna which is mounted within the radome. In operation, a transmitting antenna on the null-seeking boom directs a microwave signal through the test radome to the conically scanning radar antenna at the opposite end of the range.

The error induced in the received signal by the radome causes the null-seeking boom to be repositioned to the apparent axis of the radar antenna. Deflection of the boom, relative to the length of the range provides an accurate measure of the boresight error introduced by the radome. Recorders continuously indicate the boresight error and its in-plane and cross-talk components.

The radome holding fixture and the null-seeking boom will be mounted on the roof and closed circuit television is to be used for remote visual monitoring. An ASTRA system antenna is not yet available, therefore an MG-2 antenna and radome will be used for initial checkout of the equipment.

8.4 TELECOMMUNICATION AND NAVIGATION ANTENNAS

Design and development of ARROW telecommunication and navigation system antennas is now almost complete. The next stage will be an antenna evaluation flight testing program on an ARROW 1 aircraft (probably 25203). A review of the current status of the ARROW antennas follows:

8.4.1 UHF BELLY ANTENNA

The UHF belly antenna is a flush mounted, annular slot type, used with radio communication set AN/ARC-34 or AN/ARC-552 and with data link. The antenna operates in the 225 to 400 mc/s frequency range and provides omnidirectional coverage over the lower hemisphere.

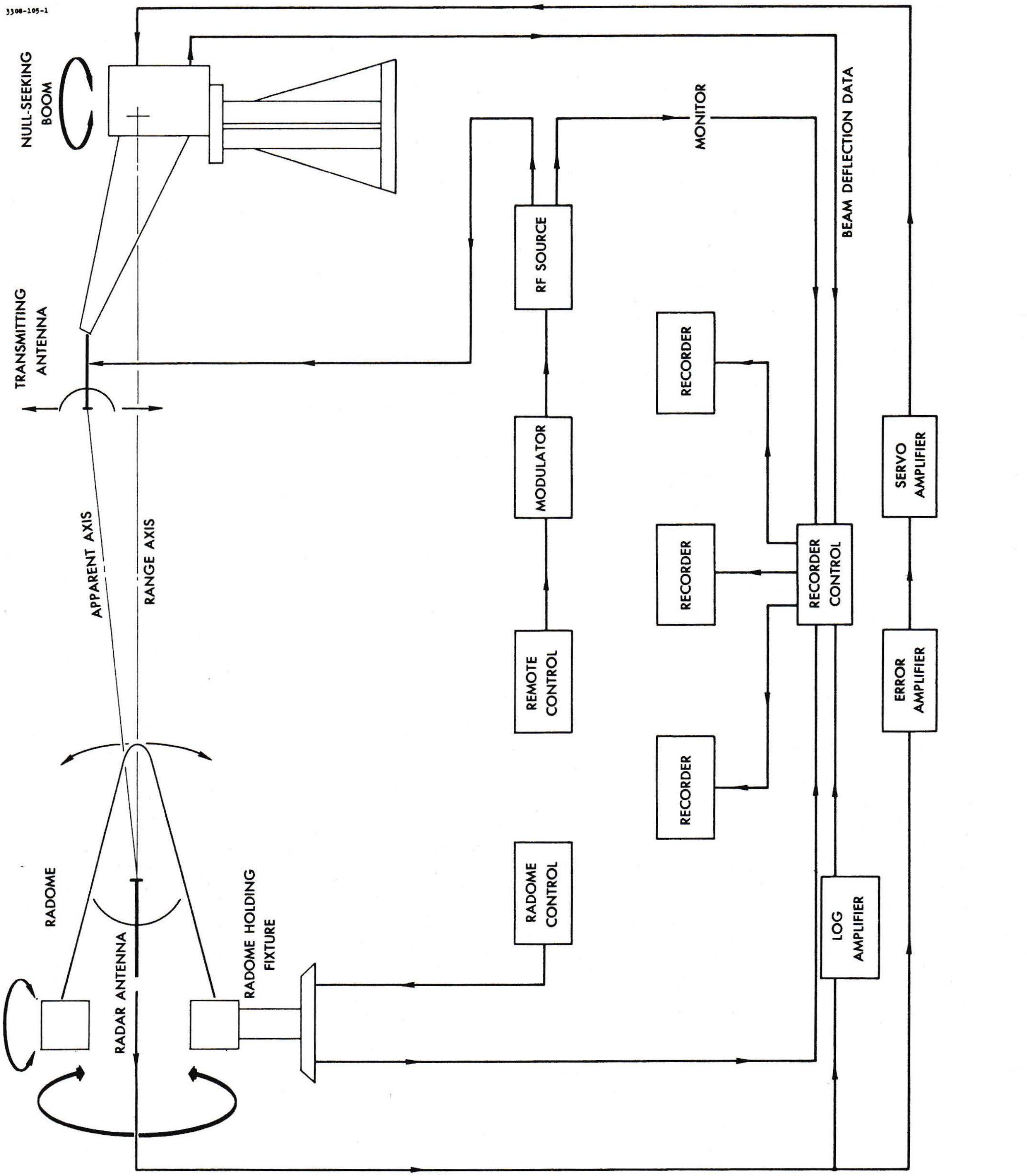

FIG. 10 AUTOMATIC BORESIGHT RANGE

The ARROW 1 version of the UHF belly antenna has a voltage standing wave ratio (VSWR) less than 3:1, and the ARROW 2 version has a VSWR less than 2:1 over the entire frequency range. Qualification tests on the ARROW 2 antenna are currently in work and will also serve to qualify the ARROW 1 version. Principal plane and conical cut pattern measurements for the UHF belly antenna have been completed.

8.4.2 L-BAND BELLY ANTENNA

A flush mounted, annular slot type L-band belly antenna is used with radar identification equipment (IFF) AN/APX-6A or AN/APX-25A. The operating frequency range is 950 to 1150 mc/s, and coverage is ominidirectional over the lower hemisphere.

Development and qualification of the L-band belly antenna have been completed and units are being installed on ARROW 1 aircraft. Some principal plane and conical cut patterns have been measured.

8.4.3 COMBINED UHF AND L-BAND FIN ANTENNA

The combined UHF/L-band antenna consists of dual fan-shaped elements mounted in the vertical fin cap. This antenna operates jointly with the UHF and L-band belly antennas in the 225 to 400 mc/s and 950 to 1150 mc/s bands respectively. Coverage is omnidirectional in the upper hemisphere.

Both elements of the combined UHF/L-band fin antenna have a VSWR less than 2:1 over the frequency range. Principal plane and conical cut patterns have been measured, and the antenna, which is fully qualified, is now ready for installation on ARROW 1.

8.4.4 X-BAND ANTENNA

An X-band antenna of the flush mounted, dual slot, horn type is installed in the upper part of the fin, for use with the air-to-air IFF equipment (AN/APX-27). The frequency range of this antenna is X-band (in the 10,000 mc/s region) and coverage is isotropic in the horizontal plane.

The RCAF has stated that omnidirectional X-band antenna coverage is required. However, this is not possible with the existing system and the RCAF has been asked if the present system is acceptable, provided interrogation is continuous throughout an attack. A ruling on this point is awaited.

Approximate patterns have been calculated for the X-band antenna, which has been qualification tested and installed in ARROW 1.

8.4.5 UHF HOMBER ANTENNA

The UHF homer (AN/ARA-25) antenna is flush-mounted on the underside of the radar nose. This antenna has a cardioid pattern and operates in the 225 to 400 mc/s frequency range. No pattern measurements have yet been made, but a program is being prepared to obtain bearing error measurements of the antenna when operating with the UHF homer equipment.

8.4.6 RADAR HOMER ANTENNA

Flush mounted antennas will be installed in the radar nose for use with the AN/ARD-501 radar homer, the operating frequency range of which is 1215 to 1340 mc/s and 2700 to 3150 mc/s.

The antenna pattern requirements of the original specification for the radar homer were not achievable and development was discontinued in July 1957. No further work has been undertaken pending a requirement decision by the RCAF.

8.4.7 DOPPLER ANTENNA

Space has been provided for a doppler radar antenna on the left-hand side of the aircraft,although no decision has been reached on the type of antenna to be used.

A four-beam antenna system, which radiates one beam forward and one beam aft on both sides of the aircraft, will be required.

8.4.8 RADIO COMPASS LOOP ANTENNA

The radio compass (AN/ARN-6) uses a loop antenna flush mounted in the electronics bay access door,and operates in the 100 to 1750 kc/s frequency band. The loop antenna is currently installed in ARROW 1 and will also be used in ARROW 2.

8.4.9 RADIO COMPASS SENSE ANTENNA

The radio compass sense antenna is a curved copper sheet, fastened to the inner surface of the dorsal fairing. It is installed in ARROW 1 aircraft and will also be used in ARROW 2. Coverage of the sense antenna is omnidirectional.

8.4.10 TELEMETRY ANTENNA

A blade type telemetry antenna, is mounted in the underside of the rear fuselage of ARROW 1 aircraft. The coverage of this antenna is not as good as was anticipated and a different type is contemplated for ARROW 2. A small, flush-mounted antenna, providing coverage in the lower hemisphere, is proposed.

8.5 INFRA-RED SUB-SYSTEM

AVRO considers that the RCA open loop gaseous nitrogen system for cooling the IR detector is impractical from the logistics support, weight and space aspects. However, it is not considered advisable to change from the open loop gaseous system at this stage because of the delay in the development program. The open loop system is therefore being developed for test purposes. In the meantime, RCA is to investigate the possibilities of developing a suitable liquid nitrogen cooling system for use in squadron aircraft. It is anticipated that a liquid nitrogen system would have decided weight and maintenance advantages.

8.6 GENIE LONG RANGE ROCKET (MB-1)

The RCAF has instructed AVRO to proceed with the installation of Genie, long range rockets in the ARROW. A program for this is being established and preliminary studies have started.

As the tolerable launch error of the Genie will be smaller than that for the Sparrow 2, it may be necessary to improve the electrical characteristics of the radome, possibly by the use of filament winding construction.

8.7 CANCELLATION OF ASTRA I PROGRAM

Subsequent to the foregoing, the Government has decided that neither ASTRA nor Sparrow will be used in the ARROW. Consequently, no further work on these systems will be performed by AVRO. Representatives from AVRO and the RCAF will shortly visit the Hughes Aircraft Company for preliminary discussions on an alternative electronic and armament system.

9.0 ENGINE INSTALLATION

9.1 IROQUOIS ENGINE WEIGHT

AVRO has been advised that the weight of the first three prototype Iroquois engines will be 4834 lb., each, instead of the 4,500 lb quoted in the Iroquois engine Model Specification (EMS-8). As a result of this weight increase, the first ARROW 2 will have a reduced performance capability.

9.2 ENGINE STARTER UNITS

AVRO has been responsible for procuring engine starter units. A total of 74 starters was ordered, and of this total, ten have been delivered to AVRO and are being installed on J75 engines. However, the RCAF has advised that since starters are considered engine accessories, the engine manufacturer is responsible for procuring and installing these units. AVRO is therefore arranging for delivery of the remaining 64 starters to Orenda who will install them on the engines, prior to RCAF acceptance of the power units.

9.3 AIRCRAFT TURNAROUND SERVICING AIDS

In order to minimize aircraft turnaround times, the RCAF requested that remote indication be provided to show the contents of the fluid systems associated with the engines. Although not in full agreement with the RCAF recommendations, AVRO agreed to comply with the intent of the request. Discussions were held between AVRO and Orenda, and an alternative proposal was submitted to the RCAF (Ref. ARROW Quarterly Technical Report No.4 - 70/ENG PUB/8 Para. 9.1.2). The RCAF's review of this proposal resulted in the following decisions:

9.3.1 ENGINE RE-OILING

The engine re-oiling couplings will be mounted directly on the outside of the engine shroud to eliminate the need for an access door. Orenda will install a thermistor-type oil level indicating system in the oil tank, and the oil levels will be shown by green indicator lights, installed by AVRO on the refuelling panel, as follows:

(a) Low Level Light -
Light "ON" indicates that oil level is above the half-full mark, and is satisfactory for flight.
Light extinguished indicates that oil level is below the half-full mark, and re-oiling is required.

(b) Full light -
Light "ON" indicates that the oil tank is full.

9.3.2 CONSTANT SPEED DRIVE AND ACCESSORIES DRIVE GEAR BOX SYSTEMS

It has been agreed that since these systems are sealed and do not normally consume oil, the need for checking oil levels on turnaround should not be necessary. The systems can be checked and serviced during routine daily inspections when the access doors are open.

9.3.3 ENGINE HYDRAULIC AND OXYGEN SYSTEMS

The RCAF has also agreed that separate indicator lights are not required for the engine hydraulic and oil systems, since they are self contained and equipped with integral indicator gauges. In addition, the hydraulic and oxygen fluid consumption is low, and checking and replenishment would only be required during routine daily inspections.

10.0 ELECTRICAL SYSTEM

10.1 POWER SYSTEM

10.1.1 ARROW 2

Alterations have been made to the aircraft wiring to allow complete interchangeability between Westinghouse and Lucas-Rotax power generating equipment. The most significant change involves the addition of wiring to accommodate the Lucas-Rotax differential current transformer which does not exist in the Westinghouse system.

10.2 ELECTRICAL SUB-SYSTEM DEVELOPMENT

10.2.1 LANDING GEAR CONTROL SYSTEM - ARROW 2

Changes have been made to bring the ARROW 2 landing gear electrical system in line with the changes to the ARROW 1 system described in para. 10.2.1 of the previous Quarterly Technical Report, and in para. 9.4.1.1 of the March 1958 Quarterly Technical Report.

The present landing gear electrical system permits the opening and closing of the nose doors for ground servicing, and sequences the lowering and retraction of the nose gear doors and leg at take-off, regardless of the ground services switch position.

10.2.2 FUEL CONTROL SYSTEM - ARROW 2

A modification has been embodied which allows the refuelling system to be operated from the emergency d-c bus when an outside source of d-c power is connected to the aircraft.

10.2.3 DAMPING SYSTEM - ARROW 1

The pilot's landing gear actuator has been modified to provide signals to the damping system when either landing gear up or landing gear down is selected. The landing gear up signal will cause an amber warning light on the warning panel to illuminate when the damping system is not in the high speed configuration. The landing gear down signal will cause the light to illuminate when the damping system is not in the low speed configuration.

10.2.4 CANOPY ACTUATION - ARROW 2

A canopy seal relay has been added in parallel with the front and rear canopy sealing valve. This relay will complete the d-c circuit to the cabin pressure warning light if the front or rear canopy latch has not been moved to the sealed position.

10.2.5 WINDSHIELD AND CANOPY DE-ICING - ARROW 2

Power for the observer/AI's canopy de-icing system has been changed from the a-c to the main d-c bus because of the change in window material. (Ref. para. 22.6). The temperature sensor in the observer/AI's right-hand window has been deleted for simplification purposes.

10.2.6 AIR CONDITIONING SYSTEM - ARROW 2

An air conditioning failure control switch has been added to the system, and the failure circuits have been modified to provide a single fail warning light. The air conditioning failure control switch has two positions, ON and NORMAL, and is located on the right-hand console of the pilot's cockpit. If the air conditioning fail warning light is on, it indicates overheating of the cockpit, equipment, fuel air, or turbine outlet air, or turbine overspeed. Selecting the control switch to ON will close the cockpit valve or equipment valve, if the fault is in one of these circuits, and the warning light will be extinguished. Any one of the other faults will shut off the main system and open the ram air system, when the temperature at the ram air inlet is below 100°F. However, the switch will not reset the main system, or extinguish the warning light for any other system fault, but its operation aids in the location of system faults, and may preclude the abandoning of a mission due to overheating in the cockpit or equipment. (Ref. para. 11.2).

10.2.7 WEAPON PACK - ARROW 2

Weapon pack circuits have been modified as follows:

(a) The relay control signals for missile firing have been re-routed.

(b) Downlock switches have been added to the launcher rear jacks.

(c) The missile lowering circuit to the external tank jettison system has been re-routed. This has been done in order to prevent inadvertent tank jettison when the landing gear override switch for pack armament ground test is operated.

10.2.8 GROUND STARTING VEHICLE

The aircraft wiring in the air conditioning, engine services and starting circuits has been modified to provide external connections to the new ground starting vehicle. These connections provide for additional services which facilitate ground servicing, as follows: intercommunication with the aircraft, tele-scramble, ground air conditioning control, a-c supply for jet pipe temperature indication and engine fuel metering, and starting control.

10.2.9 ENGINE SERVICES - ARROW 2

A modification has been added to provide for tailcone plug jettison when afterburners are selected. The plugs are jettisoned by cartridges, which are detonated when the tail cone plug relays are energized. These relays are energized when an afterburner selection is made on the throttle assembly. When the plugs are released, the afterburner fuel control system is energized.

11.0 AIR CONDITIONING SYSTEM

11.1 ARROW 2 FLOW CONTROL

11.1.1 COCKPIT BYPASS METHOD OF FLOW CONTROL

The bypass method of controlling cockpit flow described in the Quarterly Technical Report for 31 December 1957 (70/ENG PUB/5, Section 10.3) will be installed on a trial basis in aircraft 25208. The theoretical circuit diagram shown in Figure 11, shows that the pilot may have the flow control system either operative or inoperative. With the pilot's switch in the "AUTO" position, cockpit flow will be regulated to a constant 27.5 lb./min. In this case, the opening and closing of the bypass valve is controlled by the flow controller, which in turn is governed by a flow sensor in the cockpit inlet duct. When the OFF position is selected, the bypass valve is held closed, and the total flow passes through the cockpit.

11.1.2 AVRO MASS FLOW CONTROLLER

Recent testing has confirmed the basic theoretical concept applied in the design of the AVRO angular momentum mass flow controller; i.e. the retarding torque on a set of rotating blades does in fact vary linearly with the mass flow through the blades. These tests also indicated the need for some improvement to controller configuration. (Ref. Report 72/SYSTEM 22/239, Requirement for, and Future Development of an Angular Momentum Mass Flow Controller for MK 2 Air Conditioning System, Sept. 1958).

Separation of the torque detection and power unit is desirable for the following reasons:

(a) To overcome any tendency towards oscillatory instability in an associated control system, which could arise from the inertia of the originally proposed impeller and motor combination.

(b) To avoid the control problems associated with the high starting torque of the motor.

(c) To eliminate the manufacturing problems associated with the use of slip rings for supply of current to the motor.

(d) To simplify maintenance procedures.

