MAY 1958 SECRET



# ARROW 2
# ELECTRONIC SYSTEM

REPORT NO.72/SYSTEMS 13/7-2

ENGINEERING DIVISION

AVRO AIRCRAFT LIMITED.

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ARROW 2

ELECTRONIC SYSTEM

Report No. 72/System 13/7-2

MAY 1958

This brochure is intended to provide an accurate description of the system(s) or service(s) at the time of writing, and is not to be considered binding with respect to changes which may occur subsequent to the date of publication.

Revised By G D Taylor

Approved By

Authorized By

Engineering Division
Avro Aircraft Limited
Malton - Ontario

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## 1.0 INTRODUCTION

This brochure is intended to provide a general description of the ASTRA electronic system installation in the ARROW 2, and the design of those elements for which AVRO is wholly or partially responsible.

AVRO is responsible for the installation of the system as a whole and for the design, development, installation and testing of subsidiary items such as the radome and antennas. In addition the cockpit layout, system maintenance and such studies and investigations of the electronic system as may be required are AVRO's responsibility.

## 2.0 GENERAL DESCRIPTION

The complete electronic system for the ARROW 2 comprises those major electronic sub-systems necessary to the performance of the ARROW interceptor mission. The several phases of the interceptor mission indicate the various functions the electronic system must perform. The mission phases are;

(a) Navigation to a fixed or moving target and missile firing

(b) Detection, interception and tracking of the target

(c) Return to base.

These functions are accomplished by the four major electronic sub-systems: fire control, navigation, telecommunication and automatic flight control.

The various stages of ASTRA development in the ARROW 2 are as follows:

(a) Partial ASTRA - This system includes the minimum necessary communication, navigation, IFF, flight instruments and air data equipment, required to fly the aircraft during the research and development parts of the program.

(b) Developmental ASTRA- This will eventually include all the sub-systems of the complete ASTRA system. Variations in systems, however, will occur as the result of system development.

(c) Pre-production ASTRA - This will be manufactured with production tooling, but will not be subjected to full quality control and inspection.

## 2.1 SUB-SYSTEMS

### 2.1.1 FIRE CONTROL SUB-SYSTEM

The fire control sub-system includes airborne interception radar, ballistics, and kinematics, computer, missile auxiliaries, optical sight, and associated equipment. The primary functions of the sub-system are to acquire and track the target, provide the correct steering signal for manually or automatically steering the interceptor during attack, to automatically fire the interceptor's armament at the correct time, and to provide a visual indication for breakaway.

The system is designed to operate with Sparrow 2D guided missiles and long range unguided rockets.

The radar, in addition to target detection and tracking, also provides navigational aids in the form of radar beacon interrogation and ground mapping facilities. Passive homing on x-band jamming signals is provided as an added counter-countermeasure capability.

The fire control sub-system is also designed to operate in conjunction with an infra-red system for passive detection and tracking.

### 2.1.2 TELECOMMUNICATIONS SUB-SYSTEM

The telecommunications sub-system provides two-way UHF communication, voice coded data link reception, UHF homing, LF/MF radio compass, homing on L-band jamming signals (ECM Homer), air-to-air and ground-to-air IFF coverage (interrogator and transponder units), and crew interphone.

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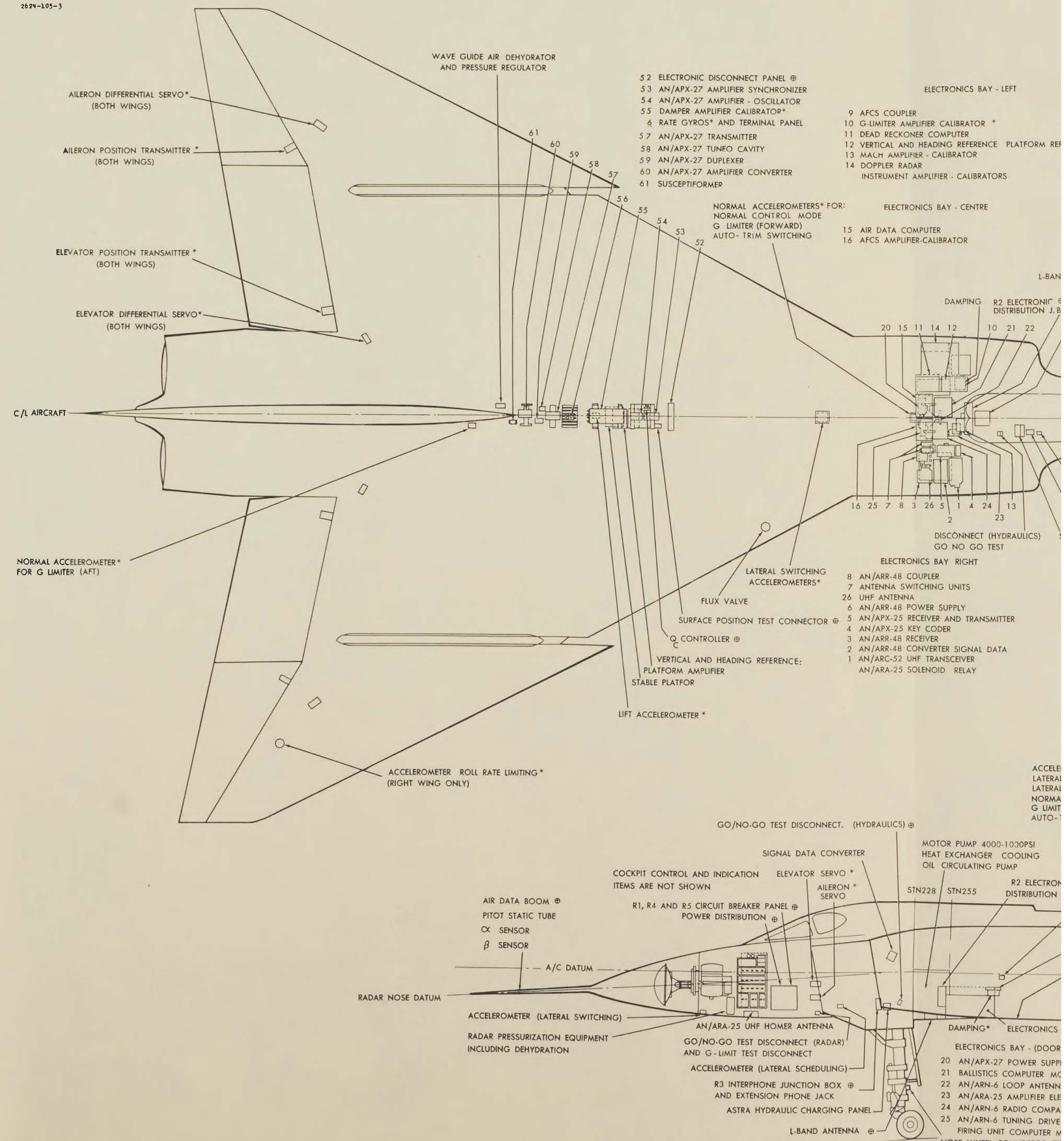


**FIG. 2 INSTALLATION OF ELECTRONIC EQUIPMENT**

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PANEL ⊕
CHRONIZER
CILLATOR
TOR*
IAL PANEL

VERTER

CELEROMETERS* FOR:
NTROL MODE
ORWARD)
SWITCHING

ELECTRONICS BAY - LEFT

9 AFCS COUPLER
10 G-LIMITER AMPLIFIER CALIBRATOR *
11 DEAD RECKONER COMPUTER
12 VERTICAL AND HEADING REFERENCE PLATFORM REPEATER
13 MACH AMPLIFIER - CALIBRATOR
14 DOPPLER RADAR
INSTRUMENT AMPLIFIER - CALIBRATORS

