JULY 1956

SECRET

CF-105 PRELIMINARY STUDY OF PROPOSED ARMAMENT STORAGE AND TEST FACILITY

Report No. LOG/105/36

AVRO AIRCRAFT LIMITED

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ARMAMENT STORAGE

AND

TEST FACILITY

Report No. LOG/105/36

JULY 1956

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1. ABSTRACT

1.1 Introduction

In May 1956, the RCAF made available to AVRO Aircraft Ltd. the plans and the development specification for Rocket Assembly and Storage Facilities which are to be built in the immediate future at the prepared all-weather bases which operate CF-100 aircraft armed with 2.75" F.F.A.A. rockets in wing-tip pods. Concurrently the Company were supplied with a draft report entitled "RCAF Logistics, Maintenance and Servicing Policy for Sparrow II Missile on the CF-100 Aircraft". The Company was asked to pass comment, as soon as possible, on this information with particular regard to the operation of CF-105 aircraft armed with Sparrow II missiles.

Since complete information on the handling and testing procedures of Sparrow II is not available and since the servicing and testing procedures of the CF-105 armament installation cannot yet be stated exactly, it was decided to issue a Preliminary Study Report on the proposed Armament Facility. It is the Company's intention to supersede this preliminary report in due course with a Final Study Report, when all the necessary information about the aircraft and its armament is available.

1.2 Purpose of Report

The purpose of the present report is,

(a) To indicate to the RCAF whether the presently planned Armament

1.2 (Cont'd) Facility is compatible with the probable requirements of the CF-105 aircraft.

(b) To establish a basis for discussions with the RCAF and for future engineering and logistics studies.

1.3 Discussion

In planning the prepared air bases for all-weather interceptor aircraft, a facility near the aircraft loading point is considered essential for preparing and storing the armament.

The first stage of this armament facility has already been designed to handle the 2.75" rockets and wing-tip rocket pods for an air base serving two squadrons of interceptors, each having 18 CF-100 aircraft. It consists of a fenced compound containing two magazines for storing explosives, an open area for storing empty pods in crates, a fuzing building for unpacking, testing and assembling the items, and an unheated building for storing loaded pods for ready use.

The RCAF plans to develop this facility later to support two squadrons of interceptors, each having 18 CF-100 aircraft armed with 4 Sparrow II air-to-air guided missiles. Because of the complex and delicate mechanisms that are required for their guidance and control, the missiles require heated areas for storage and air-conditioned, dust-free rooms for testing and assembling. Thus, a missile storage and test building is to be added to the facility and all of the buildings are to be

1.3 (Cont'd) heated and joined by covered passages.

In the third stage of development, the facility is presently planned to support a single squadron of 12 CF-105 aircraft armed with 4 Sparrow II missiles. This aircraft carries the armament in a semi-submerged position in a removable armament pack that fits into the bottom of the fuselage and which contains mechanisms to lower the missiles clear of the fuselage skin line just prior to launching them. It is proposed to reload the aircraft by removing the empty armament pack and replacing it with one that is loaded. The empty pack would then be taken to the Armament Storage and Test Facility and cleaned, inspected, tested and reloaded with missiles. Thus, in addition to the facilities for preparing the missile proper, a building would be required with provisions for storing, maintaining and servicing the armament packs.

Detailed specifications or designs for the necessary handling and test equipment cannot be given at this stage of development, since full information on the storage, assembly and test procedures for the Sparrow II missile are not at present available to the Company. However, the general requirements for the Armament Facility have been presented which, it is hoped, will be sufficient for the present.

1.4 Conclusions and Recommendations

(1) An armament storage and test facility is considered essential for each all-weather interceptor air base and it should be located as close as possible to the aircraft loading or turn-around point.

1.4 (Cont'd)

(2) All buildings and fixed equipment should be designed for handling the largest weapons that are likely to be carried on CF-100 and CF-105 aircraft. This could include ordnance of up to 15 ft. in length and 1200 lb. in weight.

(3) The armament facility as planned by the RCAF for handling 2.75" rockets and pods is considered to be adequate for the concept of operations that was specified.

(4) When air-to-air guided missiles are introduced, special installations will be required, including air-conditioned, dust-free rooms for testing and assembling the guidance and control systems and heated areas for storing these components It is recommended that these facilities be in a special building inside the armament compound.

(5) The armament facility as proposed by the RCAF for supporting two CF-100/Sparrow II squadrons is considered to be adequate for the concept of operations that was outlined.

(6) If a requirement was introduced for combined armament, such as arming CF-100 aircraft with 4 Sparrow II missiles and 2.75" rockets in pods, then additional storage buildings and possibly another fuzing building would be needed. Explosive Regulations would probably necessitate building a separate armament facility.