This separation can be achieved by using two mechanically independent blade rotors in tandem instead of one, as originally proposed. The impeller, or upstream rotor, would be driven by the synchronous electric motor and would control the angular velocity of the flow. The turbine, or downstream rotor,

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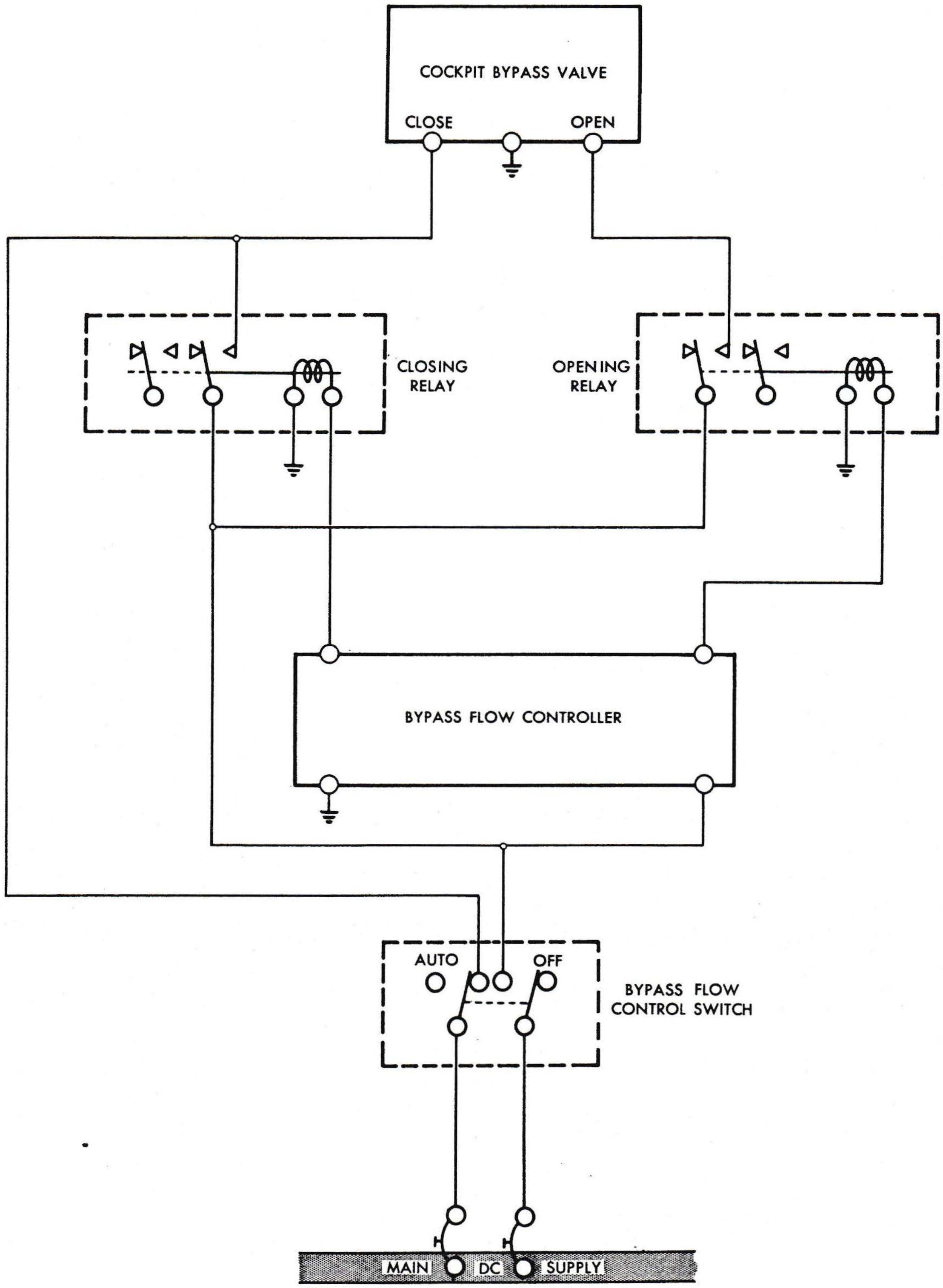

FIG. 11 COCKPIT BYPASS FLOW CONTROL SYSTEM - ARROW 2 (TRIAL INSTALLATION)

would act as the detector, operating on the principle that the torque required to straighten the flow is equal to the torque required to spin up the flow. With this arrangement, the anti-swirl honeycomb could be eliminated, and the controller turbine would be used to provide the control signals for the refrigeration turbine's variable inlet nozzle. The preliminary design of such a controller has been completed and an experimental unit is being manufactured by AVRO.

11.1.3 PROPOSED MASS FLOW CONTROL SYSTEM

In order to conserve engine power, control of total air conditioning system flow is desirable. Since the bulk of the total flow must pass through the refrigeration turbine, regulation of turbine inlet flow appears to be the obvious method of flow control. For this reason, provision has already been made to use a turbine with a variable area inlet nozzle, and an AVRO-designed angular momentum mass flow controller. A true constant mass-flow control system will thus be obtained.

The pneumatic nozzle guide vane jack of the refrigeration turbine will be controlled by the flow controller turbine, but it has not yet been decided whether this control will be by a directly operated pneumatic valve or by an electronically operated pneumatic valve.

The purely pneumatic system is attractive because of its simplicity and reliability. However, there is a possibility that friction in the guide vanes may cause the inlet nozzle to "hunt". In addition, a longer development time will be required for this system than for the electronically operated system. An electronic system, similar to that developed for the temperature control systems (Ref. Quarterly Technical Report for 30 June 1958, Section 11.1), offers a possible solution to the problem. A similar two-loop system, employing feedback in the inner loop, would provide more precise control of inlet nozzle area. Also, with the experience gained in the development of the temperature control systems, development time for such a system would be reduced.

11.2 SYSTEM FAILURE PROTECTION

ARROW 2 air conditioning system fault indication, and pilot controls for corrective action, have been changed in an attempt to simplify emergency procedures. Some aspects of these changes have already been noted in paragraph 10.2.8.

Pilot operation of a single switch is the only immediate corrective action required. The pilot, without being subjected to the pressure of urgency, can then interpret the nature of the fault and decide on the necessary final action to be taken. Only one warning light is now used to indicate a fault arising from any one of five different causes:

(a) Failure of cockpit temperature control.

(b) Failure of equipment temperature control.

(c) High turbine outlet temperature.

(d) Turbine overspeeding.

(e) High temperature of fuel system pressurizing air.

The theoretical electrical circuitry for this warning system is shown in Figure 12.

11.2.1 COCKPIT TEMPERATURE CONTROL FAILURE

When cockpit inlet air temperature exceeds 180°F, an overheat thermostat in the cockpit inlet duct will close to illuminate the warning light. Operating the failure control switch to the ON position closes the cockpit temperature control valve and breaks the warning light circuit.

11.2.2 EQUIPMENT TEMPERATURE CONTROL FAILURE

When equipment cooling air temperature exceeds 100°F, an overheat thermostat in the equipment air supply duct closes to illuminate the warning light. Selecting the failure control switch to the ON position closes the equipment temperature control valve and breaks the warning light circuit.

11.2.3 HIGH TURBINE OUTLET TEMPERATURE

If turbine outlet air temperature exceeds 80°F, a thermostat in the turbine discharge duct closes to illuminate the warning light. Selecting the failure control switch ON position trips the air conditioning system emergency control relay thus closing the system shut-off valve, the radar nose shut-off valve and both cockpit and equipment temperature control valves. At the same time, if ram air temperature is less than 100°F, the ram air relay trips to admit emergency cooling and pressurizing air to the cockpit.

11.2.4 TURBINE OVERSPEEDING

Should overspeeding of the refrigeration turbine occur, a turbine overspeed switch closes to automatically establish the same sequence of events described in the preceding paragraph. The system failure warning light is illuminated by tripping the emergency control relay.

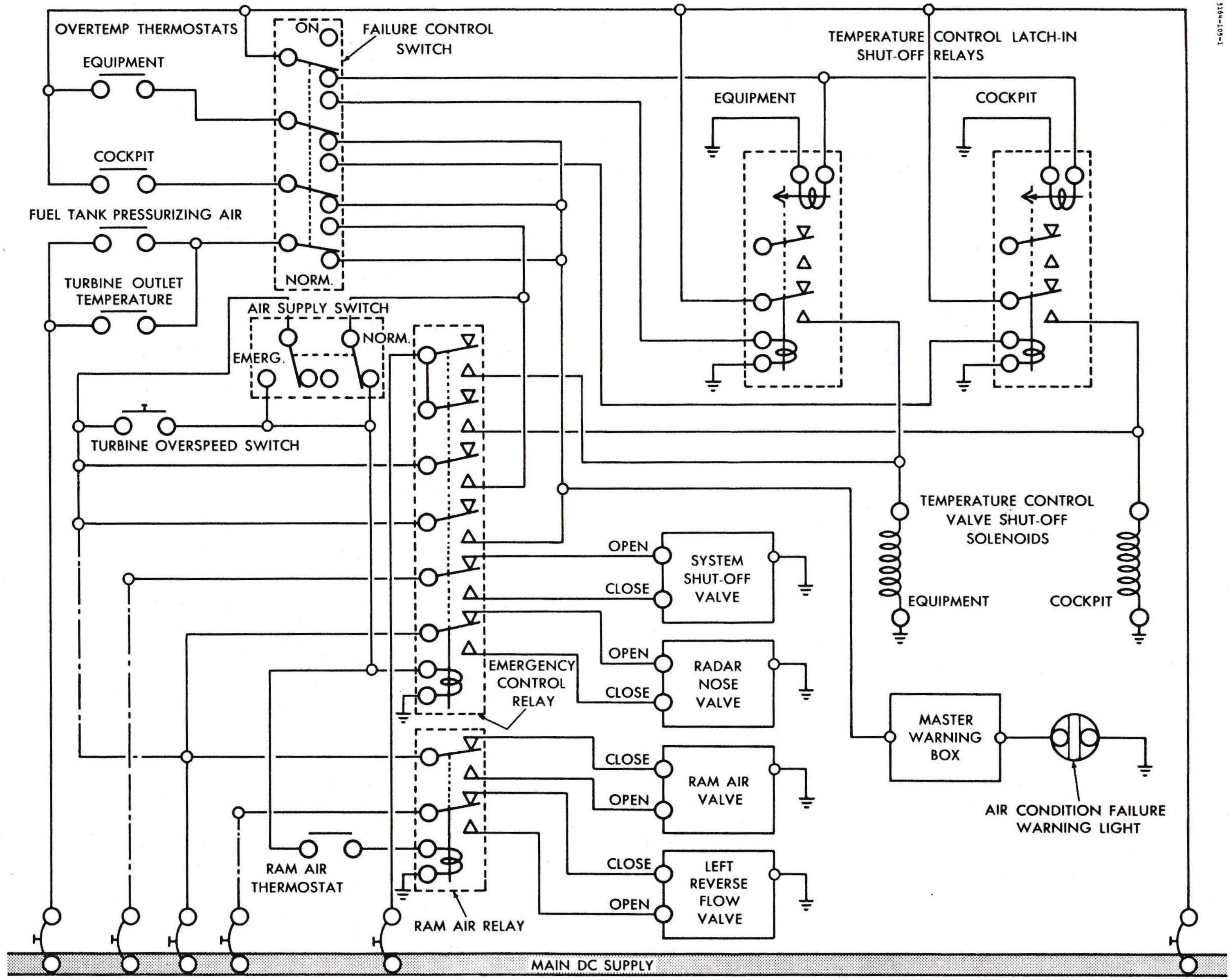

FIG. 12 ARROW 2 AIR CONDITIONING FAILURE PROTECTION

11.2.5 HIGH TEMPERATURE FUEL SYSTEM PRESSURIZING AIR

If engine bleed air at the ram air heat exchanger outlet should exceed 380°F, a thermostat located at that point closes to illuminate the warning light. Selecting the failure control switch to the ON position initiates the same sequency of events described in paragraph 11.2.3.

11.2.6 FAULT INTERPRETATION AND CORRECTIVE ACTION

If the warning light is extinguished when the failure switch is operated to the ON position, it indicates that either the cockpit or equipment temperature control systems are at fault. If the warning light does not reappear when the switch is returned to NORMAL, it indicates that the fault has cleared, and normal operation of the system resumes.

If the warning light is not extinguished when the switch is returned to NORMAL, then the fault must be due to any one or more of the remaining three causes (see para 11.2) and the flight should be aborted. Returning the failure control switch to NORMAL will not reset the ram air or the emergency control relays.

To shut off the air conditioning system for any reason, such as contaminated air, the pilot may operate the air supply switch which is wired in parallel with the turbine overspeed switch.

11.3 ENVIRONMENTAL PROTECTION FOR CREW MEMBERS

In mid-September a meeting was held between AVRO and the RCAF to discuss aircrew protective equipment in ARROW aircraft. During the meeting, the AVRO study outlining the requirements and consequent problems involved in providing for ventilated and pressurized aircrew suits was discussed. (Ref. Quarterly Technical Report for period ending June 30, 1958, 70/ENG PUB/8, section 11.4.

The RCAF stated that although a full pressure suit was preferred, the 100 lb. weight penalty involved was not acceptable. AVRO advised that a substantial weight saving could be achieved by reducing the taxiing time, thus reducing the amount of liquid oxygen required for adequate ventilation during the taxiing period. The RCAF agreed to review the taxi time requirement, with respect to the ventilation period, and to advise AVRO accordingly.

Since equipment for the full pressure suit system would not be available until 1960, AVRO will be advised to proceed with the design of an interim ventilation system which would be compatible with the partial pressure suit. In the meantime, AVRO will proceed with the design of a system compatible with both the full pressure suit and the partial pressure suit.

12.0 LOW PRESSURE PNEUMATIC SYSTEM

12.1 PITOT STATIC SYSTEM - ARROW 2

The q_c actuator system (ref. para. 15.1.5) is now monitored by a q_c pressure switch instead of the q_c transducer previously required. The q_c pressure switch is supplied with pitot and static pressure from the fin probe.

In the engine test vehicle (aircraft 25207) Orenda Engines require a transducer for the engine hot box instrumentation. This transducer will be supplied with primary static pressure from the nose boom pitot-static probe.

13.0 FUEL SYSTEM

13.1 REDUCTION OF UNUSEABLE FUEL

Actual weighing of ARROW 1 aircraft and recent calculations for ARROW 2 aircraft have shown that a large amount of fuel in the aircraft is unuseable. In order to reclaim as much of this fuel as possible, the ARROW 2 fuel system is being modified. No attempt will be made to recover the unuseable fuel in ARROW 1 aircraft.

Approximately 260 pounds of fuel will be recovered from the tributary tank system (tanks No. 1, 2, 3, 4, 6, 7 and 8) by modifying the fuel-no-air valve outlet pipes. (Ref. Figure 13). The modification will provide the outboard fuel-no-air valves with a bypass pipe in which a non-return-valve and a restricting orifice will be installed. At low fuel levels, the fuel-no-air valve inlet becomes exposed to air, and the valve closes. The fuel pressure on the delivery side of the valve then falls off and tank pressure is able to force fuel through the bypass into the transfer line. To recover as much of the fuel as possible by this method, the bypass inlet will be located at the lowest point in the tank and as close to the tank floor as possible.

Modifications to the collector tanks will permit recovery of an additional 44 pounds of fuel. The following alterations are currently in work:

(a) Installation of a sump at the aft outboard corner of the tank with consequent alteration to the booster pump aft fuel inlet pipe.

(b) Provision of holes in the tank floor stringer webs to permit drainage of trapped fuel to the sump.

13.2 ENGINE INLET FUEL PRESSURE WARNING

A fixed-datum pressure warning switch is currently used to indicate low fuel pressure at the engine fuel inlet. The switch is set to close at a fixed critical pressure datum of 15.9 psia. This pressure datum is derived by summing the specified minimum fuel inlet pressure (7.5 psia above the relevant vapor pressure) and the fuel vapor pressure at the maximum design temperature (8.4 psia at 160°F for JP4 fuel). It has been found that this arrangement can cause unnecessary and misleading warning signals when fuel temperatures are below 160°F (see Figure 15).

In order to prevent these false warnings, AVRO has investigated the possibility of designing a switch in which the critical pressure datum varies with fuel temperature. (Ref. report 71/SYSTEM 16/177, Investigation of a Fuel Pressure Switch Operating at a Variable Temperature Datum Related to Vapor Pressure, June, 1958). The study revealed that two types of switches

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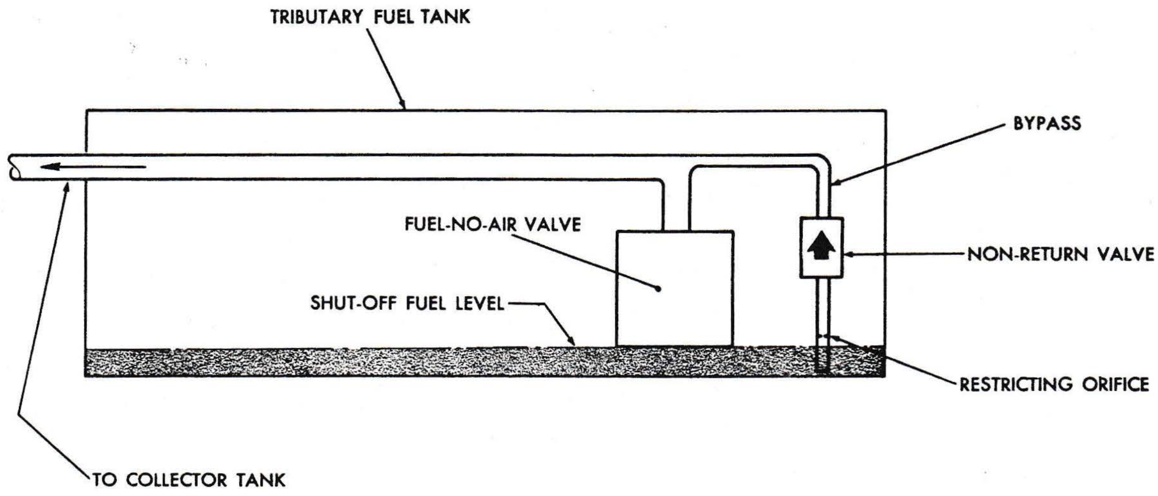

FIG. 13 FUEL - NO-AIR VALVE MODIFICATION

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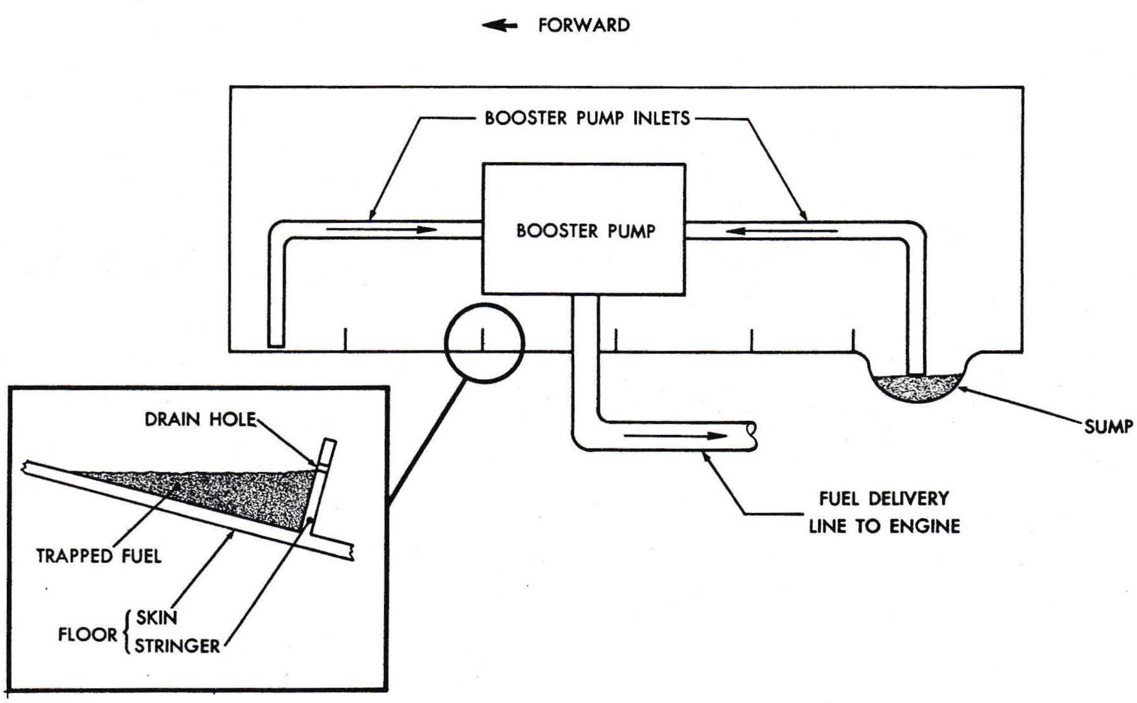