ELECTRONICS BAY - CENTRE

15 AIR DATA COMPUTER
16 AFCS AMPLIFIER-CALIBRATOR

LOCATING KEY
NOSE AFT RACK - LEFT

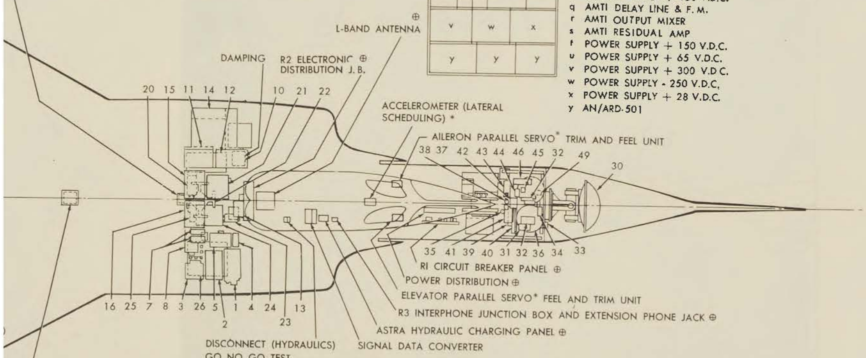
| | | | | |
|---|---|---|---|---|
| | | | | a |
| d | e | f | g | b |
| | | | | c |
| h | k | m | n | p |
| q | r | s | t | u |
| v | | w | | x |
| y | | y | | y |

RADAR NOSE AFT RACK - LEFT

a SYNCHRONIZER ELECTRICAL SN-126/APX-26
b AMPLIFIER OSCILLATOR AM-1243/APX-26
c AMPLIFIER SYNCHRONIZER AM-1241/APX-26
d SYNCHRONIZER TIMING & DISPLAY
e SYNCHRONIZER TRACKING CHANNEL
f SYNCHRONIZER POWER UNIT
h AMTI TIME AND CLUTTER GATE
i AMTI 31 AND 83 MC
k AMTI POWER UNIT
m AMTI FIRST MIXER
n SYNCHRONIZER AGC
p POWER SUPPLY + 150 V.D.C.
q AMTI DELAY LINE & F. M.
r AMTI OUTPUT MIXER
s AMTI RESIDUAL AMP
t POWER SUPPLY + 150 V.D.C.
u POWER SUPPLY + 65 V.D.C.
v POWER SUPPLY + 300 V.D.C.
w POWER SUPPLY - 250 V.D.C.
x POWER SUPPLY + 28 V.D.C.
y AN/ARD-501

RADAR NOSE FORWARD

30 RADAR ANTENNA
31 A. F. C.
32 DUMMY LOADS
33 RF PROGRAMMER
34 HIGH PASS FILTER
35 LOCAL OSCILLATOR
36 TRI-COUPLER
37 TUNING CAVITY
38 (SENSITIVITY TIME CONTROL) FERRITE
39 IF (LINEAR)
40 IF (AMTI)
41 AN/APX-26 TRANSMITTER




RADAR NOSE FORWARD

42 POST TR
43 PULSE MAGNETRON
44 PULSE TRANSFORMER
45 PULSE ISOLATOR
46 PULSE FORMING NETWORK
47 LOW PASS FILTER
48 PRE TR
49 ECM SWITCH
ANTENNA DRIVE HYDRAULICS
50 MAGNETRON COOLING HYDRAULICS
CONTENTS GAUGES FOR THE
COOLING FLUID RESERVOIR
51 RADAR HOME ANTENNAS - 4 REQUIRED ⊕
(TENTATIVE LOCATION IS NEAR STATION 70)

AL SWITCHING
LEROMETERS*

T CONNECTOR ⊕

ERENCE:

ELECTRONICS BAY RIGHT

8 AN/ARR-48 COUPLER
7 ANTENNA SWITCHING UNITS
26 UHF ANTENNA
6 AN/ARR-48 POWER SUPPLY
5 AN/APX-25 RECEIVER AND TRANSMITTER
4 AN/APX-25 KEY CODER
3 AN/ARR-48 RECEIVER
2 AN/ARR-48 CONVERTER SIGNAL DATA
1 AN/ARC-52 UHF TRANSCEIVER
AN/ARA-25 SOLENOID RELAY

| | | | | |
|---|---|---|---|---|
| A | | | | |
| B | C | D | E | F |
| G | H | J | K | |
| M | N | P | Q | |

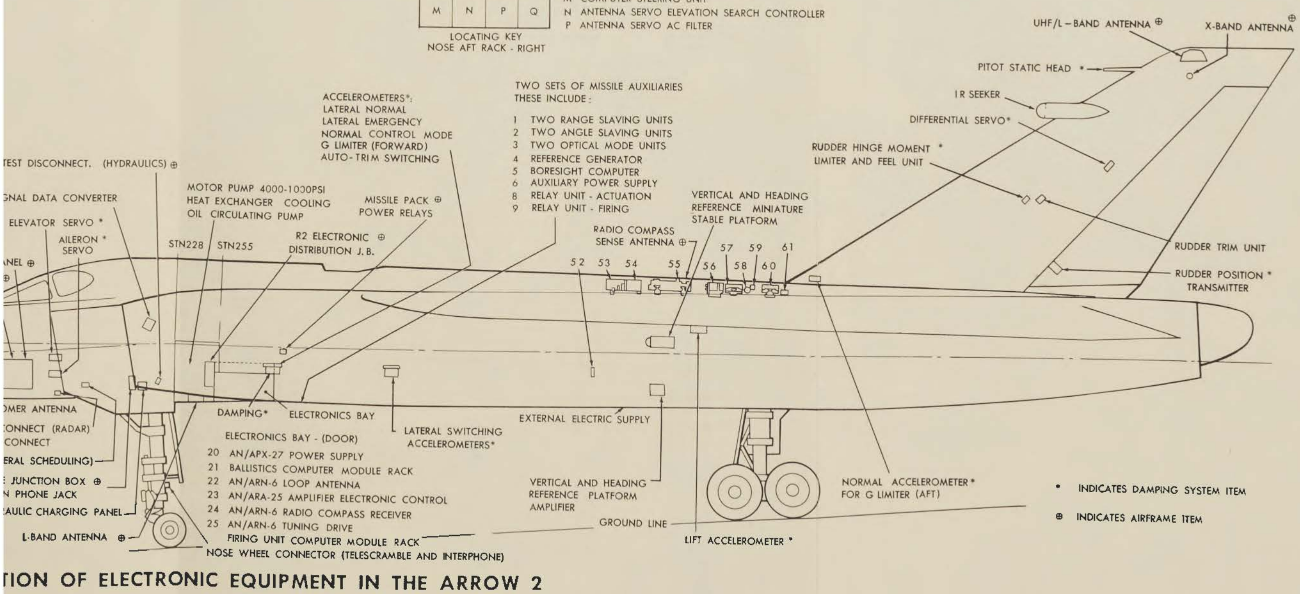
LOCATING KEY
NOSE AFT RACK - RIGHT

RADAR NOSE AFT RACK - RIGHT

A HIGH VOLTAGE POWER SUPPLY
B ANTENNA SERVO AND IR IMPLIFIER
C IR SERVO
D TERMINAL BOX
E ANTENNA SERVO ANGLE TRACKING
F ANTENNA SERVO ANTENNA DRIVE
G COMPUTER RANGE AND TIME SERVO
H ANTENNA SERVO ATTITUDE SERVO
K ANTENNA SERVO GYRO REFERENCE
M COMPUTER STEERING UNIT
N ANTENNA SERVO ELEVATION SEARCH CONTROLLER
P ANTENNA SERVO AC FILTER

TWO SETS OF MISSILE AUXILIARIES
THESE INCLUDE:

1 TWO RANGE SLAVING UNITS
2 TWO ANGLE SLAVING UNITS
3 TWO OPTICAL MODE UNITS
4 REFERENCE GENERATOR
5 BORESIGHT COMPUTER
6 AUXILIARY POWER SUPPLY
8 RELAY UNIT - ACTUATION
9 RELAY UNIT - FIRING




ELECTRONICS BAY - (DOOR)