(7) Reloading the CF-105 aircraft by changing the armament pack appears to be the best way of meeting the specified aircraft turn-around time of 10 minutes, as far as the armament is concerned.

(8) With the introduction of armament packs, an additional building will

1.4 (Cont'd) probably be required in the armament compound with facilities for storing, maintaining and servicing these weapon packs.

(9) The water mains, sanitary sewers and power lines to the armament compound should be made from the start to be adequate to serve the facility in its final stage of development.

(10) Detailed requirements for the test and handling equipment cannot be specified at this time, since information is not available concerning the assembly, testing and servicing procedures for the Sparrow II missile. Also, testing and servicing instructions for the CF-105/ Sparrow II armament pack cannot be given yet, since the design of the pack is still in an early stage.

2. INTRODUCTION

2.1 Authority for Job

RCAF letter AMC 1038CN-100 (ACT 2-1) dated 27 September 1955 to C.A.S. called for certain engineering studies to be prepared by AVRO Aircraft Limited to ensure that the RCAF would be adequately prepared to support and maintain CF-105 aircraft in the field.

RCAF letter S1038-105-11 (ACE-1) dated 4 October 1955 from T.S.D 's/ A.V. Roe Canada Limited to the Company set out in detail the sum total of AVRO Aircraft Ltd. 's development responsibility with regard to CF-105 Ground Support Equipment. List 2, appended to that letter, called up specific engineering studies which the Company were to carry out for the RCAF. One of these engineering studies referred to Armament Package Servicing and the requirement called for a Study to cover the facilities and equipment necessary for storing, testing, and servicing the missile package.

In May 1956, the RCAF made available to AVRO Aircraft Limited the plans and the development specification for Rocket Assembly and Storage Facilities which are to be built in the immediate future at the prepared all-weather fighter bases which operate CF-100 aircraft armed with 2.75 F.F.A.A. rockets in wing-tip pods. Concurrently the Company was supplied with a draft report entitled "RCAF Logistics, Maintenance and Servicing Policy for the Sparrow II Missile on the CF-100 Aircraft". AVRO Aircraft Limited was asked to pass comment on this information

2.1 (Cont'd) with particular regard to the operation of CF-105 aircraft armed with Sparrow II missiles.

2.2 Scope of Preliminary Study

AVRO Aircraft Limited had not intended to issue a Study Report on the CF-105 Armament Facility until final information would be available on the handling and testing procedures of the Sparrow II missiles and until the design of the CF-105 weapon pack for these missiles had progressed to the stage where its servicing and testing procedures could be stated exactly.

However, when the RCAF asked AVRO Aircraft Limited to advise, as soon as possible, on the probable implications of CF-105 requirements with respect to the Rocket Armament Facility which is to be built immediately, it was decided to prepare and issue this Preliminary Study Report.

The scope of this preliminary report is therefore:

(a) To describe the Armament Facility which is to be constructed at prepared fighter bases to support two all weather interceptor squadrons, each having 18 CF-100 aircraft which are armed with 2.75" F.F.A.A. rockets in wing-tip pods.

(b) To outline the additional facilities which are being planned to adapt this Armament Facility to the requirements of two CF-100 squadrons armed with Sparrow II guided missiles mounted externally in pairs under each wing.

(c) To discuss and recommend the additional facilities which will

2.2 (Cont'd) probably be needed to meet the requirements of one CF-105 squadron of 12 aircraft, armed with Sparrow II guided missiles mounted in a removable weapon pack which fits into the bottom of the aircraft's fuselage.

It should be noted that allowance has been made in the design of buildings and facilities for handling missiles larger than "Sparrow II". Fixed equipment for use inside the buildings has not been specified in detail but should, if possible, be designed to handle larger missiles, possibly up to 15 feet in length and 1200 lb. weight.

Detailed specifications or designs for the necessary handling and test equipment cannot be given at this stage of development, since full information on the storage, assembly and test procedures for the Sparrow II missile is not at present available to the Company. However, the general requirements for the Armament Facility have been presented which, it is hoped, will be sufficient for the present.

The purpose of the present study is,

(a) To indicate to the RCAF whether the presently planned Armament Facility is compatible with the probable requirements of the CF-105 aircraft.

(b) To establish a basis for discussions with the RCAF and for future engineering and logistics studies.

It is the Company's intention to supersede this preliminary report in due

2.2 (Cont'd) course with a final Study Report, when all the necessary information about the aircraft and its armament is available.