FIG. 14 PROPOSED COLLECTOR TANK MODIFICATIONS

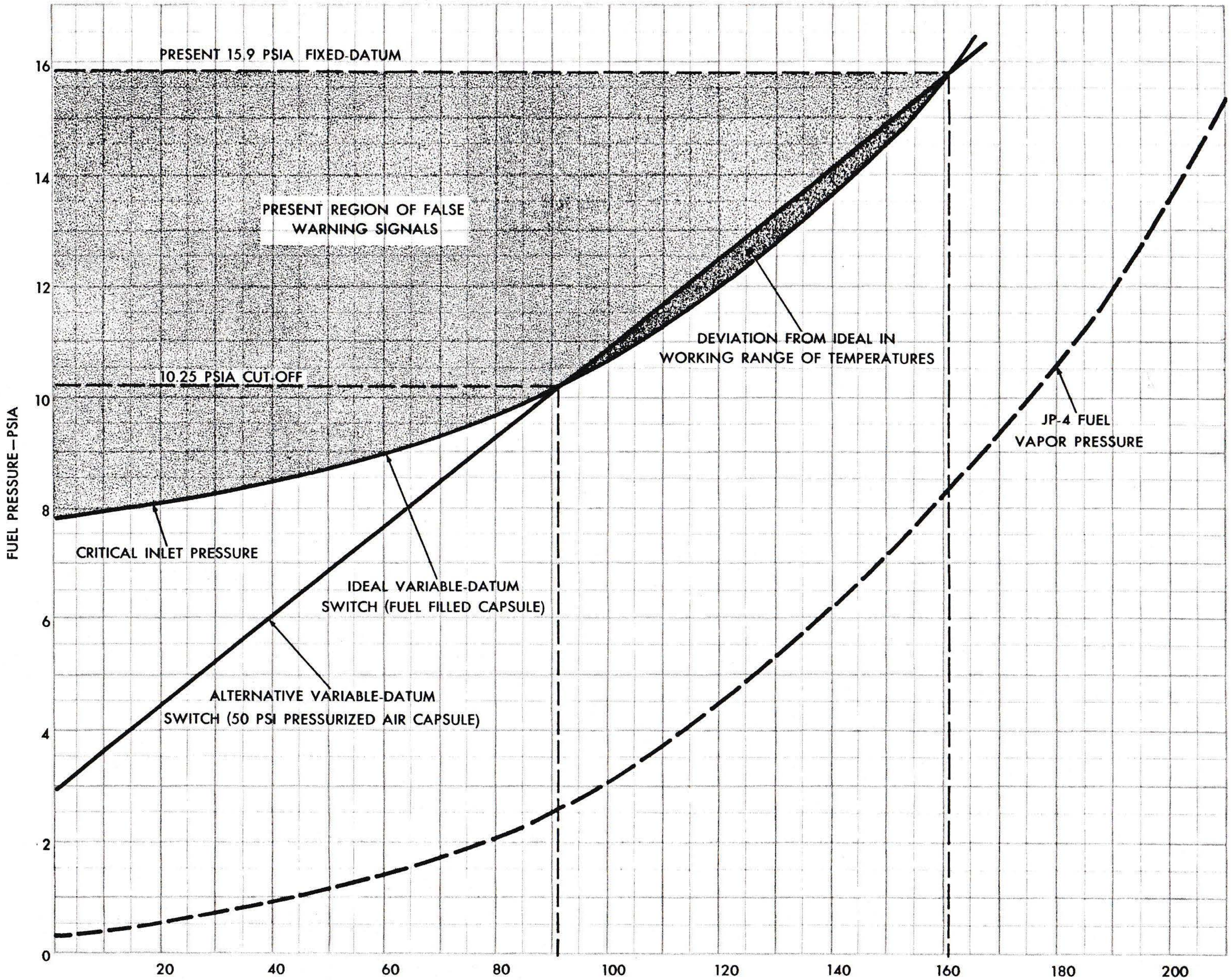

FIG. 15 FUEL PRESSURE WARNING SWITCH CHARACTERISTICS

could be constructed, one of which would completely eliminate the occurrence of misleading warning signals, and the other would substantially reduce the region in which the false signals are produced. (See Figure 15).

The suggested ideal pressure switch would be actuated by a sealed capsule containing JP4 fuel. By immersing the capsule in the fuel being delivered to the engine, the fuel sample is exposed to delivery fuel temperatures and pressures. Thus, if the capsule is arranged to operate a switch contact at the datum point of 15.9 psia when fuel temperature is 160°F, the switch will close at the pressure corresponding to any temperature along the critical inlet pressure curve, whenever the differential pressure between fuel delivery and the sealed fuel sample is less than 7.5 psi. A fuel capsule would be difficult to manufacture because of the sealing problems while fuel is contained within the capsule.

The alternative proposal would use a capsule containing air at 50 psi. In this case, however, the internal pressure exerted on the capsule would vary linearly with respect to fuel temperature, and consequently the variable datum governing the warning signal would deviate from the ideal curve. In the working range of temperatures defined by 90° to 160°F, warning signals would occur prematurely. At temperatures below 90°F, no warning signals would occur, even when fuel pressures fall well below the required minimum. To avoid this latter condition, a cut-off switch, actuated by an evacuated capsule, could be integrated into the switch design. The warning light would then appear whenever fuel inlet pressures dropped below a nominal 10.25 psia. This would, of course, tend to make a more complicated and bulkier unit.

The feasibility of introducing variable-datum pressure warning switches in ARROW aircraft will depend on further engineering studies.

13.3 PRESSURIZING AIR SUPPLY

Under certain flight and ground conditions, the engine bleed air used for fuel tank pressurization can rise to potentially dangerous temperatures. In certain conditions, JP4 fuel will ignite spontaneously when in contact with a surface at 450°. Since pressurizing air is tapped from the downstream side of the air conditioning system's ram air heat exchanger, high air supply temperatures occur when cooling in the heat exchanger is inadequate.

In ARROW 1 aircraft, inadequate cooling in the ram air heat exchanger occurs only during static ground running with the air conditioning system shut-off. The turbine driven fan is then inoperative and the cooling air flow through the heat exchanger is too low for adequate cooling of engine bleed air. In order to fully explore the potential hazard involved, ground tests will be conducted in which only one engine will be run with the air conditioning system shut-off. Fuel tank pressurizing air temperatures will be monitored to determine the engine throttle setting at which stabilized 400°F air temperature is reached, and limitations on ground running conditions will be introduced if found necessary.

Due to revised estimates of pressurizing air temperatures in ARROW 2 aircraft during Mach 2 flights above 50,000 feet, a cockpit warning light is being introduced to make the pilot aware if hazardous operating conditions occur. This light is operated by a thermostat in the pressurizing air supply. Should the warning light indicate that the high temperatures occur too frequently, additional cooling of the bleed air will be required. Consideration is being given to tapping pressurizing air from the downstream side of the water evaporator instead of the present downstream side of the ram air heat exchanger.

13.4 FUEL QUANTITY GAUGING SYSTEM

The ARROW 1 cockpit fuel quantity indicators have been giving erroneous readings, which have been caused by spurious signals picked up by the signal carrying leads at bulkhead connectors. Throughout their length, the signal carrying lead wires are shielded; the shields being grounded. By grounding the shield for each length of wire at the terminating bulkhead connector, the shielding is not necessarily at the same potential at all points along its length. To ensure that a common ground is provided for the shielding, bulkhead connectors with coaxial pins are being investigated. These would provide a continuous shield throughout the full length of the signal leads.

13.5 AVRO FUEL-NO-AIR VALVE DEVELOPMENT

13.5.1 DEVELOPMENT PROGRESS

Arrangements have now been completed with the supplier for the development and manufacture of the AVRO-designed fuel-no-air valve (Ref. para. 12.2 of the previous Quarterly Technical Report).

13.5.2 DESIGN FEATURES

Although the basic features of the valve remain unchanged, some detail changes have occurred. The most significant of these is the adoption of a photo-electric sensing system to replace the utrasonic system. This new multiprobe sensing system offers a lighter and more compact installation at lower cost. The optical sensing probe is discussed briefly in para. 13.5.3.

13.5.3 OPTICAL SENSING DEVICE

The optical fuel/air discriminating system will consist of four parallel-connected probes in series with a single amplifier. Each probe will include a light source, a prism and a light-sensitive solar cell (Ref. Figure 16).

The light source is located within the probe so that no light reaches the sensitive surface of the solar cell except by reflection from the two exposed surfaces of the prism. Total reflection occurs within the prism when the surfaces are exposed to air, and almost total transmission occurs through the surfaces when the probe is immersed in fuel. The solar cell is activated by the reflected light and generates a voltage proportional to the intensity of light incident upon it. This voltage, upon amplification provides the initial fuel-no-air valve closing signal.

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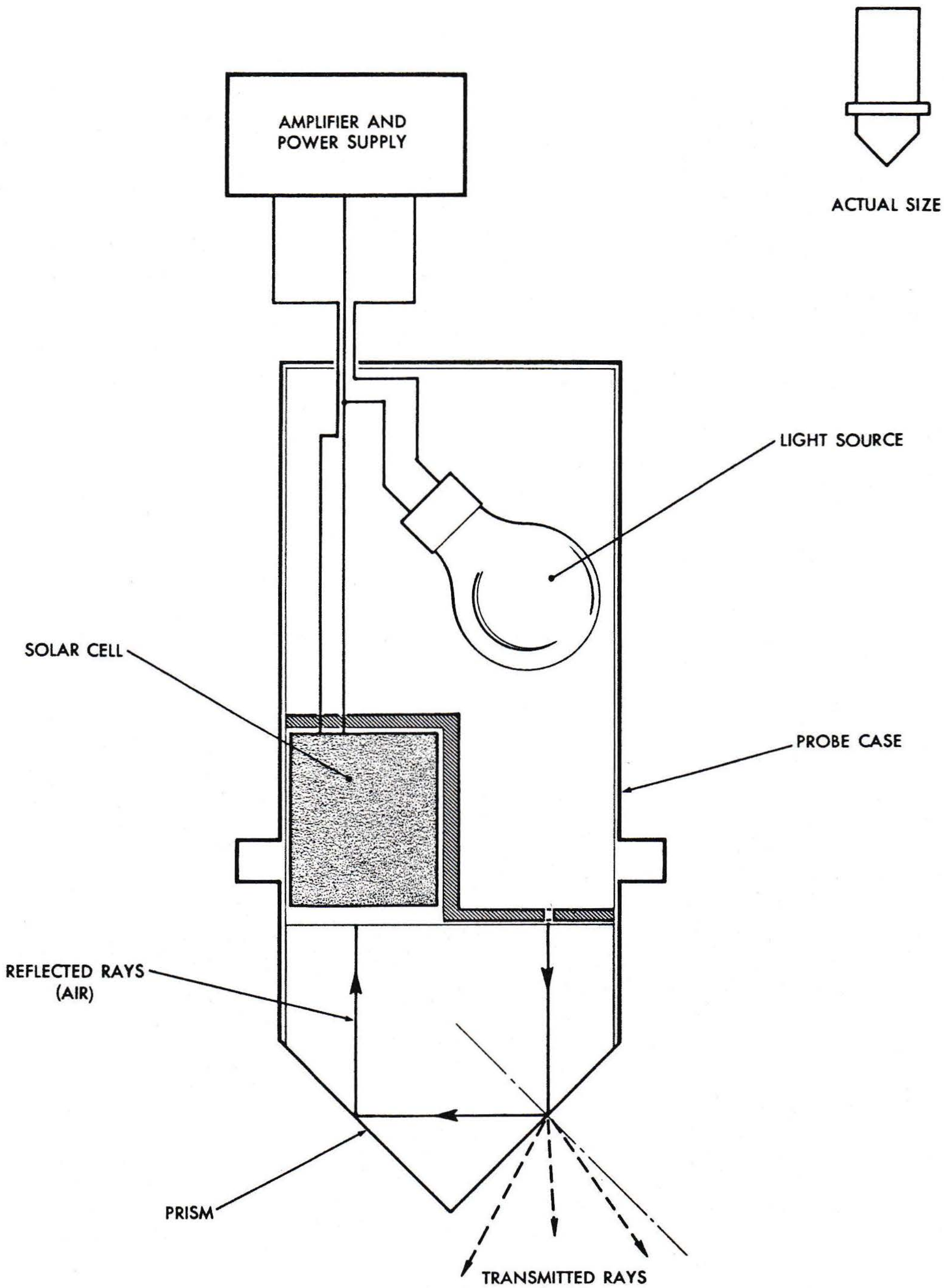

FIG. 16 OPTICAL SENSING PROBE

14.0 HYDRAULIC SYSTEM

There have been no significant flying control hydraulic system developments during the quarter. Improvements to the control system actuators and servos are reported in Section 15. With regard to the utility hydraulic system, the following work has been performed:

14.1 NOSE LANDING GEAR

Design requirements for the ARROW 2 nose landing gear have been revised to bring them into line with up-to-date aircraft landing weights and dynamic braking conditions.

Both maximum and steady braking loads were considered from the point of view of shock absorber and tire deflections, and the roll life of the existing wheels and tires. For the maximum braking case, at maximum aircraft landing weight, it was found that tire deflection would be excessive to the point of complete flattening. In the case of steady braking, it was calculated that 43% tire deflection can occur, resulting in reduced tire life and premature failure. Investigations have also indicated that bottoming of the shock absorber could also occur under certain maximum braking conditions.

As a result of these investigations, the nose gear equipment procured for ARROW 2 will be designed to meet the dynamic conditions of the revised specifications.

14.2 NOSEWHEEL STEERING SYSTEM

Preliminary design of an electro-hydraulic nosewheel steering system, to replace the original mechanically-operated arrangement, has now been completed. Trial installation and flight testing will be conducted on aircraft 25202 in order to develop an operational system for ARROW 2.

In order to prevent oversteering at high speeds, the steering control ratio of rudder bar deflection vs nosewheel angle will probably be non-linear for the ARROW 2 system. However, for trial installation purposes a selector switch in the cockpit will permit the pilot to select the steering control characteristic (ref. Figure 17). This will facilitate an assessment of the comparative merits of linear and non-linear control, from which the optimum characteristic for the ARROW 2 system can be determined. The principal advantages of the electro-hydraulic system as compared with the original mechanical system are:

(a) A reduction of steering mechanism friction effects on the rudder control system.

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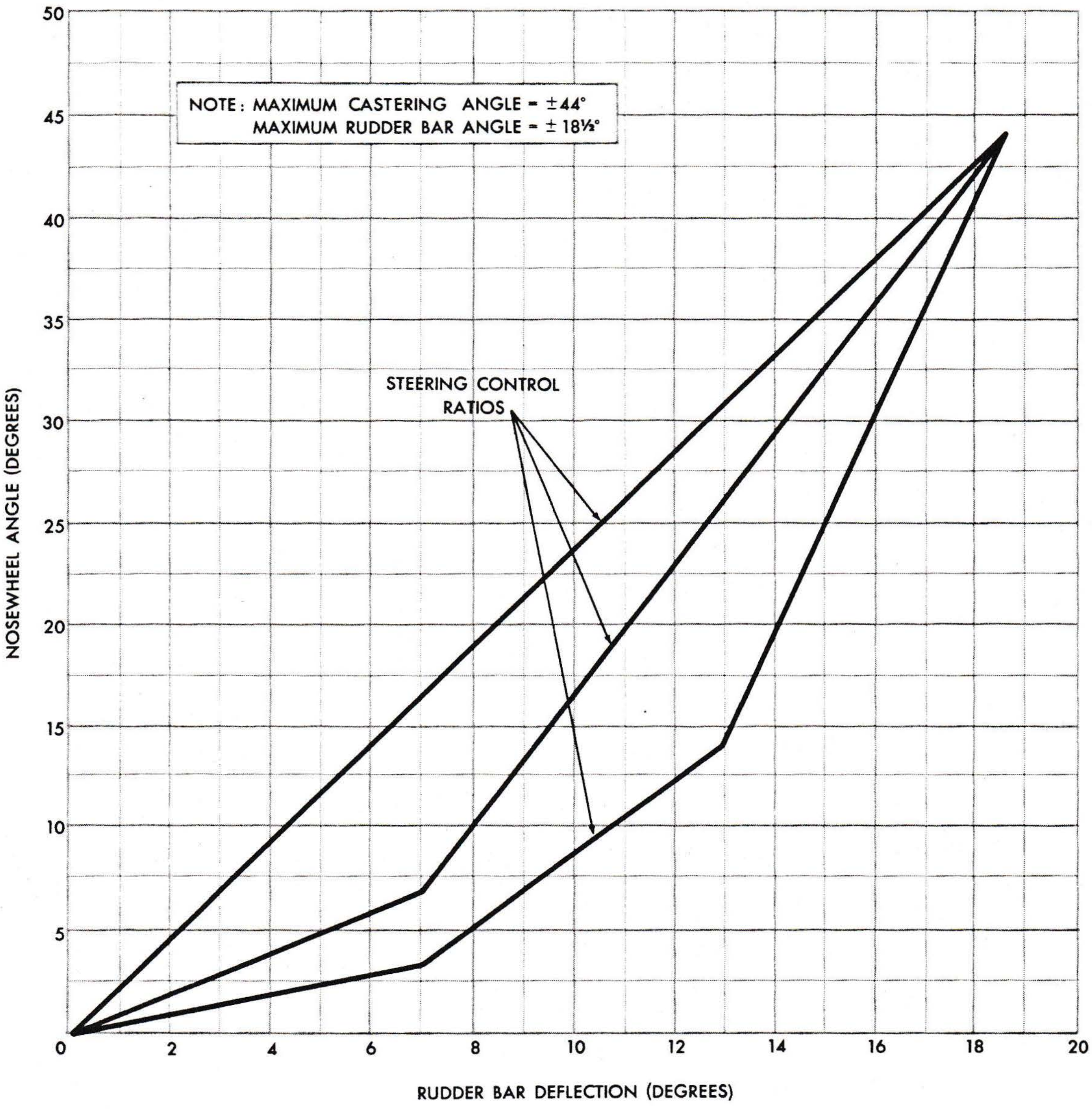

FIG. 17 NOSEWHEEL STEERING CONTROL CHARACTERISTICS (TRIAL INSTALLATION)

(b) A simpler method of achieving a non-linear steering characteristic without increasing system friction and complexity.

(c) Improved steering response characteristics.

(d) A small weight saving.

14.2.1 DESCRIPTION OF NOSEWHEEL STEERING SYSTEM

The ARROW 2 nosewheel steering system is diagrammatically represented in Figure 18. This is a closed loop, electro-hydraulic system utilizing the original ARROW 1 steering actuator, a dry-coil type Moog valve, a phase sensitive magnetic amplifier, rudder bar and nosewheel position potentiometers, solenoid-operated hydraulic valves and a hydraulic filter.

Movement of the rudder bar, which is mechanically linked to the wiper of potentiometer P_1, causes an unbalance in the bridge network (ref. Figure 18), inducing a signal in the magnetic amplifier and in turn actuating the Moog valve. The Moog valve allows hydraulic fluid to operate the steering actuator. Displacement of the nosewheel is mechanically fed back to the wiper of potentiometer P_2, causing it to re-balance the network, thereby cancelling the steering signal and preventing further movement of the actuator.