20 AN/APX-27 POWER SUPPLY
21 BALLISTICS COMPUTER MODULE RACK
22 AN/ARN-6 LOOP ANTENNA
23 AN/ARA-25 AMPLIFIER ELECTRONIC CONTROL
24 AN/ARN-6 RADIO COMPASS RECEIVER
25 AN/ARN-6 TUNING DRIVE
FIRING UNIT COMPUTER MODULE RACK

* INDICATES DAMPING SYSTEM ITEM

⊕ INDICATES AIRFRAME ITEM

TION OF ELECTRONIC EQUIPMENT IN THE ARROW 2

The telecommunications sub-system as presently defined is composed of the following equipment:

| | |
|---|---|
| (a) UHF Communications | AN/ARC-552 |
| (b) UHF Homer | AN/ARA-25 |
| (c) Radio Compass | AN/ARN-6 |
| (d) Interphone | AN/AIC-10A |
| (e) Data Link | AN/ARR-48 type |
| (f) Radar Homer (Space provisions only) | AN/ARD-501 |
| (g) Air-to-ground IFF transponder | AN/APX-25A |
| (h) Air-to-air IFF interrogator | AN/APX-26 |
| (i) Air-to-air IFF transponder | AN/APX-27 |

2.1.3 NAVIGATION SUB-SYSTEM

The navigation sub-system consists of a dead reckoning navigation computer, a doppler radar and an integrated destination indicator. The sub-system is self-contained and is capable of indicating the actual geographical location of the aircraft (with bearing and distance to target or base) at all times.

The navigation computer receives inputs from telecommunications, radar and air data equipment and supplies outputs to the fire control radar, automatic flight control system and the navigation display indicator. Display data includes present postion of the interceptor, interceptor track, range and heading to the target and radio compass, and UHF homer azimuth data.

2.1.4 AUTOMATIC FLIGHT CONTROL SUB-SYSTEM (AFCS)

The automatic flight control sub-system consists of the vertical and heading reference unit, the air data computer and the AFCS couplers.

The function of the system is to automatically control the flight path vector and orientation of the aircraft. TheAFCS commands the control surface motions through the damping system by means of the couplers.

The flight-path method of control is accomplished by reducing all outer loop commands (i.e. those received via telecommunications) to the common denominator of flight-path direction in space, compatible with basic inner loop commands.

The AFCS provides vertical and heading reference information for all other sub-systems, is the central source of air data information, and provides the outer loop control of the aircraft. The inner loop control is supplied by the aircraft damping system which, although separate from the electronic system, is designed to operate as a manoeuvering, all-attitude stability augmentor in conjunction with the AFCS.

The AFCS will enable the aircraft to operate in the following modes:

(a) Automatic attack

(b) Automatic navigation

(c) Automatic approach for landing

(d) Manual manoeuvering

(e) Pilot assist functions, consisting of:

1. Pitch attitude hold
2. Heading hold
3. Bank hold
4. Altitude hold
5. Mach hold

## 3.0 - LOCATION AND INSTALLATION OF EQUIPMENT

The location of the various electronic equipment sections in the aircraft is shown in Figure 1. A more detailed breakdown of the units contained within there sections is given in Figure 2.

3.1 FORWARD RADAR NOSE SECTION (See Figure 3)

This section contains an integrated assembly consisting of the following components:

(a) Radar receiver-transmitter

(b) Part of the AN/APX-26A air-to-air IFF interrogator

(c) Radar antenna, its associated hydraulics and forward gyro.

The following items are mounted to the lower portion of the radar nose structure:

(d) Air compressor and dehydrator, for pressurizing the wave-guide and receiver-transmitter.

(e) Pressure regulating assembly.

(f) Hydraulic accumulator and valve assembly.

(g) Line voltage control assembly.

The assembly is mounted to the aircraft by a shock-mount and slide rail assembly on each side. With the radar nose removed, the equipment package is extendable on the rails for servicing, or replacement. The cabling to this equipment is fed through a flexible conduit.

3.2 AFT RADAR NOSE SECTION

Equipment in this section is mounted on two racks (for which RCA is responsible) one on either side of the aircraft (See Figure 3).

The left-hand rack contains:

(a) The complete synchronizer group (three double modules, three single modules).

(b) The complete low voltage power supply group (two double modules, one triple module).

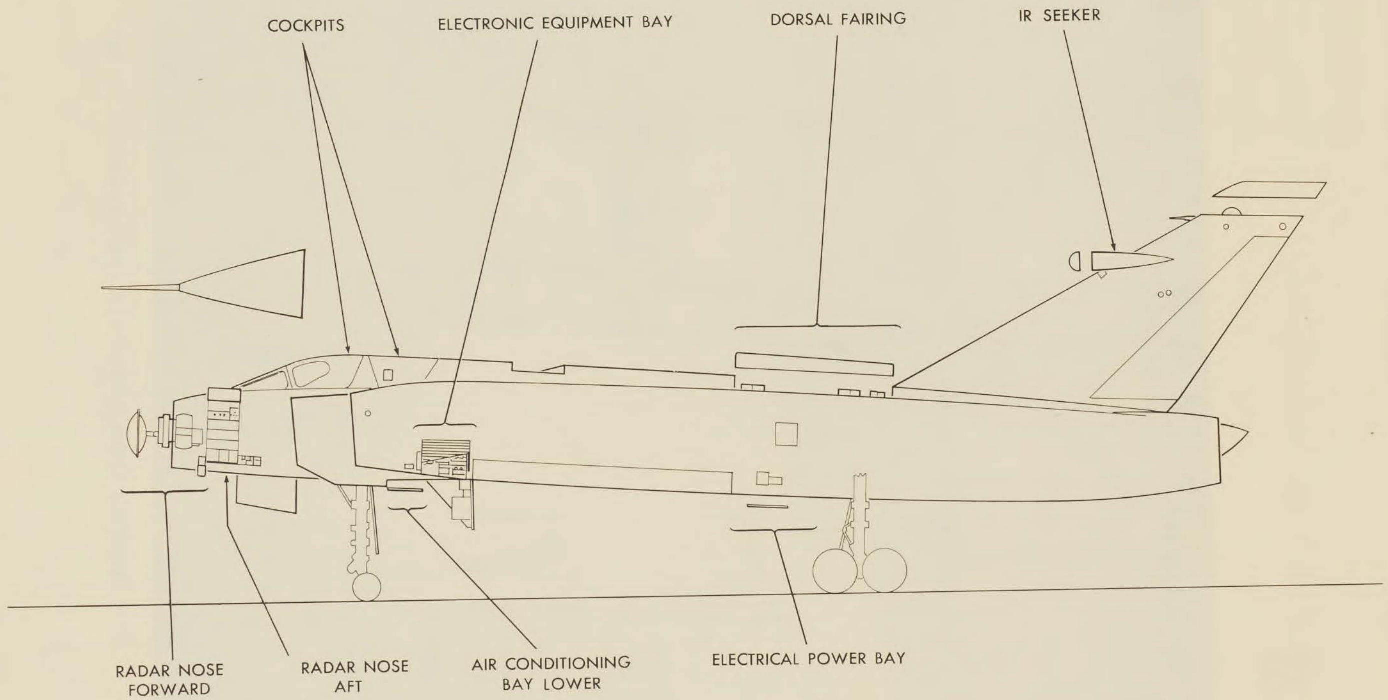



FIG. 1 LOCATION OF ELECTRONIC EQUIPMENT IN THE ARROW 2

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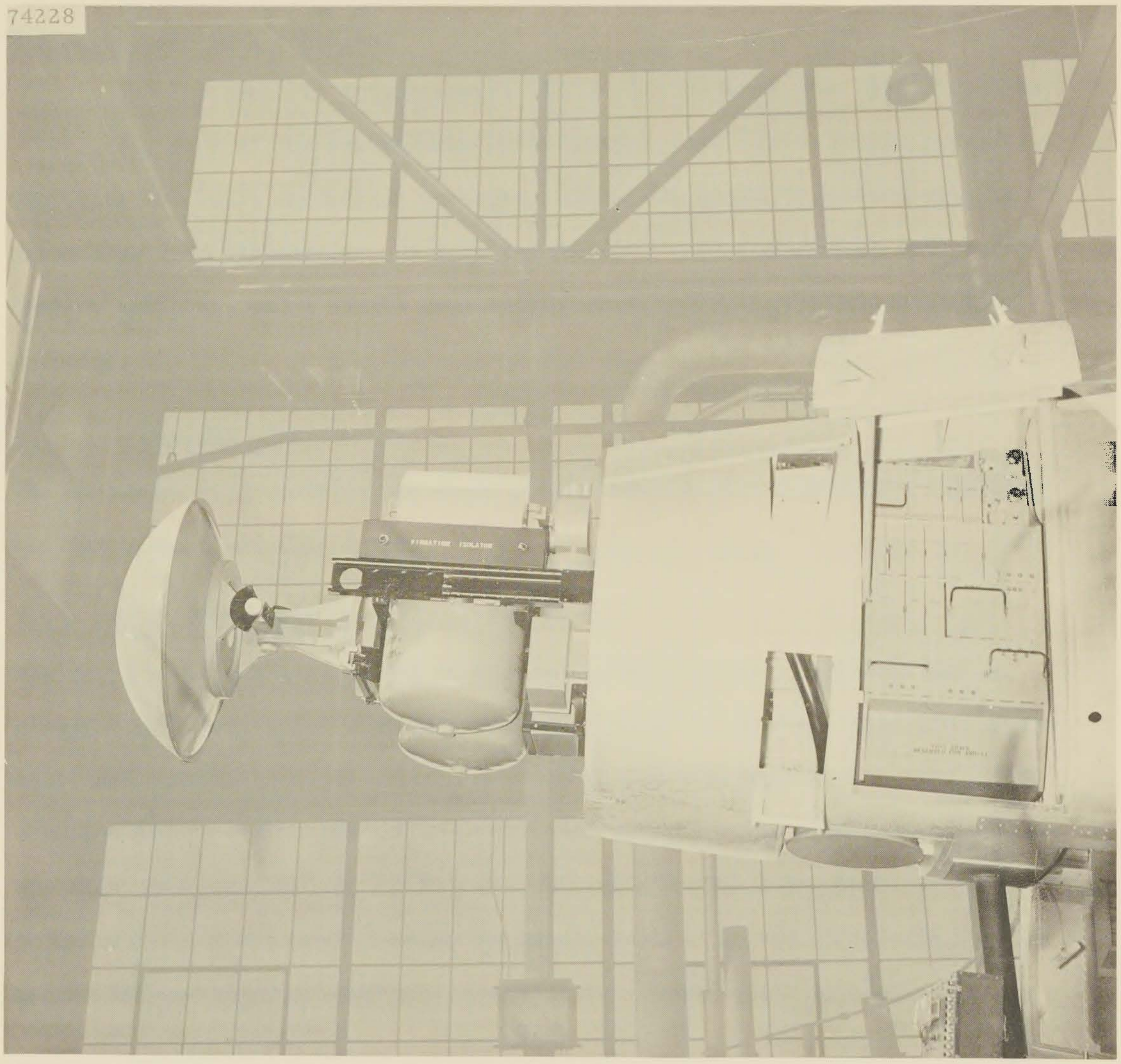


FIG. 3 FORWARD AND AFT RADAR NOSE SECTIONS

(c) The complete clutter cancellor group (two double modules, three single modules).

(d) The fire control computer group (kinematics) (three triple modules one double module, and one single module).

The right-hand rack contains:

(a) The complete antenna servo (six double modules, two triple modules).

(b) Part of the low voltage power supply group (three triple modules).

The units are built in modular packages. These are easily installed plug-in assemblies with two captive quarter-turn screws at the top of each module for locking purposes, and a single crew at the bottom of each module for jacking purposes.

3.3 NOSEWHEEL WELL

The nosewheel will contains the power distribution box, the go-no-go test plug and hydraulic fluid fill ports.

3.4 ELECTRONICS BAY (See Figure 4)

The full horizontal area of the right-hand section of the electronic bay is occupied by a tray which contains the interconnections for the data link equipment, and ducting to carry cooling air to the units mounted on the tray. The outboard side contains the UHF command transceiver, the data link pre-selector, the data link receiver and turning adapter and the data link converter and power supply. The inboard row of equipment consists of the AN/APX-25A air-to-ground IFF coder and transmitter-receiver and the data link coupler.

Two antenna switching units are located above the data link coupler. The UHF belly antenna is mounted under the tray.

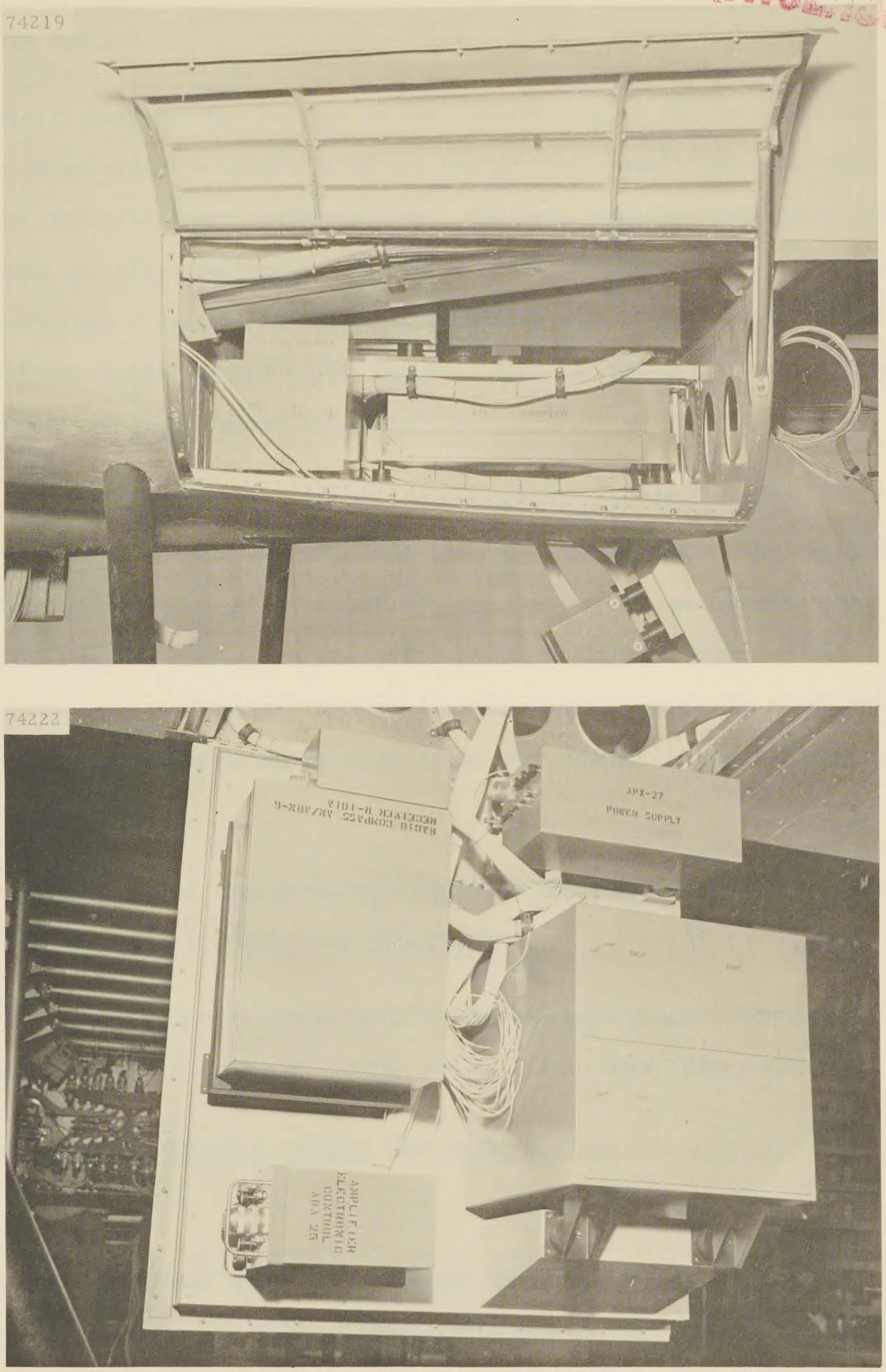


FIG. 4 ELECTRONIC BAY

Space for the doppler radar is included in the outboard left-hand section of the electronics bay.