14.2.2 HYDRAULIC CIRCUIT

Hydraulic supply for the steering system is taken from the nose landing gear line. With both the pilot's steering selector switch and the nose gear scissors switch closed, the steering selector valve (ref. Figure 19) is energized, allowing hydraulic pressure from the nose gear DOWN line to be supplied to the Moog valve for control of the steering actuator.

When steering is disengaged, the steering selector valve is de-energized and the free castering and self centring solenoid valves are opened. This disconnects hydraulic pressure from the Moog valve and opens a run-around circuit between both ends of the steering actuator, thus permitting free castering of the nosewheel. One-way restrictors are incorporated in the outflow from each end of the steering actuator to provide shimmy damping of the nosewheel.

On retraction of the landing gear, hydraulic pressure from the nose gear UP line is applied to both ends of the steering actuator, causing it to self-centre before retraction of the nose gear is complete. The Moog valve is de-energized when the nose gear scissors switch is opened by retraction of the gear.

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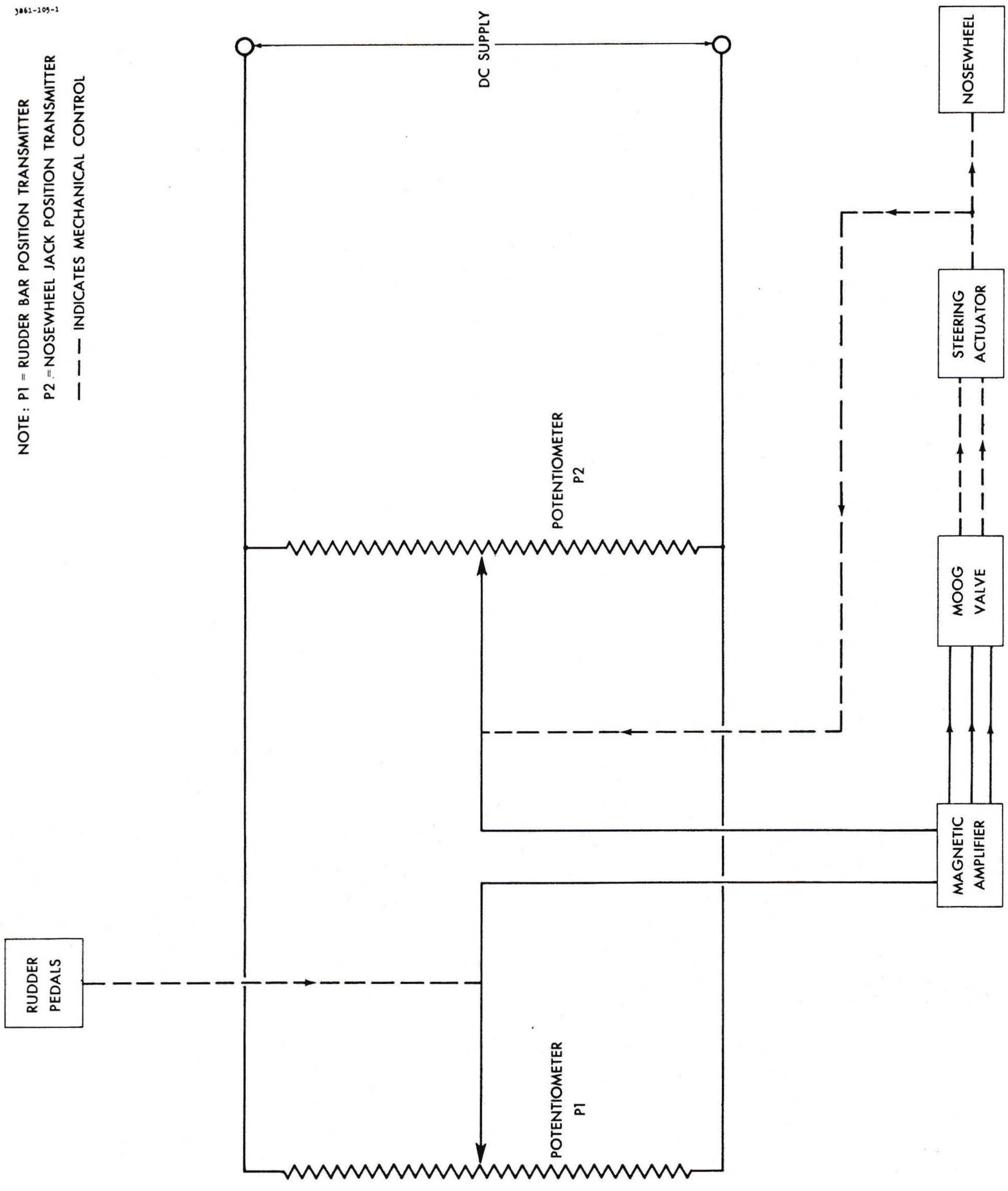

FIG. 18 SIMPLIFIED DIAGRAM OF NOSEWHEEL STEERING SYSTEM

NOTE: 1. SYSTEM SHOWN WITH STEERING ENGAGED

2. FREE CASTORING AND SELF CENTRING SOLENOID VALVES ARE OF THE NORMALLY OPEN TYPE AND ARE CLOSED WHEN STEERING IS ENGAGED

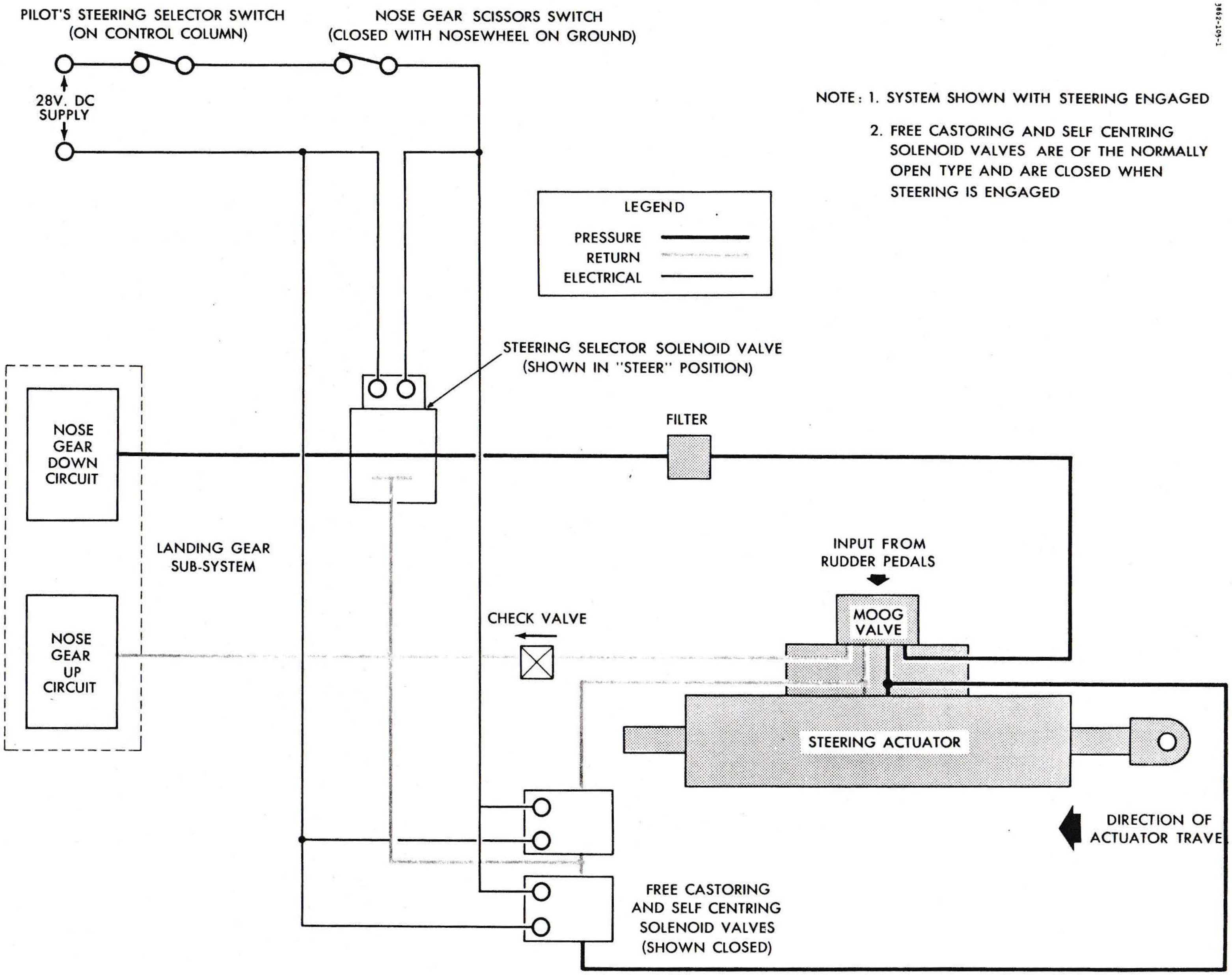

FIG. 19 HYDRAULIC SCHEMATIC - NOSEWHEEL STEERING SYSTEM

14.3 WHEEL BRAKES HYDRAULIC SUPPLY

The RCAF has indicated that the proposal to improve the wheel brakes hydraulic circuit (ref. para. 13.3 of the previous Quarterly Technical Report) does not meet requirements, and has suggested a revision to the system, which would be less complex and lighter than the AVRO proposal.

14.4 LANDING GEAR g ENVELOPE

AVRO has started an investigation into the effects of a wider g-envelope on the landing gear sub-system (ref. para. 5.1).

14.5 HYDRAULIC COMPENSATORS

Several modifications are currently being made to the ARROW 1 hydraulic system compensators in order to make them fully serviceable for development flying. These modifications were necessitated by the large number of compensator failures and are as follows:

(a) Quad rings have been substituted for the O-ring seals on the large diameter piston to improve the endurance and leak preventation qualities of the seal.

(b) Piston bearing surfaces have been chamfered to permit self alignment within the two cylinder bores and thus overcome piston seizures.

(c) Minor alterations have been made to the relief valve to prevent malfunctioning, and to obtain the required flow rate.

(d) The bleed valve has been modified to reduce the leak rate.

AVRO is currently modifying all ARROW 1 compensators to this configuration.

14.6 ARMAMENT HYDRAULIC SYSTEM (SPARROW PACK)

Ground functioning tests of the armament hydraulic system were conducted using the single missile test rig,and several equipment problems have been solved.

A major problem in the system development has been difficulty in synchronizing the launcher extension jacks, caused mainly by malfunctioning of the compensator valve during missile lowering. As an interim measure, "down" switches have been incorporated on the launcher rear jacks to ensure that a missile cannot be fired unless both forward and rear jacks are fully extended.

14.7 REDESIGN OF ARMAMENT HYDRAULIC SYSTEM

The MB-1 (Genie) long range rocket installation is now being considered, and this will simplify the armament hydraulic system. A preliminary investigations of the system requirements is currently being made.

15.0 FLYING CONTROLS AND DAMPER SYSTEM

15.1 FLYING CONTROLS SYSTEM

Investigations have continued on improvements to the flying controls system. These include an investigation of a stick gearing mechanism in the pitch axis to reduce the control sensitivity at high subsonic speeds, and improvements to the frequency response in pitch. The latter is being investigated on the flying controls system test rig, and includes the use of two parallel servos instead of one, to increase the stiffness of the control input system. In order to reduce the loads on the control surfaces and supporting structure, methods of limiting the output force of the hydraulic actuators are also being investigated.

The ARROW 2 q_c actuator system and elevator feel and trim unit designs have been finalized. In addition, improvements have been made to the rudder tension regulator quadrant and hinge moment limiter.

15.1.1 CONTROL VALVES - ARROW 1

As a result of incorrect ground handling, the elevator control valve spool stem failed on aircraft 25202. This was caused by excessive load being applied to the elevator trailing edge while installing the mechanical gust lock. As a result of this failure, the valve stem has been strengthened. Similar action has been taken on the differential servo (ref. para. 15.1.3).

Tests on the flying controls test rig have finalized the requirements for the ARROW 1 control valve dampers, and the location of the damper in the control valve linkage.

15.1.2 CONTROL VALVES - ARROW 2

The specification has been issued for the ARROW 2 control valves, and valves from several sources will be evaluated on the flying controls system test rig. It is expected that the valve forces in these new control valves will be lower than for the existing valve, and the improved stability resulting from this reduction may eliminate the need for control valve dampers and boosters. These features will be investigated in the flying controls test rig, depending on procurement of improved valves.

15.1.3 PARALLEL SERVOS AND DIFFERENTIAL SERVOS

In an attempt to eliminate contamination and leakage problems, the parallel and differential servos are being modified to incorporate "dry coil" torque motors. In addition, the ports on the parallel servos are being changed to accept flareless fittings, and to eliminate the possibility of pipes being crossed.

The differential servo spool stem has been strengthened, since control valve forces react on the differential servo through the follow-up mechanism (ref. para. 15.1.1).

15.1.4 ELEVATOR FEEL AND TRIM UNIT

A dual-motor feel and trim unit will be used to improve the elevator feel system reliability. One motor will be operative for manual trimming in the emergency mode; the second motor will be used for automatic unloading of the parallel servo when normal damper is engaged. The latter function is incorporated to eliminate stick bump with normal damper disengagement. This is accomplished by a pressure switch which will monitor the parallel servo differential pressure and pass the pressure signal to the feel and trim unit motor. The feel spring is thereby loaded to take over the entire stick reaction. Each motor will provide a rate-of-trim equal to that of the present feel and trim unit.

15.1.5 Q_c ACTUATOR SYSTEM

15.1.5.1 Q_c Actuator System - ARROW 2

Scheduling requirements for the ARROW 2 hinge moment limiter have been simplified to permit the use of a step modulated q_c actuator system.

This step system employes a switching unit in place of the magnetic amplifier and q_c transducer of the original system. The q_c pressure switch which monitors the system, receives its pressure reference from the fin pitot and static source (ref. para. 12.1).

The system schedules the hinge moment limiter, and with 150 lb. force applied to the rudder pedals, the maximum rudder deflections shown in Figure 21 may be produced. A maximum of 30° rudder deflection can be produced in the landing gear down mode. When landing gear up mode is selected, a maximum of 10° to 12° rudder deflection is possible for low q_c (up to 650 psf). At speeds corresponding to q_c 650=psf and higher, the systems permits a maximum rudder deflection of 4°.

A warning light is included in the system to indicate improper positioning of the q_c actuator at any flight condition. Should the system fail at high q_c position, the emergency system may be selected.

15.1.5.2 Q_c Actuator System - ARROW 1

The revised ARROW 2 q_c actuator system, which will not be available until 1959, will be retrofitted to all ARROW 1 aircraft. In the meantime, ARROW 1 aircraft will employ a single step q_c actuator system which is actuated by

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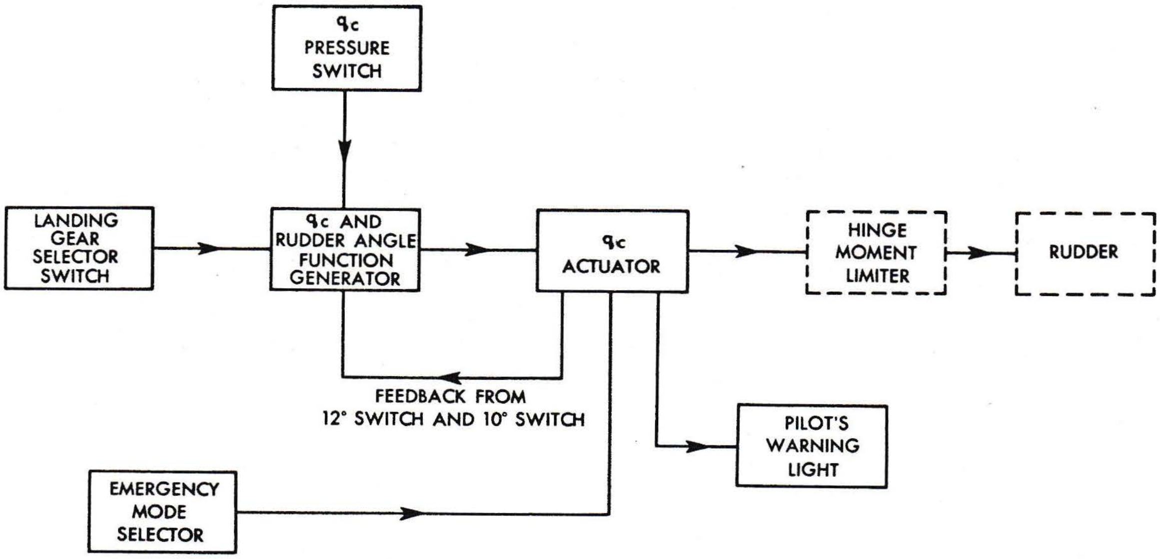

FIG. 20 Qc ACTUATOR SYSTEM - BLOCK DIAGRAM

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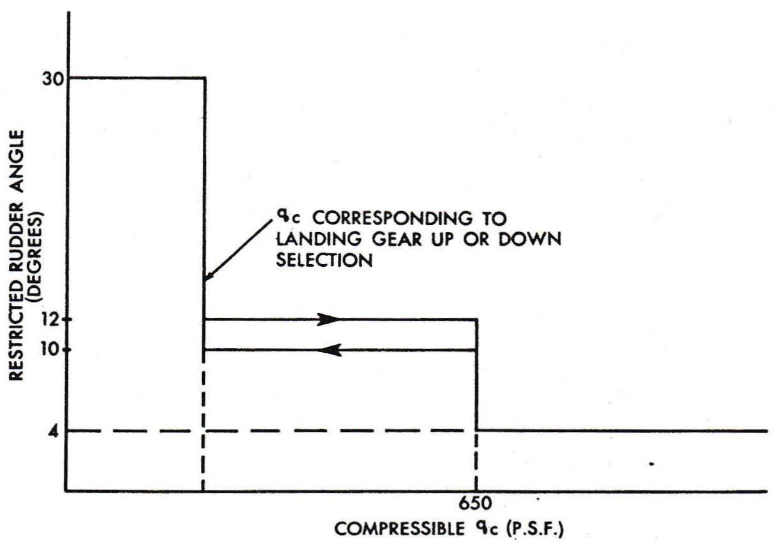
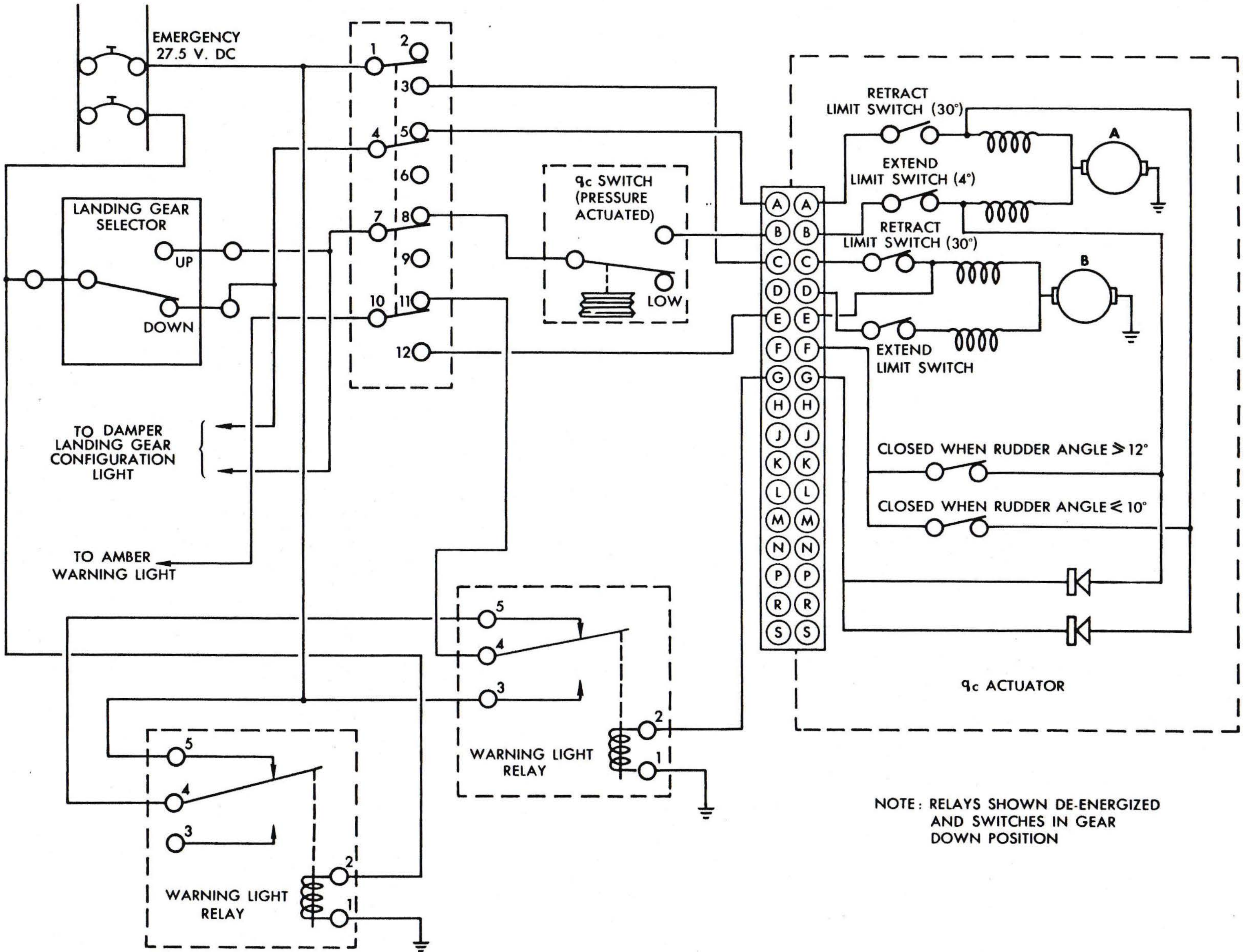


FIG. 21 Qc ACTUATOR SYSTEM - CHARACTERISTICS



NOTE: RELAYS SHOWN DE-ENERGIZED AND SWITCHES IN GEAR DOWN POSITION

FIG. 22 Qc ACTUATOR SYSTEM - CIRCUIT DIAGRAM a switch on the landing gear selector lever. One of the two existing cockpit switches for the present q_c actuator system will be wired to provide the automatic and pilot authority functions. The ARROW 1 single-motor actuators will be modified to accommodate the single step system.

15.1.6 HINGE MOMENT LIMITER

The feel springs of the rudder hinge moment limiter will be preloaded to improve rudder centring. The necessary modifications are being retrofitted to all ARROW 1 aircraft.

15.2 DAMPER SYSTEM

Development dampers will be installed in aircraft 25206, 25207 and 25208 along with the ARROW 1 damper controls arrangement in the cockpit. This will enable AVRO to install a damper system in time to meet the production schedules for these aircraft. The development dampers will not include the g-trim indicator nor the landing gear down configuration warning light. The 1.5 volt filter (Ay), designed to overcome the rudder divergent oscillation problem, will be used in the development damper system in addition to the stick command filter. These units were discussed in the previous Quarterly Technical Report (ref. para. 14.2.3 and 14.2.4).

Production dampers are scheduled to be installed in aircraft 25209 and subsequent aircraft.

In order to check the compatibility of the automatic flight control system (AFCS) with the damper system, the AFCS will be investigated and installed in aircraft 25202, which is the flying controls test vehicle. The AFCS equipment for these tests will provide the pilot assist modes (hold functions) only.

15.2.1 MODIFICATION TO PRODUCTION DAMPERS

In order to increase reliability, several modifications are to be incorporated in the production damper:

(a) The power switch on the function selector will be replaced with an emergency damper disengage switch.

(b) The landing gear configuration (up and down) will be selected manually, and the test switch will be eliminated. It is intended to eventually incorporate automatic mode switching.

(c) A damper landing gear configuration indicator light will be installed to indicate when the landing gear selector and the damper landing gear configuration selector are not in agreement.

15.2.2 ACCELEROMETERS

The incorporation of "thumper solenoids" on the damper system accelerometers is being investigated. (Automatic test features are already incorporated on the g-limiter accelerometers). This would permit ground tests to be conducted without removing the aircraft sensors.

15.2.3 RUDDER MONITOR

The rudder monitor includes two lateral switching accelerometers and a sideslip switch. However, only one of the two accelerometers has been employed on aircraft flown. Recent rudder monitor studies have shown that the one-accelerometer system set at .3g provides adequate protection against damper failures throughout the flight envelope, except at speeds above 700 kts. EAS, and at supersonic speeds above 60,000 ft. The main advantage of the two-accelerometer system is that it gives better protection against nuisance disengagements. Further studies are required before a decision can be made on the necessity for revising the system.

The overshoot in slideslip angle, after switching from normal damper to emergency damper, has necessitated a reduction in slip switching angle from 10° to 6°.

16.0 OXYGEN SYSTEM

16.1 OXYGEN SYSTEM - ARROW 1

The basic design of the ARROW 1 oxygen system is now complete, although three minor alterations are under consideration as a result of operating experience:

(1) A warning system to indicate excessive oxygen consumption.

(2) A press-to-test switch on the contents indicators.

(3) More positive identification of the engaged position of the oxygen converter quick disconnect.

16.2 OXYGEN SYSTEM - ARROW 2

A scheme for attaching the emergency oxygen bottle to the ejection seat has been submitted to the Martin-Baker Aircraft Company Limited. The brackets will be attached to the seats by Martin-Baker, but AVRO will be responsible for the installation of the oxygen bottles.

17.0 ARMAMENT SYSTEM

17.1 ARROW 2 WEAPON PACK

During the past quarter, drawings were prepared for the production weapon pack, incorporating the changes resulting from the test program. (ref. para. 28.7).

17.2 MISSILES

17.2.1 MISSILE PROTECTION

A jettisonable cover has been designed to protect the missile from the excessive skin temperatures which will be encountered at speeds in excess of Mach 1.5. A one-inch airspace will be maintained between the outer surface of the protective cover and the missile to act as a heat barrier. Preliminary wind tunnel tests have been conducted at NAE on the jettison characteristics of the cover. However, the results were inconclusive and more elaborate tests were being conducted prior to the cancellation of the Sparrow 2D contract.

17.3 ALTERNATIVE WEAPONS (GENIE)

As a result of an RCAF request for alternative weapon installations on ARROW aircraft, a design study has been submitted by AVRO to the RCAF. This study was presented in two parts; "The Installation of Two Genie Missiles in the ARROW Aircraft" Report No. 72/SYSTEMS 26/165 and "Program Proposal for Genie Rocket Installation in ARROW Aircraft" Report No. 72/ENG PLAN/20. In early September AVRO was informed by the RCAF that the thirty-eighth and subsequent aircraft must have complete provisions to carry either the Sparrow 2 or Genie weapon packs.

The proposed installation will provide for the carriage of two Genie long range rockets, capable of being fired in separate attacks. This installation would allow additional internal fuel to be carried within the weapon pack structure. It was proposed that re-arming with Genie rockets be accomplished without lowering the pack from the aircraft.

Ground support equipment will be designed to meet these requirements.

AVRO will amend the mathematical model to include a study of operational procedures and tactics that will optimize the "figure of merit" for the weapon system with Genie rockets.

17.4 CANCELLATION OF THE SPARROW MISSILE PROGRAM

As a result of the Government decision to cancel the Sparrow missile development program, AVRO started design work an a Genie missile installation.

18.0 ESCAPE SYSTEM

A proposed development program for the ARROW escape system (Report No. 72/SYSTEM 24/205 - "Development Program for the ARROW Escape System"), has been approved by the RCAF. This program is intended to form the basis for testing and developing the existing escape system, up to its maximum performance.

Preliminary discussions have been held between AVRO and Martin-Baker regarding the development of the escape system. Martin-Baker is developing the MK 5 seat for the U.S. Navy, and intends to continue this development program until successful sled ejections (with dummy occupants) can be made at 740 knots. In addition, live ejections may be conducted from an aircraft flying at 695 knots at 10,000 ft.

18.1 LINKED EJECTION

Investigations have shown that the present system of ejection, in which both crew members eject themselves independently, is unsatisfactory under some flight conditions. It is therefore proposed to introduce a linked escape system. This system will utilize automatic sequencing which would first eject the observer and then the pilot. The ejection sequence will be initiated by the pilot. Independent ejection will be possible at any time prior to pilot initiation of the sequence, or in the event of sequencing system failure.

At AVRO's request, a linked escape system for the ARROW, is under consideration by Martin-Baker. They have requested AVRO to supply a wooden mock-up of the cockpit area, and this will be shipped to Martin-Baker as soon as it is available.

18.1.1 ARM AND HEAD RESTRAINT

Arm and head restraints are under consideration by Martin-Baker for the MK 5 ejection seat. These restraints will be incorporated in the AVRO-proposed linked escape system.

18.2 DUPLICATE CANOPY FIRING CARTRIDGES (For Canopy Opening)

Martin-Baker has investigated and will provide preliminary design drawings of a system employing duplicated canopy firing cartridges. Detail design will be finalized when the cockpit mock-up has been received from AVRO.

18.3 SLED TESTING OF THE ESCAPE SYSTEM

Coleman Engineering has tendered on the sled test portion of the proposed escape system development program, and negotiations are under way between AVRO, Coleman and USAF for the use of the sled testing facilities at Hurricane Mesa.

19.0 DRAG CHUTE

19.1 RELEASE MECHANISM - ARROW 1 AND 2

It has been found that the force required to operate the drag chute release mechanism was excessively high, and the control could be moved inadvertently to JETTISON when selecting STREAM. To overcome this condition, the spring damper in the drag chute release mechanism will be replaced with a spring loaded lever, arranged so that approximately 13 lb. is required to move the cockpit control from the STOW position (the present load is specified as approximately 28 lb.). The control force will gradually decrease to 10 lb. as the STREAM position gate is reached. Between STREAM and JETTISON, the control force will remain at approximately 10 lb.

19.2 DRAG CHUTE PACK - ARROW 1

During a recent landing of aircraft 25202, the drag chute failed to deploy. The drag chute doors opened, but the pilot chute fouled and was not ejected into the airstream. This drag chute pack was one of the earlier types in which the pilot chute pocket lies flush with the top of the deployment bay. Other packs of the same type were examined and it was found that in several packs, the pilot chute was caught under the seam of the pilot chute pocket flaps. In each case when the pilot chute release pin was withdrawn, there was a slight hesitation before the pilot chute ejected.

All deployment bags with the flush type pilot chute containers have been returned to the manufacturer to have the pilot chute pocket altered to the raised type, and also to have the pocket flaps modified to the latest drag chute design. In addition, the leather sleeve which fits over the clevis has been shortened to prevent any possible interference with positioning the pack in the drag chute box.

19.3 DOOR POSITION INDICATOR - ARROW 1 AND 2

A mechanical indicator is being incorporated in the rear fuselage stinger to provide a positive indication to servicing personnel that the drag chute doors are locked. The indicator consists of a lever which lies flush with the door skin when the doors are locked.

19.4 SLEEVE TYPE DRAG CHUTE PACK

The sleeve type drag chute pack was discussed in para. 18.1 of the previous ARROW Quarterly Technical Report. Three such packs have been ordered and will be delivered when drag chute retaining loops have been installed.

PART 4

STRUCTURE

20.0 STRESS ANALYSIS

20.1 THERMAL STRESS ANALYSIS

The thermal stress analysis program was discussed briefly in paragraph 19.1 of the previous ARROW Quarterly Technical Report. The completion of stage 1 of this program has established the approximate thermal stress values in the major structural members of the ARROW. An analysis of the results will determine the extend of future study.

20.2 STRUCTURAL INTEGRITY PROGRAM - ARROW 1

An analytical program is being set up to automatically calculate airframe stresses from data inputs, such as aircraft motion, fuel distribution, Mach number and altitude. The stresses measured during the structural integrity flights will be compared with the analytically derived airframe stresses.

20.3 THIRD STRUCTURAL MATRIX

The third structural matrix which was described in the March issue of the ARROW Quarterly Technical Report, is continuing.

20.4 STRESSING OF HYDRAULIC PIPING

The stress investigation of ARROW hydraulic piping is continuing. Stress investigations of the flying controls system hydraulic piping is nearly complete, and the utility system will be investigated next. Various piping is being changed on ARROW 1 aircraft where greater pipe strength or flexibility is required.

NOTE: Stress analysis on individual aircraft components is discussed in detail in Section 22.

21.0 ARROW 2 MOCK-UP

21.1 SUMMARY OF MOCK-UP ACTIVITIES

As the result of the ARROW 2 mock-up conference held in September 1957, a total of 252 change requests required investigation. The effect of these changes are being determined by AVRO, RCA, Martin-Baker and the RCAF.

21.2 STATUS OF MOCK-UP CHANGE REQUESTS

The current status of the 252 change requests are listed below.

Subject	Code	Change Requests	STATUS: Under Initial Investigation	Undergoing Corrective Action	Completed	Demonstration Required
Cockpit	A	62	11	11	40	5
Structure	B	51	5	3	43	1 *
Engine Installation	C	17	-	-	17	-
Electrical	D	22	2	4	16	-
Air Cond'g	E	7	-	2	5	-
Low Press. Pneumatics	F	1	-	-	1	-
Fire Exting. System	G	3	-	-	3	-
De-Icing	H	2	-	-	2	-
Fuel System	I	11	2	1	8	1
Hydraulics	K	15	-	2	13	-
Oxygen System	L	5	-	1	4	1
Instruments	M	7	2	-	5	-
ASTRA I	N	34	4	3	27	1 *
Armament	O	15	2	4	9	1
TOTALS		252	28	31	193	10

* Explanatory data will be provided in lieu of demonstration for these items.

The following items will be either demonstrated or covered by letter(s) to the RCAF.

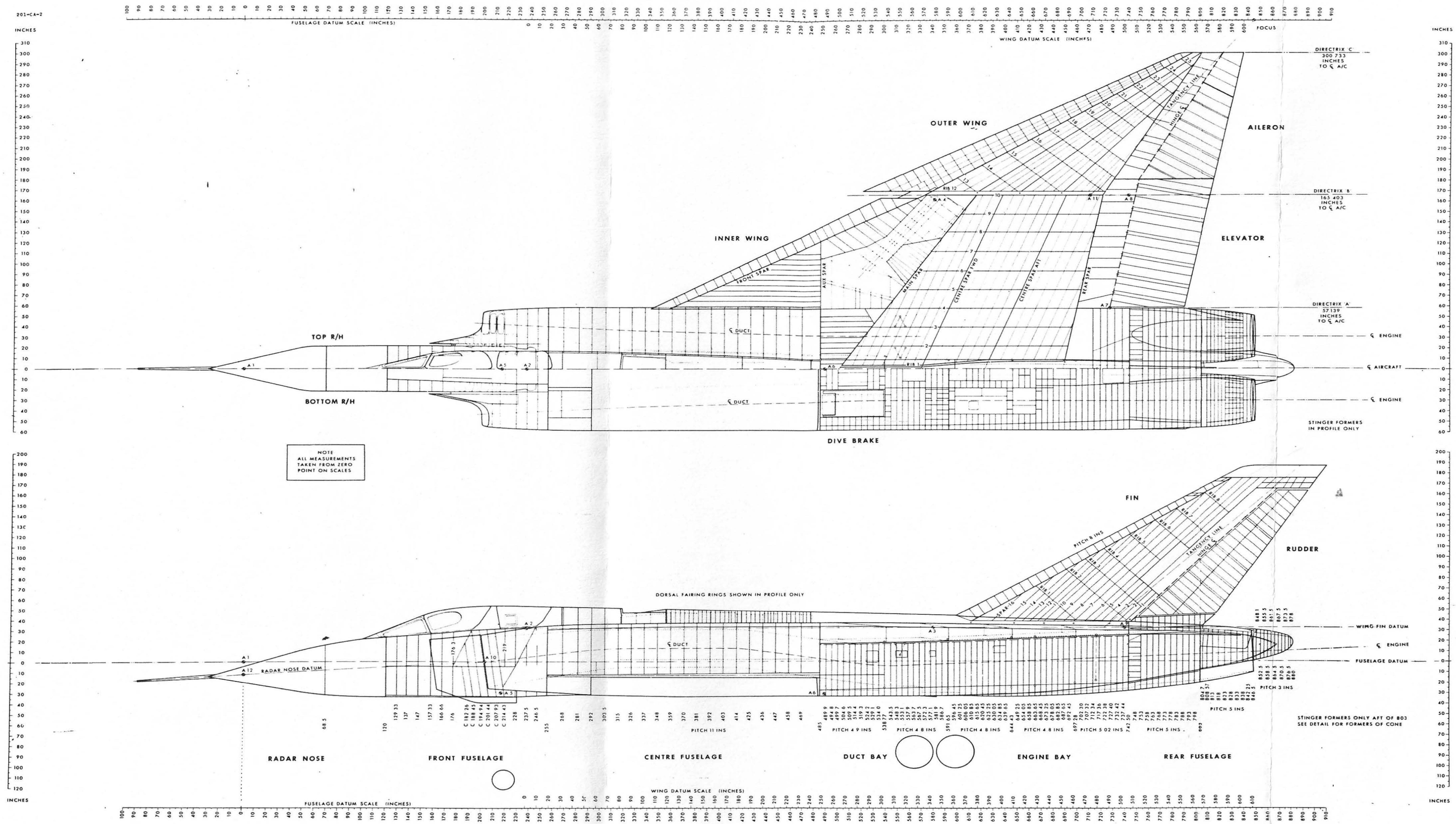


FIG. 23 ARROW STATION AND DATUM LINES

Description	Ref. Code	Form of Demonstration
Pilot's and observer/AI's seat	A. 24	Aircraft
Console lights	A. 8 (Cat. 1)	Aircraft
Cockpit lights	A. 12 (Cat. 1)	Aircraft
Map lights	A. 37 (Cat. 1)	Aircraft
Intensity of light	A. 38 (Cat. 1)	Aircraft
Facilities for bladder tank removal	B. 11 Pt. 2	Letter
Facilities to remove fuel booster pump gear box	I. 1 (Cat. 1)	Aircraft
Seat oxygen equipment	L. 5	Aircraft
Antenna multiplexing	N. 18	RCA to clear by letter.
Missile umbilical plug and rail	0. 7	Test rig

Items in the above list with their category marked in brackets e.g. (Cat. 1) were changed as a result of the mock-up conference, and will be redemonstrated.