Two layers of equipment are located in the inboard side of the left-hand section. The lower level contains theAFCS coupler, the g-limiter amplifier-calibrator of the damper system(airframe responsibility), the Mach amplifier calibrator and the attitude amplifier calibrator. The upper level includes the vertical and heading reference repeater, and the dead reckoning navigation computer which is made up of four units: ground speed computer, computer and relay unit, target data computer and ground speed integrator.

The following equipment is mounted on the electronics bay centre door: the AN/ARN-6 radio compass receiver with its servo tuning drive, the amplifier of the AN/ARA-25 UHF homer, the AN/APX-27, air -to-air IFF transponder power supply, and a module rack containing parts of the ballistics computer and kinematics computer. The radio compass loop is mounted inside the electronics bay door. The UHF homer solenoid relay is mounted on the forward bulkhead of the electronics bay.

Mounted from the top of this section, toward the aft end, from right to left, are the AFCS calibrator and the air data computer.

The modules in the racks on either side of the bay have plug-in retaining features similar to those described for the aft radar nose (para. 3.2).

3.5 PILOT'S AND OBS/AI's COCKPIT (See para. 4.3)

3.6 DORSAL

The following electronic units are contained under the dorsal fairing: the susceptiformer for the radio compass sense antenna, air-to-air IFF transpondor components, damper rate gyro and damper amplifier calibrator. (See

Figure 5).

This equipment is installed on shock mounted trays and is accessable through removable fairings.

3.7 AIR CONDITIONING EQUIPMENT BAY ( LOWER)

The following equipment, associated with the electronics system, is located in the air conditioning equipment bay area: air-oil heat exchanger for hydraulic fluid and coolant, coolant pump and accessories and hydraulic power conversion equipment.

3.8 ARMAMENT BAY ROOF

Some of the IR electronic equipment will be located in the armament bay roof. Installation details are currently being studied.

3.9 DUCT BAY

The duct bay area contains the lift accelerometer and two components of the vertical and heading reference unit.

3.10 FIN

The fin contains the IFF waveguide, auxiliary pitot head, UHF/L-band antenna, X-band antenna and the IR seeker head and amplifier system. (See para. 6.2.9).

4.0 SUBSIDIARY AIRFRAME ASPECTS

4.1 RADOME

The radome forms an ogival-shaped dielectric housing for the ASTRA 1 radar antenna and is designed for optimum electrical performance consistent with the state of the art, aerodynamic, structural and environmental requirements. Allowable limits of electrical performance (boresight error and error slope,

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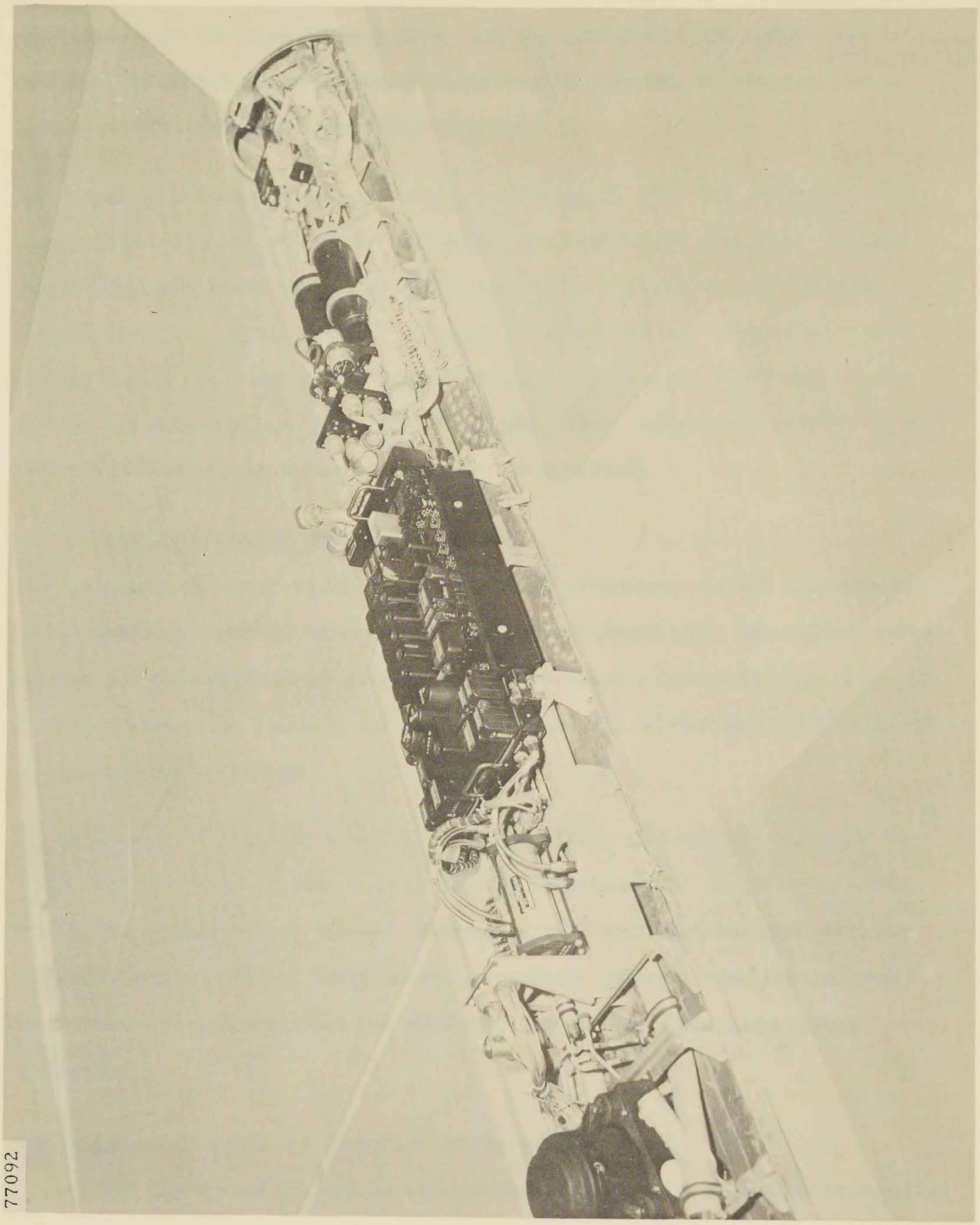

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FIG. 5 EQUIPMENT UNDER DORSAL FAIRING

power transmission and antenna pattern distortion) are based on the operating requirements of the fire control radar, and are detailed in the radome specification. AVROCAN E-411. AVRO has subcontracted the design, manufacture and testing of the radome to a specialist vendor.

The radome is 6 feet 8 inches in length and weighs 160 lb. The polyester resin glass-cloth laminated wall is of the solid, half-wavelength type with a slight longitudinal thickness taper. It has a dielectric constant of 4.07 and loss tangent of 0.012. Metal fittings are used to attach the air data boom to the radome, and to attch the radome to the fuselage. Tubing and electrical wiring for the air data boom are installed within the radome and arranged so that their effect upon the electrical characteristics is minimized.

## 4.2 TELECOMMUNICATION ANTENNAS

AVRO is responsible for design, manufacture and performance of the telecommunication antennas, with the exception of the radio compass loop, the doppler radar antenna and the UHF homer antenna, which are government furnished as part of the ASTRA 1 system. The location and installation of all telecommunication antennas is an AVRO responsibility.