21.3 CANCELLATION OF ARMAMENT AND ELECTRONIC PROGRAMS

The recent Government decision to cancel the Sparrow 2D missile and ASTRA I electronic system will affect the status of mock-up change requests, particularly with regard to those two systems. This change will be reflected in the next Quarterly Technical Report.

22.0 COMPONENT DESIGN

22.1 WING DESIGN - ARROW 1 AND 2

As a result of fatigue tests conducted on the tank structures, modifications are required to wing fuel tanks 3 and 4. The modifications (local reinforcing) will be introduced on aircraft 25208 and will be retrofitted to all earlier aircraft.

A fuel sump is being incorporated in fuel tank No. 5 to decrease the amount of unuseable fuel (ref. para 13.1). This change will be introduced on aircraft 25208, 25212 and subsequent.

Three cameras will be installed on aircraft 25208 to record jettison characteristics of the long range fuel tank. Two of the cameras will be located in a fairing on the left-hand outer wing. The third camera will be located in a fairing mounted on the radar nose (ref. para 22.3.2).

22.2 WING STRESS - ARROW 1 AND 2

The fatigue analysis is continuing on the elevator and aileron control boxes.

The schemes for the split elevator and aileron have been stress approved. (Ref. previous ARROW Quarterly Technical Report, para 21.1).

22.3 RADAR NOSE DESIGN

22.3.1 RADAR NOSE DESIGN - ARROW 1

Schemes for the fixed camera installation in aircraft 25203 have been completed. The preliminary investigation on the installation of a strike and servo camera in aircraft 25204 and 25205 has not yet been completed.

22.3.2 RADAR NOSE DESIGN - ARROW 2

Design work has been completed for the instrumentation installation in aircraft 25207 and drawings are currently in work for aircraft 25209 and subsequent. Drawings are also in work for the recording camera to be used in conjunction with the jettison tests on the long range tank. (Ref. para 22.1).

22.4 RADAR NOSE STRESS - ARROW 1 AND 2

Work continues in clearing design changes and instrumentation drawings.

22.5 FRONT FUSELAGE DESIGN

22.5.1 FRONT FUSELAGE DESIGN - ARROW 2

The air intake side skins and stiffeners (between stations 202 and 255), have been redesigned to prevent cracking of the external side skins. Design work has been completed on the flying controls booster installation, and cockpit ducting and silencers. The design for partial ASTRA installation in aircraft 25206, and full ASTRA in aircraft 25209 and subsequent has also been completed.

22.6 FRONT FUSELAGE STRESS - ARROW 1 AND 2

The preliminary investigation has been completed on the use of Sierracin 880 with sierracote demisting medium for the windshield and canopy. The main advantages of this material with respect to glass, which is used at present, are the considerable reduction in weight and the improved optical properties.

Material evaluation tests are in progress, and qualification testing of the Obs/AI canopy window, employing Sierracin 880, will be conducted in the near future.

22.7 CENTRE FUSELAGE DESIGN

22.7.1 CENTRE FUSELAGE DESIGN - ARROW 2

As a result of repeated failures, the dorsal fairing latches are currently being redesigned.

Fibreglass heat exchanger outlet ducts are being manufactured on an experimental basis for evaluation.

22.8 CENTRE FUSELAGE STRESS - ARROW 1 AND 2

Work continues on clearing design changes. Material evaluation and investigations will continue on the Fibreglass heat exchanger outlet when the duct has been manufactured.

22.9 DUCT BAY DESIGN - ARROW 1 AND 2

No major design work has been done on the duct bay during the past quarter.

22.10 DUCT BAY STRESS - ARROW 1 AND 2

Work continues on the clearing of minor changes.

22.11 ENGINE BAY DESIGN

22.11.1 ENGINE BAY DESIGN - ARROW 2

Design work has been completed for relocating the air flow restrictor shroud and variable restrictor (reference previous Quarterly Technical Report, para 21.11).

22.12 ENGINE BAY STRESS - ARROW 1 AND 2

Work continues on the clearing of minor changes.

22.13 REAR FUSELAGE DESIGN - ARROW 2

The design of the jettisonable nozzle for the ARROW 2 has been temporarily suspended because of higher priority work. However, production drawings for the necessary structural provisions have been completed and stress approved.

22.14 REAR FUSELAGE STRESS - ARROW 2

An investigation is being conducted to determine the possibility of producing a lighter and more easily manufactured tailcone for the ARROW 2, while at the same time reducing the possibility of skin buckling.

22.15 FIN AND RUDDER DESIGN - ARROW 1 AND 2

Design work has been completed for the IR seeker installation on aircraft 25209 and subsequent, and for the dummy IR seeker to be used for a trial installation on aircraft 25202.

Present design work includes incorporating the nitrogen cooling system for the IR seeker.

22.16 FIN STRESS

The preliminary stress clearance of the IR seeker installation has been completed. The schemes for the split rudder have been stress approved.

22.17 LONG RANGE TANK DESIGN

Design work has been completed for the following:

(a) Introduction of a weak portion in the rear fairing at the fuel disconnect location. This will reduce the possibility of damage to the fuselage structure during tank jettisoning.

(b) Increase in length of the rear fairing to reduce aerodynamic drag.

Design work on the tank is complete, except for the rear fairing and fin.

22.18 LANDING GEAR DESIGN

Subsequent to the failure of the L.H. main landing gear on aircraft 25201 (ref. previous Quarterly Technical Report), the ARROW 2 landing gear was examined to determine its suitability for use on the ARROW 1. However, stress investigations showed the ARROW 2 landing gear to be unacceptable, as the extension mechanism links were under-strength. In order to temporarily overcome the friction problems in the ARROW 1 landing gear extension mechanism, a stronger extension spring was incorporated (ref. previous ARROW Quarterly Technical Report).

A redesign of the ARROW 1 landing gear extension mechanism has since been undertaken, and the design changes will be incorporated in an interim ARROW 2 landing gear. A complete review and partial redesign of the final ARROW 2 landing gear is being undertaken by Dowty in England.

22.18.1 LANDING GEAR DESIGN - ARROW 1

The redesign of the ARROW 1 main landing gear is continuing. Several modifications are being made to the locking mechanism and extension springs. The extension spring force will be increased to 1000 lb in the extended position and to approximately 200 lb in the contracted position. This increase in spring force has necessitated an increase in strength of the retraction chain and its attachments.

The extension mechanism is being redesigned to reduce friction, which is considered to be the initial cause of the left-hand main landing gear failure on aircraft 25201 (ref. previous Quarterly Technical Report para 21.18).

The main landing gear retracting jack lug which is attached to the upper portion of the back stay, failed during retraction tests on aircraft 25203 and 25204. As a temporary measure, this has been remedied by replacing the cross shaft spacer with a fitting which incorporates an integrally machined retracting jack lug, and by removing the retraction lug from the back stay. In addition, the landing gear pivot door has been modified to provide clearance for the new retracting lug. The present retracting lug which is mounted on the back-stay, is now being redesigned and the back-stay will be retrofitted to all ARROW 1 aircraft.

On several occasions, following retracting tests on aircraft 25202 and 25203, bending of the landing gear up-lock hook was noted, and in some cases the cracking of the uplock side casing occurred. The bending was caused by improper adjustment of the up-lock, and cracking of the side casing was due to insufficient clearance between the up-lock hook and the side casing. This problem has been overcome by trimming the up-lock to prevent interference with the side casing, and incorporating a retaining spring to maintain centring of the hook.

22.18.2 LANDING GEAR DESIGN - ARROW 2

The design of an interim landing gear for the ARROW 2 is in progress. The gear will use the modified ARROW 1 shortening mechanism and legs manufactured to the original ARROW 2 landing gear design.

The proposed objectives in the redesign of the ARROW 2 main landing gear include revisions to the leg shortening mechanism, the main leg forging and the top end of the shock absorber strut.

22.18.3 TIRES

In order to reduce tire wear and tread damage, AVRO is investigating the replacement of the standard tread tires, currently used, with a tire having an improved, fabric-base laminated tread. Ribbed pattern, fabric-tread tires are currently being evaluated on ARROW 1. An improved tire, with a fabric reinforced dimple-type tread is proposed for ARROW 2.

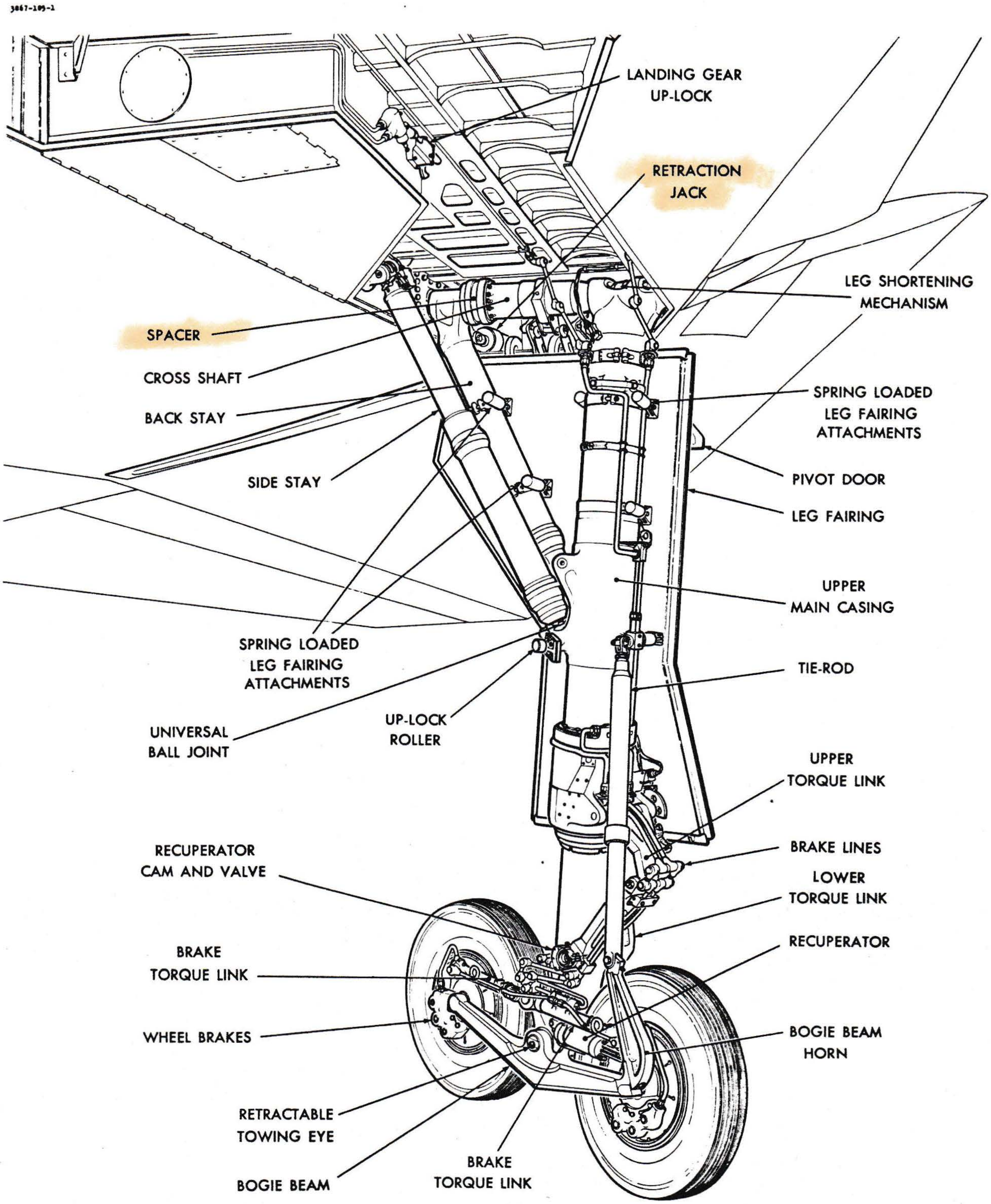


FIG. 24 LEFT-HAND MAIN LANDING GEAR ASSEMBLY

PART 5

RELIABILITY, MAINTENANCE AND SUPPORT

23.0 MAINTENANCE AND RELIABILITY

23.1 PERSONNEL REQUIREMENTS DATA (PRD)

AVRO's portion of the PRD study is proceeding according to schedule and a preliminary report covering eight systems was forwarded to the RCAF at the end of September.

During the reporting period, several meetings were held between AVRO and other associate contractors to discuss the respective personnel requirements. Contractual arrangements however, have not yet been made by the DDP with Orenda Engines and Canadair Limited, and this is resulting in a serious delay in the program agreed to between AVRO and the RCAF. Since the commencement of Phase 4 (Planned Maintenance Study) of the PRD program depends upon receipt of all associate contractors submissions, it is impossible to predict either the commencement date of Phase 4 or the final completion date of the entire PRD study.

23.2 MAINTENANCE INSTRUCTIONS

All the necessary maintenance instruction reports and inspection schedules have been issued and are being used by AVRO personnel. These documents will be amended as experience is gained during the development flight test program.

23.3 GROUND SUPPORT EQUIPMENT

Maintenance Report No. 70/GEQ/2-2 (Ground Equipment Required for AVRO Development Program) was issued 12 September 1958 and covers the ground support equipment required for the 37-aircraft program.

23.4 RELIABILITY ANALYSIS

A Defect Reporting System proposal is being prepared by AVRO for the RCAF. This system will provide quick, complete and accurate data on all equipment, and structural component defects in the field. The data will be used to conduct statistical reliability analysis on the ARROW Weapon System and will lead to:

(a) Product improvement

(b) Optimization of preventative maintenance, by adjustment of overhaul and replacement schedules.

(c) Improvement of maintenance techniques and inspection procedures, by studies of man-hours and down times.

(d) Optimization of the weapon system logistics support, by ensuring the availability of spares based on results of performance statistics.

Development defects and utilization data have been collected from the first four aircraft during the past quarter. Monthly tabulations of defects are being prepared to assist in spares provisioning. The use of the IBM 704 to record utilization data has started, and the records for 25201 are currently being recorded.

23.5 EQUIPMENT QUALIFICATION

The qualification status of bought-out equipment items for ARROW 1 is now as follows:

Qualified items	209
Limited flight approval items	292
Items which do not require qualification action	231
Government furnished airborne equipment	49
Items to be qualified	17
TOTAL	798

The qualification status of bought-out equipment items for ARROW 2 is as follows:

Qualified items	19
Qualified items common to ARROW 1 and 2	76
Items which do not require qualification action	63
Items common to both ARROW 1 and 2 (unqualified)	114
Items applicable to ARROW 2	289
TOTAL	561

This total does not include electronic system or Government Furnished Airborne Equipment, all of which is currently under review.

24.0 GROUND SUPPORT EQUIPMENT

24.1 GROUND SUPPORT EQUIPMENT - ARROW 1

Engineering is complete on the Goodyear brake wrench and the engine alignment template. Five items are required to complete the ARROW 1 ground support equipment:

(a) Winch to raise the fire extinguisher bottles into the aircraft.

(b) * Nose landing gear door lock.

(c) * Complete aircraft adapter sling.

(d) * Wind sensor cover.

* During the past quarter, these items have been added to the ARROW 1 ground support equipment list by AVRO, and are currently being designed.

The requirement for a canopy pip-pip removing tool has not been deleted.

24.2 GROUND SUPPORT EQUIPMENT - ARROW 2

The following items have been added to the ARROW 2 ground support equipment list, and are currently being designed:

Radar door strut.
Accessories gearbox installation stand.
Nose wheel axle extractor.
Oxygen converter trailer.

Engineering has not yet been completed on the following items which are required for the ARROW 2 ground support equipment:

Weapon pack test console.
Air conditioning compressor exhaust cover.
Armament harmonization stand.
Main landing gear installation stand.
Nose landing gear installation stand.
Universal stand for removal of aileron and elevator control boxes.
Constant speed unit support.
Aircraft component slings for:
  - Radar pack.
  - Ailerons.
  - Aileron control box.

The following items of bought-out ground support equipment have yet to be completed:

Air turbine engine starter.
Power and air conditioning truck.
Squadron-type flight line test equipment for ARROW 2 damping system.
Pitot static tester.
Damper test stand.
Test equipment for damping system hydraulic servo valve.
Test equipment for General Radio Corporation Model MD-1 variable capacitor.
Test set veritherm.
Iroquois engine shipping stand (air).
Fuel CG system test equipment.
Tests set-fuel sequencing control system.
Tool expander and compressor for Marman joints.

24.2.1 MOBILE GROUND POWER UNITS

Proposals for air conditioner/generator units and starter units have been received from equipment vendors. An engineering evaluation has been completed on the proposals and recommendations forwarded to the Procurement Department.

24.2.2 IR SEEKER COOLING (GASEOUS NITROGEN)

AVRO has requested RCA to undertake the servicing of the IR seeker cooling system at Malton and Cold Lake. In addition, RCA was requested to investigate alternative systems with a view to reducing the weight and servicing problems associated with the existing gaseous system. However, further work on this cooling system has now been stopped as a result of the recent Government decision to cancel the ASTRA I contract.

24.2.3 WEAPON PACK TEST CONSOLE

An interim weapon pack test console has been designed and is being manufactured. This unit will provide a means for determining the final console configuration. This console will now require modification as a result of the cancellation of the Sparrow 2D contract.

24.2.4 DAMPER TEST EQUIPMENT

Evaluation of damper test equipment is continuing during the current flight test program. Honeywell has not yet produced a proposal on test equipment for the production type damper. AVRO is attempting to expedite the preparation of this proposal because of the long lead time required to develop and produce this equipment.

A critical situation has arisen in the procurement of the remaining interim damper test equipment for use in the development program. The RCAF was requested early in July to arrange procurement authority for this equipment, but such authority has not yet been received. Any further delay in the supply of this equipment will seriously affect the progress of the development program.

24.3 GROUND SUPPORT EQUIPMENT EVALUATION CONFERENCE

An engineering evaluation of the available ground support equipment was held by the RCAF from 23 to 26 September. Items of equipment demonstrated are listed in an Amendment to AVRO Report 72/GEQ/11 (Proposal for the Ground Support Equipment Demonstration and Evaluation Conference). A number of changes were recommended by the conference and these are currently being actioned.

25.0 AIR BASE FACILITIES

25.1 AIRCRAFT RUN-UP BASE

The study for an aircraft run-up base, discussed in the previous Quarterly Technical Report, has not yet been issued, as more detailed information is required from Orenda Engines Limited on defect analysis of an installed engine.

25.2 2ND LINE MAINTENANCE FACILITY

A preliminary draft of this report is being revised to reflect changes caused by the cancellation of the Sparrow and ASTRA contracts.

26.0 WEAPONS SYSTEM TRAINER

26.1 AIRCRAFT SYSTEMS TRAINER

A preliminary specification for the ARROW Aircraft Systems Trainer (AST) has been received from the RCAF, and design work is proceeding. Contractual authority has not yet been received from the DDP.

26.2 GROUND EQUIPMENT TRAINER

A technical proposal for the ARROW 2 Ground Equipment Trainer (GET), submitted to the RCAF in June 1958, has not yet been approved by the RCAF.

26.3 CANCELLATION OF ASTRA I AND SPARROW 2D PROGRAMS

Subsequent to the information contained in Sections 23 to 26 inclusive, the Government cancelled the ASTRA electronic system and the Sparrow 2D missile programs. This will necessitate a review of the entire maintenance and ground support equipment requirement, which will be reported as information becomes available.

PART 6

TESTING

27.0 STRUCTURAL GROUND TEST PROGRAM

27.1 STATIC TESTING OF THE COMPLETE AIRCRAFT

Tests have been completed on the landing gear spring back case. Preliminary tests, applying loads up to 60% of limit load, were satisfactory. However, during subsequent tests to 70% limit load, the right-hand main landing gear back stay failed at 60%. These tests will be repeated at a later date, using an improved back stay which is now undergoing tests at Dowty Equipment Limited.

Fatigue tests were conducted on the right-hand elevator, and the shear fitting at rib 4 failed just aft of the rear spar at 60% limit load. The fitting was removed and testing to 100% limit load was resumed. Repeated applications of 100% limit load were discontinued after 33 cycles, when excessive movement of the inboard end of the top skin splice was observed at the rear spar. Examination of the skin revealed cracks at a 1/8 in. dia. hole adjacent to the edge of the skin. In addition, attachment holes at the inboard end of the skin were found to be elongated. The 1/8 in. dia. hole is not shown on engineering drawings and is apparently used for manufacturing purposes. The Manufacturing Division has been notified of this condition and is taking appropriate action.

Repairs and minor strengthening modifications to the failure area have been completed and elevator fatigue tests will be resumed at a later date.

Preparations are being made to conduct tests on the rolling pull-out case, using limited instrumentation. Only strains and deflections in the critical areas will be measured during this test, which has been instituted to enable flight testing to continue within an extended flight envelope.

Adjustments to the test rig counter-balancing system have been completed. In addition, the wing fuel tanks have been filled with Pella oil and pressurized to 26 psi in readiness for the ensuing rolling pull-out tests. A preliminary test loading to 5% revealed minor faults in the engine side loading linkage. These faults were rectified prior to further preliminary tests to 25% of limit load, during which faults in the engine tie-down became evident. The fin whiffle tree support caused an unequal loading on the engine rear tie-down rods when more than 10% limit load was applied to the aircraft. Investigations are in progress to rectify this prior to conducting further rolling put-out tests.

27.2 STRAIN GAUGE INSTRUMENTATION

Tests are still being continued to investigate the effects of time and environment on strain gauges. So far, results indicate that time and environment do not materially affect the gauges.

27.3 PRODUCTION ENGINE DUCT TEST

Proof pressure tests have been conducted on the engine duct installed in aircraft 25204. A secondary purpose of the tests was to ensure that the pressure removed any minor duct deformations which may have been caused during manufacture.

Future tests on production engine ducts are now the responsibility of the Manufacturing Division.

27.4 DEVELOPMENT OF HIGH TEMPERATURE STRUCTURAL TEST TECHNIQUES, AND INVESTIGATIONS OF TEMPERATURE DISTRIBUTION THROUGH TYPICAL STRUCTURAL SECTIONS

Work on these subjects is in abeyance and test rigs and specimens have been placed in storage.

27.5 ACOUSTIC FATIGUE TESTING

Tests are being continued to determine the effect of adding damping material to fuselage side skin panels which are subjected to acoustical pressure and frequency.

Tests at room temperature on an undamped panel resulted in failure of the panel after approximately one hour, at 149 db. A similar panel damped with viscous tape at areas of high stress, has endured nine hours without failure, under similar temperature and noise conditions.

High temperature tests have been proposed and arrangements for heating the specimen are now under investigation.

Acoustic fatigue tests have been completed on a stinger panel, and investigations of crack propagation have been made.

Further tests have been conducted on a tail cone panel, but have been delayed for re-installation of strain gauges which were damaged during testing. Strain gauge leads continue to fracture during tests, and Tatnol foil-type gauges will be used on future acoustic testing, in place of the Baldwin gauges.

27.6 ENGINE LIFTING MECHANISM FATIGUE TEST

Fatigue tests have been completed on five specimens of the engine lifting mechanism, with the following results:

Test Loading (Pounds)	No. of Cycles to Failure
0 to 5,320	10 million without failure
0 to 8,520	155,500
0 to 15,000	20,500
0 to 21,300	4,900
0 to 21,300	3,715

These results are considered satisfactory, and no further fatigue testing is anticipated. A static strength test now in preparation is expected to complete this program.

27.7 STRENGTH OF DIMPLED JOINTS IN N. 155 (STAINLESS STEEL) MATERIAL

Samples have been made of typical plate joints in N. 155 material, employing the dimpled riveted plate technique. The samples have been examined by the Metallurgical Laboratory to ensure that they are free from cracks, and tests are now in progress.

27.8 STRENGTH AND ABRASION TEST OF REAR PIVOT BEARING

Strength and abrasion tests have been conducted on one specimen of the landing gear pivot bearing. The tests involved rotating the bearing through 90° while under a 41,600 lb load; this load was then removed and 186,000 lb loading was applied at right angles to the direction of the first load. The loading cycle was repeated 200 times. The bearing was stripped and examined for wear after each 50 cycles of loading. Measurements after completion of testing showed that the bearing axial clearance had increased .0063 in. and the radial clearance had increased .0025 in. These results are now being analyzed.

27.9 ATTACHMENT OF AILERON CONTROL BOX SKIN TO MAIN TORQUE BOX AT REAR SECTION

Specimens representative of the aileron control box to main torque box skin attachment have been manufactured. A range of specimens were manufactured: some with close tolerance bolt holes and the others with approximately .006 in. clearance holes for the attachment bolts.

Static strength tests at AVRO resulted in failure of the attachment at 22,000 lb loading, and this is considered satisfactory. Four specimens have undergone fatigue tests at Krouse Testing Machines Inc., and the results are currently being analyzed. A further sixteen specimens, representing various portions of the attachment, are to be dispatched to Krouse for testing.

27.10 DUCT PRESSURE CYCLING TESTS - ARROW 2

Pressure tests have been conducted on a duct from the centre fuselage portion of the air conditioning system. Pulsating pressures from 25 psi to 190 psi at 790°F were applied. The duct successfully withstood 10,000 cycles of testing, and this was considered satisfactory. A duct from another portion of the air conditioning system was also tested, at pressures from 10 psi to 60 psi, at 790°F, and this was also considered satisfactory.

27.11 ATTACHMENT OF TRAILING EDGE HINGE TO ELEVATOR CONTROL - FATIGUE TEST

Fatigue tests conducted at Krouse Testing Machines Inc. on 21 specimens were not entirely satisfactory. Three specimens were modified to incorporate ribs, but subsequent static tests on these were also unsatisfactory. Additional modified specimens are being manufactured for further static testing at AVRO prior to the resumption of fatigue tests at Krouse.

27.12 THREADED JOINT ON BACKSTAY OF MAIN LANDING GEAR - STATIC AND FATIGUE TESTS

Static strength tests have been completed at AVRO on the threaded joint of the main landing gear backstay. Failure occurred at 397,000 lb loading and this is considered satisfactory. Additional specimens are now undergoing fatigue tests at Krouse Testing Machines Inc.

28.0 SYSTEMS GROUND TEST PROGRAM

28.1 FUEL SYSTEM

Conversion of the ARROW 1 test rig for use on the ARROW 2 fuel system test program is progressing, but equipment shortages are delaying completion. It is considered that testing can begin about mid October.

Development tests have continued on the collector tank air ejector using an ejector with an extended length of parallel throat. The results were satisfactory, but the increased length of the ejector prevented installation in the aircraft. Tests were then continued in an attempt to reduce the ejector length without reducing its efficiency below the required limits. The length was reduced from 23.8 in. to 21.8 in. and resulted in an insignificant lowering of ejector performance. To facilitate installation in the aircraft, it is now considered that the length can be further reduced to 20 in. without serious loss of efficiency.

Subsequent to the satisfactory tests conducted on small diameter "On Mark" couplings (ref. previous Quarterly Technical Report), further tests have been conducted on two-inch and three-inch diameter specimens. The tests were unsatisfactory due to the inability of the couplings to withstand the test pressures involved. Additional samples of Wiggins and "On Mark" couplings have been ordered for further tests.

Development tests on a modified fuel-no-air valve sensing unit have produced a unit which functions in all attitudes over a limited range of differential pressures.

28.2 FLYING CONTROLS SYSTEM

28.2.1 COMPLETE MECHANICAL SYSTEM TEST RIG

As a result of damper development tests, damper constants have been established for all three axes. Dampers have been satisfactorily developed for the aileron and rudder, and their location in the system has been established. Further work will be necessary before the elevator damping is considered satisfactory.

Tests of the elevator system stiffness were unsatisfactory as the system did not incorporate the latest modifications installed in the aircraft. Further testing is therefore required. Tests conducted on the stick force mode in the pitch axis, using a Bell stick grip and amplifier, were satisfactory, though further improvement is desirable. In an effort to eliminate the Honeywell electronic filter, tests were conducted on the stick force mode with a damper installed at the stick, and with parallel servo relief valves adjusted to open at a range of settings which were lower and higher than normal. The test results showed the Honeywell filter is necessary for stable operation of the system.

Frequency response tests have been conducted on the elevator control system, using valve-type dampers. Other tests were conducted using linkage-type dampers installed at various locations in the system. Good results were obtained using linkage-type dampers with reduced damping coefficients working in conjunction with two parallel servos, one at the front and one at the rear of the control quadrant. Further frequency tests of the elevator system followed, with accumulators installed in the system, with and without check valves installed, and with front and rear quadrants locked, to eliminate backlash. A slight improvement was evident when check valves were installed, but results are at present under investigation. Preparations are now in progress for aileron control system stiffness tests.

It has been decided to use Vickers hydraulic pumps in the flying control system. (Ref. para 27.2.1 of the previous Quarterly Technical Report).

The AVRO-designed cable tension regulator quadrant is to be installed in the flying control system. (Ref. para 27.2.1 of previous Quarterly Technical Report).

28.2.2 AILERON CONTROL SYSTEM FUNCTIONAL TESTS

The work of splitting the test rig aileron, in accordance with the latest aileron design, is almost complete (Ref. previous Quarterly Technical Report). The right-hand aileron test rig is being modified in preparation for duty cycling tests with loaded aileron surfaces.

28.2.3 RUDDER CONTROL SYSTEM FUNCTIONAL TESTS

Splitting of the test rig rudder has been completed, and the latest aircraft modifications are now being incorporated on the test rig, prior to duty cycling tests with loaded surfaces.

28.2.4 ELEVATOR CONTROL SYSTEM FUNCTIONAL TESTS

Preparations are being made to split the elevator specimen to confirm with the latest elevator design, and to modify the test rig in readiness for duty cycling tests with loaded surfaces.

28.2.5 HYDRAULIC SYSTEM STEEL TUBING TESTS

Initial pressure cycling tests at the Weatherhead Company, on 3/4-in. and 5/8-in. specimens resulted in early failure of the specimens. The test pressure was reduced in order to obtain stress data, and further tests are currently being conducted. Manufacture of 1/4-in. diameter specimens of an improved material at AVRO has been delayed by a shortage of suitable mandrils.

Influence coefficient tests have been conducted on pipes from the rudder control system, and results are being analyzed.

28.2.6 AILERON JACK FATIGUE TESTS

An aileron jack, modified to the latest design, has been subjected to fatigue tests. Test pressure at the jack was 4,300 psi and jack movement was 5 1/4 in. After 150 cycles of operation it became apparent that insufficient clearance existed between the moving linkage and the rig. The test rig was modified and testing was resumed. A total of 7,100 cycles of operations have so far been achieved. However, it has been necessary to dismantle the test rig in order to install new control valve "O" rings, a new control valve damper, and to replace the jack piston mounting nut. Testing will resume when this work is completed.

28.3 AIR CONDITIONING SYSTEM

28.3.1 ARROW 1

Tests on the ARROW 1 air conditioning system have been directed towards improving conditions in the radar duct, where temperature stratification has been evident. A vortex generator has been developed which improves conditions in the duct.

The production version of the AVRO-designed cockpit temperature controller was tested with satisfactory results.

28.3.2 ARROW 2

Where possible, rig calibrations have been in progress, but lack of some bought-out equipment items is delaying completion of the test rig.

Instrumentation is being installed for the mass flow distribution tests.

Cockpit heating conditions in ARROW 1 and 2 aircraft are still being investigated on the metal mock-up. Insulation is now being installed on some bulkheads which up to now have been uninsulated, and testing will be resumed when this work has been completed.

Leak detection tests have continued using both the Fenwall and pressure sensing type systems. In each case, the results have been satisfactory.

28.4 ELECTRICAL SYSTEM

Manufacture of the loadbanks for the complete breadboard testing of the ARROW 2 electrical system is almost complete. Manufacture of the simulation panels and wiring harness is in progress, but complete conversion of the breadboard to ARROW 2 status is delayed by lack of the necessary equipment items.

The armament system electrical breadboard circuits were modified in order to correct faults revealed during previous tests. Test requirements were fulfilled satisfactorily, although further investigations are now in progress in an effort to improve the circuitry for the system.

28.5 LANDING GEAR SYSTEM

28.5.1 NOSE LANDING GEAR SYSTEM TESTS

Frequency response tests conducted on the electro-hydraulic nose wheel steering system were satisfactory. Initially the potentiometer used in the system was considered unsuitable for flight, but this has now been approved, and will be retained in the system. Tests have been conducted to establish the flow characteristics of the Moog valve incorporated in the nose wheel steering system. Pressure tests on the Moog valve adapter block were satisfactory.

Preparation for testing the nosewheel steering magnetic amplifier are now in progress.

28.5.2 MAIN LANDING GEAR

Main landing gear tests have been directed towards qualifying main landing gear components for installation in the aircraft.

A modified door actuating jack has now been received from Dowty, and preparations are underway for landing gear door system tests.

28.6 CANOPY AND ESCAPE SYSTEM

A proposal has been received from the Coleman Engineering Company for the ARROW escape system sled test program, and is now under consideration. Preliminary discussions have taken place between AVRO and the Special Projects Branch at Wright Air Development Centre on the use of USAF facilities for the program. (Ref. para 18.3).

Tests to determine the canopy opening and closing loads show that they are not excessive at room temperatures, and are within the capacity of the system actuators.

28.7 SPARROW MISSILE PACKAGE

28.7.1 MISSILE EXTENSION MECHANISM TEST

Assembly of the test rig was completed and preliminary functioning tests revealed a discrepancy in jack volumes, which prevented proper functioning. Modified jacks were installed in the rig and preliminary functioning tests resulted in damage to the newly modified jacks. Further modified jacks were obtained from Dowty and functioning tests conducted in an unloaded condition. Inspection of the mechanism after 200 accumulated cycles of operation has revealed wear in the telescopic links and bushings.

The test rig was being re-assembled for further tests when instructions were received cancelling further work on the missile extension mechanism.

28.7.2 MISSILE INSTALLATION ON ARROW 2

Manufacture of the missile pack was completed by the Experimental Department and it was installed in a ground servicing rig in the Ground Test Laboratory.

28.7.3 DEVELOPMENT OF MISSILE LAUNCHER

Eighty test firings have been completed, using the production type missile launcher. Examination revealed some wear on the launcher rail, but this is considered negligible. Difficulties experienced in removing shear pin fragments from the safety catch assembly have been overcome by modifications to the safety catch. Missile launcher development has now been stopped as a result of the recent Sparrow 2D missile cancellation.

28.7.4 QUALIFICATION OF DETONATOR ASSEMBLIES

Further samples of explosive bolts were made, incorporating AVRO-designed modifications. Tests were conducted and three out of four samples sheared satisfactorily. Orders have since been issued cancelling further tests.

28.8 MISCELLANEOUS SYSTEM TESTS

28.8.1 TESTS ON AUTOMATIC QUICK-DISCONNECT COUPLINGS FOR GROUND ENERGIZERS

The redesigned air conditioning quick-disconnect coupling is not yet available for testing, but preparations are being made for tests on the intercommunications and engine starting couplings. (Ref. para 27.5.3.1 of previous ARROW Quarterly Technical Report).

28.8.2 TESTS ON CONNECT-O-MATIC AND PARKER LOW PRESSURE COUPLINGS

During pressure tests on Connect-o-matic and Parker hydraulic couplings, considerable fluid was lost from each type, and connection could not be made against 200 psi system pressure. A screw-type coupling, made by the Midland Gear Co., gave satisfactory results, but did not satisfy the connecting time requirements. Further specimens manufactured by York Gear will be tested when available.

28.8.3 LIFE TEST - SWIVEL JOINT 1/4-LINE TYPE

The hydraulic swivel joint was subjected to 100,000 cycles of operation in conjunction with pressure pulsing, and completed the tests satisfactorily at room and high temperatures.

Similar tests at high temperature, with vibration applied, were also satisfactory, and no further tests are anticipated.

28.8.4 DRAG CHUTE OPERATING FORCES

Ground tests conducted on aircraft 25203 revealed that a force of 65 lb. was required on the drag chute release lever to operate the drag chute. This was considered excessive and efforts are being made to reduce this force. (Ref. para 19.1).

29.0 FLIGHT TESTING

29.1 AIRCRAFT 25201

An inspection of the aircraft was completed to assess the damage resulting from the accident reported in the previous Quarterly Technical Report. X-ray and dye crack detection techniques were used to supplement the visual inspection.

It was found necessary to repair the aircraft in the following areas; fuselage skin under the left and right-hand engine bays, the left-hand intake ramp, nose section structure, left-hand speed brake, skin under the left-hand outer wing, and the main landing gear structure.

Repairs to the aircraft have been completed, and the incorporation of design modification in the fuel and flying controls systems has also been completed. Damaged instrumentation in the aircraft has been replaced and installation of the instrumentation electrical patch panel has been completed.

The aircraft is now being prepared for flight.

29.2 AIRCRAFT 25202

29.2.1 GROUND WORK PRIOR TO FLIGHT

Prior to the first flight of aircraft 25202, the instrumentation patch panel was installed and the aircraft damping system was made operative in three axes. During subsequent flight simulation tests one of the flying control valve rods was found to be broken. This was removed and repaired and further flight simulation tests were satisfactory.

The ARROW 2 main landing gear, installed in the aircraft as an interim measure, has been replaced by a modified ARROW 1 assembly, as stress investigation has revealed the ARROW 2 landing gear to be unacceptable. (Ref. para. 22.18).

Instrumentation pack modifications to extend the instrumentation facilities, were completed.

29.2.2 FLIGHT TEST

The first flight of aircraft 25202 took place on 1 August 1958 and was of 1 hour 21 minutes duration. The flight was made to assess the handling qualities at subsonic speeds with the damper system operative in the yaw axis only. An altitude of 30,000 feet was attained, but speed was limited to 350 kts. when rudder vibration became evident during yaw damping tests. Vibration was also apparent when flying with the landing gear extended. Subsequent ground adjustments to the yaw damper, and rubber buffers installed on the landing gear doors have successfully reduced these vibrations to an acceptable level. After this flight, the aircraft was grounded for adjustment and calibration of the damping system roll and pitch axes. Subsequent to the grounding period twelve further flights were completed, and the accumulated flying time on this aircraft to the end of September was 12 hours 14 minutes. Five flights were made to assess the aircraft handling qualities at subsonic and supersonic speeds, with the damper system operative in the yaw and roll axes. A speed of Mach 1.86 at an altitude of 50,000 feet was attained during these flights. During initial flights it was found that the engagement of the damper roll axis caused the control column to lock. The engaging relay in the damper roll axis circuit was replaced and this appeared to remedy the defect during ground testing, but the fault re-occurred during two subsequent test flights. After further investigation, the amplifier-calibrator unit in the damper system was replaced and no further trouble was experienced.

Two flights were made to investigate the range and functioning of the instrumentation telemetry system and the VHF radio. Test results were satisfactory. During the second flight, the right-hand alternator constant speed unit failed. This was replaced and tested satisfactorily.