All antennas are installed internally, either within the aircraft structure or flush with the aircraft skin and are located to provide the necessary coverage for the telecommunication system. Where required, provision has been made for switching between fin and belly antennas to obtain optimum reception (antenna multiplexing requirements are the responsibility of the electronic system contractor).

The following antennas are installed in the aircraft:

(a) The X-band antenna is located near the top of the fin, and is required for use with the AN/APX-27 air-to-air IFF transponder. Two waveguide-fed, vertical-slot radiators, located one on either side of the fin, provide isotropic coverage in the horizontal plane. The antenna is horizontally polarized.

(b) The combined UHF/L-band antenna, located in the fin cap, operates in conjunction with separate UHF and L-band antennas located in the belly of the aircraft to provide completely omnidirectional coverage. Both elements of the vertically polarized, combined antenna are coaxially-fed fans, with the fans opening upwards to cover the upper hemisphere. The lower or UHF radiating element of this antenna is used for UHF communications (AN/ARC-552) and data link (AN/ARR-48 type). The upper, L-band element is used for air-to-ground IFF (AN/APX-25A).

(c) The UHF belly antenna, located to the right of the electronics bay access door, is a coaxially-fed, flush-mounted, vertically-polarized annular-slot antenna, which operates in conjunction with the UHF element of the combined antenna in the fin. Coverage is omnidirectional over the lower hemisphere.

(d) The L-band belly antenna, located forward of the electronics bay, is a coaxially-fed, flush-mounted, vertically-polarized annular-slot antenna, which operates in conjunction with the L-band element of the combined antenna in the fin. Coverage is omnidirectional over the lower hemisphere.

(e) The AN/ARN-6 LF-MF radio compass antenna system consists of a directional loop antenna, and a sense antenna. The loop antenna is the Bedix Radio type LPA-6A, mounted in the electronics bay centre access door. This antenna has a narrow beam width in the horizontal plane, and a wide beam width in the vertical plane. It is vertically polarized and features an efficient method of quadrantal error compensation.

(f) The radio compass sense antenna consists of a curved copper sheet fastened to the inner surface of the fibreglass-laminated dorsal fairing. Coverage is omnidirectional and the antenna is sufficiently close to the electrical centre of the aircraft to minimize the effect of tilt angles. Polarization of the sense antenna is vertical.

(g) The AN/ARA-25 UHF homer antenna is flush-mounted on the underside of the radar nose. It is vertically polarized and has a cardioid radiation pattern.

(h) The AN/ARD-501 radar (ECM) homer antennas (4) will be mounted in the nose of the aircraft. These antennas will enable the azimuth and elevation of radar-jamming installations to be determined for homing purposes. Since the design philosophy of the radar homer is not yet finalized, it has not been possible for antenna development to proceed.

(i) Doppler radar is defined as part of the ASTRA 1 navigation subsystem. An X-band radome panel will be provided for the doppler antenna when equipment details have been finalized.

### 4.3 COCKPIT LAYOUT

AVRO and RCA jointly responsible for the composition and layout of the electronic system displays and controls in the cockpits.

#### 4.3.1 PILOT'S COCKPIT (Figure 6)

ASTRA 1 equipment in the pilot's cockpit is mounted on the two consoles (one along each side of the cockpit) and the main instrument panel.

## 5.0 SERVICES TO ELECTRONIC SYSTEM

### 5.1 ELECTRICAL POWER SUPPLY

115/200 volt, 400 cps, 3-phase power for the electronic system is provided by the aircraft electrical power system. The primary a-c buses feeding the electronic services are normally supplied by the left alternator. Should the left alternator fail, or be shut down, the a-c loads are automatically transferred to the right alternator. On failure or shut-down of both alternators, emergency a-c loads are supplied by a hydraulically driven a-c generator. 27.5 volt d-c power for the electronic services is fed from the main d-c bus, which is supplied by the transformer-rectifier units, or the battery-supplied emergency d-c bus.

#### 5.1.1 POWER DISTRIBUTION

The power requirements for ASTRA 1 equipment have been established by RCA and the power distribution system in the aircraft has been designed to adequately meet these requirements. Separation of essential and non-essential loads was adopted as a basic philosophy in design of the power distribution system. This facilitates maximum protection of essential flight services such as the damping system, telecommunications and flight instruments.

The main power supply centre for the electronic services (excluding the armament system) is located in the nosewheel well and includes the power distribution buses and control relays, power bus protection breakers and circuit protection breakers. In this area there are three a-c power distribution buses and three d-c buses arranged as follows:

AC - #1 primary a-c bus supplies the radar equipment.

- #3 primary a-c bus supplies the normal damping system and all other electronic loads, including those connected to the emergency a-c bus.

- The emergency a-c bus is energized when both aircraft alternators fail or shut down. It supplies the emergency damping system, essential flight instruments and the telecommunications equipment.

DC - #1 main d-c bus supplies the radar and miscellaneous electronic equipment.
- #3 main d-c bus supplies the normal damping system and AFCS.
- The emergency d-c bus is energized by the battery when the main d-c bus is de-energized by double alternator failure or shut-down. It supplies the emergency damping system, essential flight instruments and the telecommunications equipment.

Power for the armament system is fed directly from the aircraft electrical system, via the weapon pack shut-off relays located on the aft face of bulkhead 296, to the control relays and protection breakers installed in the weapon pack. The armament power distribution buses are arranged as follows:

AC - #2 primary a-c bus supplies the armament system including missiles and missile auxiliaries.

DC - #2 main d-c bus supplies the armament system.
- The emergency d-c bus for the armament system is supplied from the emergency bus in the main supply centre, and feeds the missile and launcher actuation system.

A main electronics junction box is located in the air conditioning duct bay; it provides an interconnection centre for the distribution of power for the main supply centre (nosewheel well) to all parts of the aircraft, except the radar nose and the weapon pack. Power for the radar nose is fed directly to the forward nose section and the right-hand rack of the aft nose section from the main supply centre. A separate interphone junction box is located at the right-hand side, to the rear, of the nosewheel bay and is used as an inter-connection centre for the pilot's and OBS/AI's intercom. The use of this separate junction box eliminates the possibility of intercom interference being caused by the use of a junction box common to other equipment.

### 5.1.2 AIRCRAFT WIRING

RCA is responsible for internal and inter-module wiring, terminating in connectors mounted on the equipment racks, or tail cables from RCA or GFE equipment items. AVRO provides the external circuit wiring between the racks and all other electronic areas. The aircraft wiring allows for the possible enlargement of the external circuits by the provision of extra, unused receptacle contacts with spare wires installed. The installation of the electronic system wiring is basically in accordance with specification MIL-W-5088A.

## 5.2 COOLING AND PRESSURIZATION

Cooling and pressurization of the electronic equipment is provided by the aircraft air conditioning system. A system of ducting is arranged to convey 88 lb/min. of conditioning air, at a temperature of 70°F, to the various electronic equipment areas (Note: Ducting in the radar nose is provided by RCA, and AVRO is supplying plenum chambers only). The cooling air is sufficient to maintain the equipment environment below 140°F. When the air conditioning system is operating on emergency ram air, no cooling air is supplied to the nose radar. Air flow requirements for ASTRA I equipment were specified by RCA and the air conditioning system has been designed to provide the following distribution of cooling air:

| | lb/min. |
|---|---|
| Nose radar | 46.5 |
| Dorsal equipment | 4.3 |
| Fuselage radar | 19.0 |

| | |
|---|---|
| Sparrow auxiliaries | 7.5 |
| Dorsal radar | 5.0 |
| Stable platform | 1.5 |
| IR radar (armament bar roof) | 1.5 |
| IR radar (fin) | 2.5 |
| | 88.0 lb/min (approx) |

A nitrogen cooling system is currently being developed to maintain the temperature of the infra-red seeker head detector within the correct operating limits.

The liquid cooling system for the magnetron and the radar antenna drive hydraulic system is provided by RCA. However, AVRO is responsible for all inter-unit plumbing and the supply of cooling air to the RCA heat exchanger. Pressurization of the radar antenna, waveguide, magnetron, oil reservoir, pulser and power supply is a function of the ASTRA I equipment, but inlet air to the compressor is supplied by the air conditioning system.

## 5.3 AIR DATA INPUTS

Air data reference inputs to the electric system are supplied by an air data boom on the nose of the aircraft. Uncorrected static and pitot pressures are piped from the air data boom to the air data computer, normal damping system and cockpit instruments. Indicated angle of attack and yaw data is furnished for the air data computer, the fire control system and the damping system by vane-type relative wind sensors (alpha and beta vanes) mounted on the nose boom. A pitot-static probe, mounted on the fin leading edge, provides inputs to the emergency damping system.

## 5.4 HYDRAULIC SUPPLIES

Power for the ASTRA I radar antenna drive is supplied by the flying controls hydraulics 'A' system. Hydraulic fluid at a pressure of 4,000 psi is piped to the antenna drove in the air conditioning equipment bay (lower) at 3.5 gpm. A check valve and a 4,000 psi accumulator are built into the supply lines, the latter to maintain the antenna drive presuure should the flying controls draw off sufficient fluid to starve the antenna system. Quick-disconnect couplings are installed in the pressure and return lines to facilitate installation and removal of the antenna installation.

## 6.0 MAINTENANCE AND OVERHAUL OF THE ELECTRONIC SYSTEM

In this section only the broad aspects of maintenance and overhaul are dealt with since they are covered in detail in a report prepared jointly by RCA and AVRO entitled "Preliminary Report on Maintenance and Overhaul of the ASTRA I Advanced Electronic System" (RCA Report No. AR-25). In addition, although considerable thought has been given to the maintenance procedures and the maintenance and test equipment required to support the electronic system, much of the design detail has not been finalized. The electronic system is presently in the initial stages of development, and changes will occur which will effect maintenance procedures before the equipment is delivered to squadron service.

### 6.1 MAINTENANCE PHILOSOPHY

It is not intended to discuss the complete ARROW aircraft maintenance philosophy but the following important facts have been taken into consideration in the design and maintenance planning for the electronic system.

Operation of an ARROW squadron in peacetime will be concerned primarily with attaining and maintaining a high degree of proficiency in the all-weather interceptor role. It will consist of a limited operational program superimposed on a training program. The object is to have a satisfactory potential of operational aircraft available at any time. The all-weather interceptor squadron will have a unit establishment of 12 operational aircraft. Full logistic support will be provided on the base in the form of a single support organization and the squadron will not be required to operate from any other base unless similar support is provided.

For each squadron, two aircraft will be at operational readiness at all times and two readiness hangars will be located at one end of the main runway. These aircraft will be capable of becoming airborne within two minutes from the time warning is given. This includes time to taxi from the readiness hangar to the runway end. A time of 15 minutes will be allowed to replace aircraft scrambled from a readiness hangar or becoming unserviceable in a readiness hangar.

Ground support equipment in the readiness hangars will be capable of maintaining aircraft in the "available" condition (15 minutes to go) indefinitely and providing for random periods of not more than 30 minutes at "standby" (two minutes to go). The maintenance organization will be capable of receiving and "turning-around" operational ARROW aircraft at the rate of four every 15 minutes, providing that the aircraft have no major unserviceabilities.

The peacetime utilization of the ARROW aircraft revises a minimum of 200 sorties per squadron per month. A sortie is assumed to have a duration of approximately 1 hour 20 minutes.

## 6.2 EQUIPMENT ACCESS AND REMOVAL

### 6.2.1 FORWARD RADAR NOSE SECTION

Access for limited sevicing is provided in the forward radar nose section, and consists of four panels, approximately 6 in by 12 in. The panels are located two on either side, top and bottom, toward the rear of the section. Access can be gained to replace crystals (upper right-hand door), charge the hydraulic accumulator (lower right-hand door), replace the compressor and dehydrator and adjust the magnetron line voltage (lower left-hand door) without removing the radome. Complete access is provided when the radome is removed. The integrated assembly can then be extended forward on its slide rails for complete servicing, inspection and/or repair.

On installation, the complete forward radar nose package is lowered onto the fully-extended slide rails with a hoist, using the lifting eyes on the package frame. The wiring is then connected. For removal, this procedure is reversed. Many of the smaller assemblies, including the antenna, are removable and/or replaceable without removing the entire integrated assembly.

### 6.2.2 AFT RADAR NOSE SECTION

Access to this area is gained through two upward opening doors, one on each side of the aircraft. These doors are secured by snap-locks, and may be supported in the open position by stays.

### 6.2.3 ELECTRONICS BAY

Access to the electronics bay is gained by a door on each side of the bay and an electrically actuated, downward opening centre door. The centre door is hinged at the aft end and is secured by Camloc fasteners and snap-locks. The control for the electric motor is located adjacent to the door and is readily accessible. Panels in the aircraft skin, one beneath the right-hand section, and one in the centre door, give access to the belly UHF antenna and the radio compass loop, respectively.

All the components mounted in this section are easily removable and/or replaceable independently of each other, except for the following two cases:

(a) the flight control ampliphier must be removed in order to replace the data link coupler.

(b) the air data computer must be removed in order to replace three units of the dead reckoning computer.

Modules in the two module racks in this section have similar retaining features to those detailed in section 3.2

With the possible exception of the doppler equipment, which has not yet been adequately defined, no special procedures or tools are required for installation and removal of the equipment in this section.

6.2.4 DORSAL

Access to the equipment mounted in the dorsal is accomplished by removing the fairings over the area. To remove the rear dorsal fairing, a cable between the radio compass antenna and the susceptiformer must be disconnected. A hand hole, covered by an access panel, is provided for this purpose. All the electronic equipment is on shockmounted trays and is readily accessible.

6.2.5 AIR CONDITIONING EQUIPMENT BAY (LOWER)

Access is provided to the air conditioning equipment bay by removal of the air conditioning access panel, which is located in the lower skin of the aircraft.

6.2.6 DUCT BAY

Access to the equipment contained in the duct bay is gained by removing the electrical power bay access panels. These panels are located in the lower skin of the duct bay and held in place by a nuber of quick-release type fasteners.

6.2.7 TELECOMMUNICATIONS ANTENNAS

Access to the various antennas is gained as follows:

| | | |
|---|---|---|
| UHF/L-band antenna | - | Removal of the fin cap |
| UHF belly antenna | - | By opening the electronic equipment bay, centre access door. |
| L-band belly antenna | - | Removal of the lower air conditioning equipment bay panel. |
| UHF homer antenna | - | Removal of the antenna access panel on the underside of the radar nose. |
| Radio compass loop | - | Through the radio compass loop access panel in the electronic equipment bay, centre access door. |
| Radio compass sense antenna | - | Removal of the sense antenna disconnect panel, and then the dorsal fairing. |
| Radar homer antenna | - | Location not yet decided upon. |
| Air-to-air IFF antennas | - | Removal of the right and left antenna access panels at the upper end of the fin rear spar. |

### 6.2.7.1 Waveguide for Air-to-Air IFF Antenna

The X-band waveguide for the air-to-air IFF antenna is installed in the fin and extends from the aft section of the dorsal, through the fin leading edge for about eight feet, then aft and up inside the fin to the antenna. Access to the waveguide joints for inspection and seal replacement is provided by access panels in the fin. Access to the complete waveguide is gained by removing the waveguide joint access panels, the antenna, the aft dorsal fairing and the fin leading edge. The installation is not designed for removal of the waveguide other than by major structural breakdown.