One flight was made to check buffet and handling characteristics at altitudes of 20,000 ft. and 40,000 ft. Onset of buffet occurred at approximately the same values of nw and angle of attack as expected, and only increased gently with further increase in the angle of attack, up to as high as 14°. The tests were made at M= .7 at 25,000 ft. (buffet commenced at and angle of attack of 9° and 1.9 G), and at M= .8 at 40,000 ft. (buffet commenced at angle of attack of 9 to 10°).

Three flights were made to assess the handling qualities of the aircraft with damping in all axes. Pitching oscillations became evident during these flights, and ground tests are being conducted to investigate the cause.

Prior to flight #11, type VII fabric tires were installed on the left-hand forward and right hand aft main landing wheels for assessment purposes. The type VII fabric tires proved superior to the standard tires normally used and showed greater resistance to cuts and abrasions. (Ref. para. 22.18.3).

An RCAF pilot flew the aircraft on flight #12, and attained Mach 1.7 at 50,000 feet. During the landing run, the drag chute canopy collapsed due to failure of a number of suspension lines and chute ribbons. Subsequent examination revealed the chute to be wet, due to rain entering the drag chute stowage. This increased the chute weight by seven pounds.

During flight #13, the pilot reported that at 40,000 feet with afterburners operating and at speeds between Mach 0.9 and Mach 1.2, the engines would only deliver 95% maximum RPM. This is currently being investigated.

29.3 AIRCRAFT 25203

29.3.1 PRE-FIRST FLIGHT TAXIING TESTS

Taxiing tests were conducted on aircraft 25203 prior to the first flight. Assessments were made of the damping system, brakes and drag chute. It was considered that this aircraft displayed superior taxiing characteristics to aircraft 25201 and 25202. All tests of the damping system, brakes and drag chute were satisfactory.

At the conclusion of the tests, and prior to engine shut-down, the right-hand engine air conditioning bleed connector became uncoupled, and the hot air released caused damage to the shroud, formers and outer skin. This damage has been repaired and preparations for the first flight have been completed. It is considered that improper installation of the connector was responsible for the failure, and the coupling procedure has been improved.

29.3.2 FIRST FLIGHT

The first flight of aircraft 25203 took place on 22 September and was of 1 hour 8 minutes duration. An initial assessment of the aircraft was made, within the flight limitations imposed by the design certificate.

Operation of the yaw damper was tested in all modes. When the landing gear was extended prior to landing, the landing gear cockpit indicator indicated an unlocked condition on the right-hand main landing gear. The aircraft was manoeuvred to apply side force on the landing gear, and the chase aircraft reported that the gear appeared to be locked down. The landing was successfully completed, and subsequent inspection showed that the down lock micro-switch, on the right-hand landing gear side stay, had not functioned properly due to insufficient movement of the switch actuating rod. The mechanism has been modified to prevent a recurrence of this fault.

29.4 FLIGHT TEST INSTRUMENTATION

29.4.1 AIRCRAFT INSTRUMENTATION

The installation of instrumentation in the aircraft has continued, and progress is as follows:

Aircraft	Instrumentation Installed	Instrumentation Serviceable
25201	90%	69%
25202	86%	76%
25203	76%	56%
25204	53%	33%
25205	31%	28%

The instrumentation patch panels for aircraft 25201 and 25202 have been completed and installed. Instrumentation patch panels will not be installed in any further aircraft as the panel electrical connections are considered unreliable. Methods of achieving reliable connections to the instrumentation leads in the aircraft are now under investigation.

29.4.2 DATA HANDLING SYSTEM

The ASCOP system of data handling has been the subject of a complete investigation.

Tape recordings were generally unintelligible, but clear passages were found which could be related to the flight briefing. This indicated that the ASCOP system was capable of producing intelligible tape recordings.

An ASCOP system was assembled on the bench, and tests were conducted with the commutator coupled to an oscilloscope. The distorted signals observed during this test were considered to be caused by poor operation of the commutator contacts. The contacts were lapped, but subsequent tests showed very little improvement. In addition, the commutated signals were again badly distorted, after only ten hours running.

Tests were then conducted using a two-pole 30 x 30 Instrument Development Laboratories (IDL) commutator in place of the ASCOP commutator, and this gave improved results. Analysis of tests indicated that the ASCOP system is generally acceptable, although the commutator is unreliable and d-c amplifier cooling is inadequate.

New ASCOP commutator and amplifier units were obtained and aligned to the latest ASCOP procedures. The system was assembled and installed in the rocket bay of CF-100 aircraft 18185. Recordings were made with the aircraft electrical systems operating and simulated instrumentation signals provided by a d-c signal generator. Results were satisfactory on the playback, and few signals had failed to record. Signal distortion was within 2%. The installation was then flight tested with the ASCOP system accepting only simulated instrumentation signals from the d-c signal generator. The resultant tape recording was only partly satisfactory.

Modifications to improve the common mode rejection capability of the amplifier were designed and have been submitted to ASCOP for incorporation in future units. Investigation showed that the minimum pulse width of the signals used with the ASCOP system was too low. This could be remedied by increasing the minimum pulse width from 160 to 200 microseconds at a tape speed of 10 in/sec., or by increasing the tape speed to 20 in/sec. Increasing the tape speed was impracticable as the tape running time would have been inadequate. Minimum pulse width was increased to 200 microseconds. Tests of a superior grade of recording tape showed no improvement in recorded results.

An ASCOP system was installed in ARROW aircraft 25202 and was flight tested, using a d-c signal generator to supply simulated instrumentation signals. The first flight was unsatisfactory due to a wiring error in the ASCOP system, but satisfactory recordings were made on two subsequent flights. A ground test was then conducted, using signals from the aircraft instrumentation transducer. The recorded signals showed a high degree of interference and many signals were lost. The interference and signal loss is considered to be caused by the presence of multiple grounding points in the aircraft electrical system, and inadequate electrical bonding between the pack and the aircraft. This is currently under investigation. Plans for developing an IRIG analogue tape system for ARROW aircraft have been reconsidered, and alternative recording arrangements are being designed.

29.4.3 GROUND STATION

Fading of the FM/FM transmission during flight tests has been investigated, but the results were inconclusive. Several schemes for improving transmission have been investigated, but it was considered impossible to provide completely fade-tree transmission, since the antenna in use will be blanked during certain parts of an aircraft manoeuvre. Efforts were then directed towards providing protection for the Sanburn Recorder pens when FM/FM transmission fading occurs. Normally, when the transmission fades, the Sanborn recorder pens are subjected to violent movement as the signal distortion level rises, and this causes damage to the pens. Circuit modifications have been introduced which remove the pens from the circuit when signals fade and become distorted.

The new design of millisadic invervalometer is now being tested. Results so far have been satisfactory.

The Consolidated Engineering Corporation (CEC) tape recorder is now in use and is proving satisfactory.

PART 7

TECHNICAL DATA

30.0 SPECIFICATIONS ISSUED

30.1 MODEL SPECIFICATIONS

Report No.	Description	Issued
72/MS/1	Model Specification for ARROW 2 Airframe and GSM installations	Aug 1958
AAMS 105/1 Appendix 1	Aircraft Equipment List	Sept 1958

30.2 AVROCAN SPECIFICATIONS

To date, approximately 455 Avrocan Equipment Specifications (Series 'E') have been prepared for the ARROW. An index of these Specifications (AVRO ref. E.I. Gen. 489/199 dated 30 Sept 1958) has been issued to the RCAF.

30.3 DESIGN CERTIFICATES

71/PROJ 7/1-2	Design Certificate for Flight Trials of ARROW 1 Aircraft Serial #25201	Sept 1958
(Amendment #2 cancels 71/PROJ 7/1-2 see Amendment #7 71/PROJ 7-7)		
71/PROJ 7/7	Design Certificate for Flight Trials of ARROW 1 Aircraft Serial #25202 - 25205 inclusive	
Amendment #3	"	July 1958
Amendment #4	"	Aug 1958
Amendment #5	"	Sept 1958
Amendment #6	"	Sept 1958
71/PROJ 7/7	Design Certificate for Flight Trials of ARROW 1 Aircraft Serial #25201 - 25205 inclusive	
Amendment #7	"	Sept 1958

31.0 REPORTS ISSUED

31.1 PRELIMINARY DESIGN PROPOSALS

No preliminary design proposals were issued during the reporting period.

31.2 WEIGHT AND BALANCE

Since weight and balance reports are issued monthly as required by CAP 479, an index of these reports will not be included in the Quarterly Technical Report.

31.3 WIND TUNNEL DATA

Report No.	Description	Issued
70/W TUNN/14	Review of Wind Tunnel Armament Tests and Theoretical Fuselage Flows	Aug 1958
71/W TUNN/13	Wind Tunnel Tests on Vertical Tail with IR Tip Pod Installation	Aug 1958

31.4 PERFORMANCE REPORTS

Report No.	Description	Issued
71/PERF/7	ARROW 1 Estimated Non-Dimensional Performance Curves for Flight Analysis	Sept 1958
71/PERF/19	ARROW 1 Take-Off and Landing Performance	Aug 1958
72/PERF/22	Performance with Uprated J-75 P6 Engines	Aug 1958
72/PERF/25	Miscellaneous ARROW 2 Performance	Aug 1958
72/PERF/26	Work for the "Periodic Performance Report No. 14"	Aug 1958
Periodic Performance Report 14	ARROW 2 Performance	Aug 1958

31.5 STRUCTURAL STRENGTH TESTS

No formal structural test reports were issued during the reporting period.

31.6 AIRCRAFT GROUND AND FLIGHT TESTS

No ground test reports were issued during the reporting period. The following flight test reports were issued:

Report No.	Description	Issued
71/FAR/31	Flight Results - Investigation of J-75 RPM Drops	Sept 1958
71/FAR/34	Manoeuvre Limiter Devices in the ARROW Damper	Aug 1958
71-72/FAR/37	Proposed Methods for Correction and Presentation of Flight Test Stability Data	Aug 1958
71/FAR/38	Aircraft Response Predictions	Sept 1958
71/FAR/43	Preliminary Stability and Damper Analysis of First Seven Flights (ARROW 1 #25202)	Sept 1958
71/FAR/44	Technical Design Department Report on Flight Test findings.	Sept 1958

31.7 FUNCTION TYPE TESTS

Each item of equipment manufactured to an AVROCAN Specification will undergo qualification testing. All functional type test data and qualification test reports for bought-out equipment are being indexed under AVRO drawing numbers and retained at AVRO.

31.8 VENDORS' REPORTS

Vendors' reports on equipment supplied to AVRO for use on the ARROW aircraft will be retained on file at AVRO.

31.9 ASTRA I SYSTEM

AVRO has not compiled any formal reports on the ASTRA I system during the period covered by this report.

31.10 STRESS ANALYSIS REPORTS

Report No.	Description	Issued
7/0554/12	Fuselage Torsion Station 255 - 485	Aug 1958
7/0554/32	Air Conditioning Equipment Tray Station 255 - 315	Aug 1958

31.11 SYSTEMS REPORTS

Report No.	Description	Issued
71/SYSTEM 15/211	Production Test Procedure for Qc Actuator System	Aug 1958
71/SYSTEM 16/216	Reduction in Residual Fuel	Aug 1958
71/SYSTEM 16/233	Improvements to Defuelling Facilities	Aug 1958
71/SYSTEM 24/217	Escape System - Rigging and Functional Procedure	Sept 1958
71-2/SYSTEM 13/232	Antenna - U. H. F. Annular Slot (formerly referred to as CF-105R-0021)	Sept 1958
71-2/SYSTEM 19/234	Preliminary Main Landing Gear Retraction and Extension Velocities	Aug 1958
71-2/SYSTEM 19/238	Nose Wheel Dynamic Loads	Sept 1958
72/SYSTEM 11/242	Pilot's Switch Selection for Lowering and Retracting Missiles	Sept 1958
72/SYSTEM 12/230	Requirements for Beta Display - Pilot's Cockpit	Aug 1958
72/SYSTEM 13/7-2	ARROW 2 Electronic System	July 1958
72/SYSTEM 13/228	Schematic - Qc Actuator System	Aug 1958
72/SYSTEM 15/229	Block Diagram - Qc Actuator System	Aug 1958
72/SYSTEM 15/244	Required Defuelling Changes	Sept 1958

Report No.	Description	Issued
72/SYSTEM 18/29-2	Required Low Pressure Pneumatic System	July 1958
72/SYSTEM 19/220	Utility Hydraulic System	Sept 1958
72/SYSTEM 19/225	Schematic Drawing - Landing Gear with Electrical Sequencing on the Nose Gear	Aug 1958
72/SYSTEM 19/231	Schematic Drawing - Landing Gear Schematic (Electrical Nose and Mechanical Main)	Aug 1958
72/SYSTEM 19/237	Operational Flight and Tactics Trainer	Aug 1958
72/SYSTEM 21/30-2	ARROW 2 Oxygen System	July 1958
72/SYSTEM 22/48-2	ARROW 2 Air Conditioning System	July 1958
72/SYSTEM 22/223	Air Supply - Production Test	Aug 1958
72/SYSTEM 22/226	Air Conditioning - Production Test Procedure	Aug 1958
72/SYSTEM 22/239	Requirements for, and Future Development of an Angular Momentum Mass Flow Controller for ARROW 2 Air Conditioning System	Aug 1958
72/SYSTEM 22/245	Control and System Management Air Conditioning System	Sept 1958
72/SYSTEM 23/31-2	ARROW 2 Fire Protection System	July 1958
72/SYSTEM 26/8-2	ARROW 2 Sparrow 2 Missile Installation	July 1958
72/SYSTEM 29/221	Constant Speed Drive - Production Test Procedure	Aug 1958
72/SYSTEM 29/222	Accessories Gear - Box Production Test Procedure	Aug 1958
72/SYSTEM 29/240	Flight and Tactics Trainer for Constant Speed Drive Oil System	Sept 1958

Report No.	Description	Issued
72/SYSTEM 29/241	Flight and Tactics Trainer for Accessories Gear Box Oil Cooling System	Sept 1958

31.12 EQUIPMENT DESIGN REPORTS

Airborne and Group Equipment, Maintenance and Reliability.

Report No.	Description	Issued
71/GEQ/5	ARROW 1 - Inhibiting Equipment for J-75 Engine, Afterburner, Accessory Drives and Gear Boxes	July 1958
72/GEQ/17	ARROW Ground Equipment - Recommended Spare Parts List	Sept 1958
70/AIREQ 00/1	Airborne Equipment List	Sept 1958
71/AIREQ 00/2	Hydraulic System Contaminated Control System	July 1958
71/AIREQ 19/2	Report on Nose Wheel Steering Meeting held May 15/58	July 1958
72/AIREQ 22/3	ARROW 2 - Temperature Control Valves #525018 and 525019	Aug 1958
72/MAINT 13/1	Maintenance Philosophy - Electronics Fire Control Sub-System - Missile Auxiliaries - Missile Safety Testing	Aug 1958

31.13 GENERAL TECHNICAL DESIGN REPORTS

70/INT AERO/21	Comparison between A75-B25, J75-B23 and IROQUOIS 2 on Basis of Uninstalled Net Thrust and Static Fuel Consumption	Aug 1958
71/INT AERO/22	Thrust Derivatives	Aug 1958
71/INT AERO/24	Air Bleed due to Zone 1 Ejector	Sept 1958
71/INT AERO/25	Comparison of Performance of the ARROW 1 with J75-A25 to the ARROW 1 with J75-A27 (i.e. Overspeeded J75-A25 Engine)	Sept 1958

Report No.	Description	Issued
72/INT AERO/20	Revised Restrictor Geometry and Spring Characteristics	Aug 1958
71/AERO DATA/14	Summary of Air Data Boom Test Data	Sept 1958
70/ELASTICS/10	Effect of Elasticity and Buckling on Thermal Stresses in Beams	Aug 1958
71/ELASTICS/9	Flexibility of Aircraft with full effective Structure (Aileron and Control Box omitted)	Sept 1958
71/ELASTICS/11	Main Landing Gear Stiffness and Landing Loads	Aug 1958
70/STAB/4	ARROW 1 - Estimated Non-Dimensional Performance Curves for Flight Analysis	Sept 1958
70/STAB/40	Determination of Flow Around the Fuselage of the ARROW, Using Associated Legendre Functions of the Second Kind	Aug 1958
70/STAB/42	Control and Duty Cycles	Sept 1958
70/STAB/43	Latoral Dynamic Stability with Improved Tail Stiffness	Aug 1958
70/STAB/44	Conditioning the Mathematical Stability Model for Automatic Reception and checking of Flight Analysis Derivations	Sept 1958
71/STAB/41	The Longitudinal Short Period when W = 60,000 lb and C.G. = .30 $\overline{C}$	Aug 1958
70/LOADS/15	Elastic Wing Loads During Rolling Pull Out, Including the Effect of Fin Load	Sept 1958
71/LOADS/21	Air Loads on a Fairing for FASTAIR 16-M.M. Camera	Sept 1958
71/LOADS/24	Report on Bearing Friction Investigation	Sept 1958

Report No.	Description	Issued
71-2/LOADS/22	Investigation of Elevator Loads	Aug 1958
71-2/LOADS/23	Investigation of Landing Gear Extending Mechanism	Sept 1958
72/LOADS/12	Dynamic Manoeuvring Loads for an Asymmetric Aircraft	Sept 1958
72/LOADS/25	Internal Pressure in the Sparrow Missile Cocoon and Armament Bay due to the Failure to Jettison of the Missile	Sept 1958
GEN/COMPT D/2	Introduction to the IBM 704 at AVRO Aircraft	Aug 1958
70/THERMO/31	An Analytical Solution of Standby State Temperature Distribution in Joints	Sept 1958
70/THERMO/32	Effects of Neglected Variations of Physical Properties with Temperature on Thermal Stresses	Sept 1958
70/THERMO/33	Equilibrium Temperature of an Isolated Skin	Aug 1958
72/THERMO/34	Temperature Distribution in the Navigator's Canopy Panel	Sept 1958
72/TACTICS/2	Intercept Simulation in SAGE Environment	Sept 1958
72/TACTICS/13	The Mathematical Model of the ARROW 2 Weapon System	Aug 1958
72/TACTICS/14	Comments on Specification WSC-1	Aug 1958
72/TACTICS/15	Comments on RCAF Specification WSC-1-4	Aug 1958
72/TACTICS/16	A Mathematical Model of the Midcourse Guidance of the ARROW 2 Weapons System by SAGE	Aug 1958

Report No.	Description	Issued
72/TACTICS/18	Comparison of ARROW 2 and BOMARC in the Air Defence of Eastern Canada	Aug 1958
70/ENG PUB/8	ARROW Quarterly Technical Report for Period Ending June 30, 1958	July 1958
71/ENG PUB/9	Report on Accident to AVRO ARROW 1 #25201 at Malton (Pt. 1 Investigation)	July 1958
71/ENG PUB/10	Report on Accident to AVRO ARROW 1 #25201 at Malton (Pt. 2 Damage & Repairs)	Sept 1958
71/PROJ 7/14	Installation of ASTRA I in ARROW Aircraft #25205	July 1958
71/PROJ 7/15	Development Program for ARROW Aircraft #25204	Aug 1958
72/PROJ 7/8	Iroquois Engine Development ARROW Flight Test Program	Aug 1958
72/PROJ 7/11	ARROW 2 - Extended Combat Radius Version	July 1958
72/PROJ 7/12	ARROW Weapon Pack Development Progress Report	July 1958