## 6.3 GROUND TESTING AND SERVICING

Details of the electronics system test equipment are beyond the scope of this brochure. Generally it is intended that special purpose GO/N)-GO test sets will be designed for the fire control and automatic flight control sub-systems, primarily for first line maintenace. Other special purpose test equipment will include a fire control computer test set, and fire control and flight control test benches. General purpose test equipment, both military and commercial, will be required for use with the test benches. *

## 6.3.1 FIRE CONTROL SUB-SYSTEMS GO/NO-GO TEST SET

### 6.3.1.1 General Description

The purpose of the fire control sub-system GO/NO-GO test set is primarily to ensure that the sub-system is serviceable to the extent that the aircraft may perform a prescribed mission successfully. The test set may be used in the "Readiness" condition as a quick, accurate check on the fire control sub-system, but is also capable of being used in first line maintenance for trouble isolation. As much of the fire control as possible will be tested by a GO/NO-GO test set, consistent with the complexity of the required equipment. The number of external controls will be kept to a minimum. No adjustments will be necessary during its operation as a test set. The set will be designed to give positive indication when used to carry out GO/NO-GO checks in the system.

### 6.3.1.2 Functional Requirements

The fire control sub-system GO/NO-GO test set will enable the following tests to be conducted:

(a) It will synthesize, and inject into the system, signals which accurately simulate the returned signal during a straight line lead collision attack.

(b) It will inject this signal into the system in a manner which will constitute a valid exercise, and permit appraisal of the sub-system performance.

(c) In the GO/NO-GO mode of operation, it will operate the fire control

* NOTE: Missile Auxiliaries Test Procedure has not yet been established.

sub-system, and those additional units which serve to integrate it with other sub-systems, in a manner which will assure compatibility.

(d) In the trouble-shooting mode of operation, it will provide for adjustment of the misaligned circuits of the fire control sub-system, whenever this procedure is consistent with the operational status of the aircraft.

(e) In the trouble-shooting mode of operation, it will provide for isolation of fire control faults to particular areas or units, to an extent consistent with the operational status of the aircraft.

6.3.1.3 Location of Aircraft Connection

The fire control sub-system GO/NO-GO test set will be connected by a single cable, to a test connection located on the right-hand side of the nosewheel well.

A standard RCAF 4G/1596 maintenance platform will be required to reach this test point.

6.3.2 COMPUTER TEST SET

6.3.2.1 General Description

The computer test set will be used mainly in second line maintenance to test and align the computer and to isolate particular areas of the computer for testing.

6.3.2.2 Functional Requirements

(a) The test set will be designed for testing and aligning the computer, harmonizing sections of the computer with each other and performing marginal tests of individual servo loops.

(b) It will operate so that the individual computer area to be tested and aligned will be isolated. In addition, the test set will be equipped to tie in this individual area with the necessary auxiliary circuits and monitoring devices built into the test set.

6.3.2.3 Location of Aircraft Connection

The computer test set will be connected to the aircraft at two points. One cable with three connectors will be attached to receptacles in the computer modules in the aft nose section. The second cable will be connected to the tracking loop circuitry in the electronic equipment bay.

6.3.3 FLIGHT CONTROL SUB-SYSTEM GO/NO-GO TEST SET

6.3.3.1 General Description

This test set will be employed during primary inspection in first line maintenance, to indicate the serviceability of the flight control sub-system. Detail design of this test equipment has not yet been finalized, but the indication will probably take the form of red and green lights or meters.

6.3.3.2 Functional Requirements

(a) The test set will verify the serviceability status of the automatic flight control sub-system.

(b) The test set will, in conjunction with the damper system test equipment, provide a complete dynamic check of the flight control sub-system and the damper system.

(c) The test set will be designed to locate faults down to the level of the particular unit concerned.

6.3.3.3 Location of Aircraft Connection

The flight control sub-system GO/NO-GO test set will be connected directly into the flight control sub-system in the electronic bay. A standard RCAF 4G/1596 maintenance platform will be used to gain entry to this area.

6.3.4 RADAR ANTENNA OPERATION DURING GROUND TESTING

During the GO/NO-GO checking of the fire control sub-system it will be necessary to operate the radar antenna. Hydraulic power (1000psi) for this operation will be supplied by a hydraulic rig. Two quick-disconnect fittings will be provided in the nosewheel well at the bottom of the Obs/AI's Bulkhead. Access to the fittings will be gained by using a standard RCAF 4G/1596 maintenance platform. A limit switch will be provided at the quick-disconnect point, which will automatically cause the isolation valve to close when the hydraulic connection is made. This will protect the ASTRA hydraulic system should the regular hydraulic test machine trailer be plugged in at the same time, during ground servicing. The antenna will not be operable in the extended position.

6.3.5 ANTENNA HYDRAULIC RESERVOIR AND MAGNETRON RESERVOIR FILLING

A charging and level indication panel will be provided in the nosewheel well. The panel will contain a fluid level gauge and charging connection for the antenna hydraulic reservoir and magnetron coolant reservoir. A charging valve and gauge for the 80 cu. inch hydraulic accumulator is also included on the panel.

6.3.6 FORWARD NOSE SECTION INSPECTION POINTS

In order to gain access to replace crystals, charge the accumulator, and service the radar air compressor and dehydrator without removing the radome, four small doors are provided (ref. para. 6.2.1).

6.3.7 GROUND HANDLING EQUIPMENT

6.3.7.1 Nose Dock

In order to provide a working platform on which to service the nose section area, including that portion of the system accessible through the side access doors, a nose dock type of maintenance stand will be required. This platform would wrap around the nose section and be capable of being manhandled into position.

It is proposed that a crane (capable of handling major components of the ASTRA I system) be built into the nose dock. Consideration has also been given to providing a sliding rack for radome removal, instead of slinging the radome off the aircraft. Details of the nose dock have not yet been finalized.

## 7.0 STUDIES AND INVESTIGATIONS

Studies and investigations to be completed by AVRO, and to be approved jointly by RCA and AVRO, are as follows:

(a) Investigation of electrical power requirements and power supply equipment. AVRO will check data supplied by RCA.

(b) Investigation of installation, configuration, volume, weight, cooling, presurization and environment of the electronic equipment. AVRO will check the data supplied by RCA.

(c) Design study on integral displays, controls and cockpit layouts, including the division of functions between the two cockpits. AVRO will monitor RCA activities to ensure compatibility with aircraft, and with the operational requirements specified by the RCAF.

(d) Investigations of missile stowage, launching and power requirement. AVRO is responsible for the design of the weapon pack and the investigation of missile launching, etc.

(e) Air data and flight data requirements. AVRO will supply RCA with information on characteristics of $P_t$ and $P_s$ lines and alpha and beta sensors.

(f) Investigation of snap-up and breakaway for automatic attack mode. AVRO will supply RCA with available aircraft data as requested.

(g) Investigation of best installation design for infra-red scanner on fin. AVRO responsibility after RCA decision on scanner diameter.

(h) Investigation of the range of pitch and roll at which engagement of the AFCS can be accomplished and the range of pitch attitude under AFCS control. AVRO will supply aircraft data as required by RCA and approve acceptable RCA reports.

(j) Multiplexing study. AVRO will participate in this study where the characteristics of AVRO-furnished antennas are involved.

(k) Investigation of equipment safety during pullout in presence of radiation and shockwaves. AVRO will provide shockwave characteristics and equations of aircraft dynamics.

REFERENCE REPORTS

1. Proposal For An Advanced Electronic Weapon System For the CF-105 - RCA
2. RCA - AR11 Issue 2 Model Specification For the ASTRA Electronic System For the ARROW Aircraft.
3. AAMS-105/2 Issue 1, July/1957. Model Specification for ARROW 2 Supersonic Interceptor Aircraft.
4. 72/SYSTEMS 11/27. ARROW 2 Electrical System.
5. 72/SYSTEMS 22/48. ARROW 2 Air Conditioning System.
6. 72/SYSTEMS 18/29. ARROW 2 Low Pressure Pneumatic System.
7. AR-22 Issue 2. Joint Report On Cockpit Instrumentation.
8. ARROW Statement of Work.
9. AR-25 Preliminary Report on Maintenance and Overhaul of the ASTRA I Advanced Electronic System.