3. ARMAMENT FACILITY CONCEPT

In planning for the introduction of modern all-weather interceptor aircraft into the aerial defence system, increasing importance is being placed on the use of well-prepared bases and adequate ground support equipment. This is borne out in current RCAF plans for the air bases from which it will operate CF-100 and CF-105 interceptor aircraft.

These air bases will require, in addition to the runways and usual maintenance hangars, special buildings and installations to ensure that the interceptors can be serviced, reloaded and scrambled in the shortest possible time under all conditions of weather. Alert Hangars have been planned and will be close to the main runway for sheltering armed aircraft in the highest state of readiness; First Line Maintenance Hangars have been proposed for carrying out primary maintenance and for sheltering serviceable aircraft in a state of readiness; Turn-Around Installations have been suggested and an Armament Facility is required for storing and preparing the air-to-air weapons currently being used and considered. A typical layout for part of such an air base is presented in Fig. 1, which shows a proposed location of alert hangars, turn-around facility and armament facility in relation to the main runway.

The proposed Armament Facility consists in essence of a fenced compound which contains magazines for the storage of explosives and areas or buildings for storing, testing and assembling various armament components. The facility should be self-contained and as close as possible to

3. (Cont'd) the aircraft loading or turn-around point, as shown in Fig. 1, in order to:

(a) Keep the handling of weapon components to a minimum.

(b) Keep transportation of ready-use weapons to a minimum.

(c) Keep all explosives in one area which is well removed from the main buildings on the air base.

(d) Make patrolling and protecting the facility as simple as possible.

Armament supplies would be brought by road transport to one gate of the compound and would be taken from there to the designated points for storage. Then, as required, armament components would be drawn from stores, inspected, tested, assembled and put into a ready-use storage facility close to the exit gate which leads to the aircraft loading area or turn-around point.

When siting this Armament Facility, RCAF Magazine and Explosive Safety Orders must be observed and the magazines may have to be some distance away from the armament test buildings at some air bases, in order to comply with those regulations which specify minimum distances from civilian property.

4. PROJECTED ARMAMENT FACILITY FOR TWO CF-100 SQUADRONS ARMED WITH WING-TIP ROCKET PODS

4.1 General Requirements

The armament storage and test facility which is described in this chapter has been designed by the Royal Canadian Air Force to support two squadrons using CF-100 aircraft fitted with wing-tip rocket pods and armed with 2.75" folding-fin rockets. To determine the size of the facility, it was assumed that each squadron would have 18 aircraft, of which 12 would be serviceable for combat operations, and that 12 firing sorties would be flown per month by each serviceable aircraft.

The storage areas have been designed to cater for one month's supply of pods and rockets. Since the pods are expendable, 2 pods and 58 rockets are required for each sortie, so that space is required for storing about 600 pods and about 17,000 rocket heads and rocket motors. Also, it was specified that provision should be made to store at least 48 pods per squadron in the fuzed condition. For this, "ready-use" storage shelters are planned with space for storing up to 200 fuzed pods. The flow of fuzed pods from the fuzing building is estimated at 3 pods per hour.

The pods and rockets are brought to the armament compound by truck and are taken to the designated areas for storage; rocket motors and rocket heads in the magazines, and pods in the open area indicated in Fig. 2. As they are needed, the pods, rocket motors and rocket heads are drawn from storage and taken to the fuzing building. Here they are unpacked,

4.1 (Cont'd) inspected, tested and assembled to provide fuzed pods, ready for installation on to the aircraft. A supply of fuzed pods is kept in a ready-use storage building close to the gate which leads to the aircraft loading point.

If the air base is to be used by a single squadron, rather than two squadrons, then only one magazine would be needed in the armament facility and the "ready-use" stores would be made to accommodate 120 fuzed pods rather than 200.

4.2 CF-100 Rocket Pods

The CF-100 Mk. 5 aircraft is armed with a total of 58 x 2.75" folding-fin rockets which are stowed in expendable, faired pods that are fitted to the wing tips. Fig. 3 shows a 2.75" rocket and the main components of a wing-tip rocket pod. Thses pods are 127" long, 20" in diameter, and weigh 178 lbs. empty or 728 lbs. when loaded with 29 rockets.

Each pod consists of three main components:

1. A structural center body containing the attachment fittings, the rocket launching tubes, a navigation light and wiring.
2. A plastic nose fairing which is shattered by the rockets as they leave the pod on firing.
3. A plastic tail cone which is jettisoned by an explosive link just prior to firing the first rocket.

The pods are delivered to the air base fully assembled, but without rockets, in plywood shipping crates and are to be stored in the open in the

4.2 (Cont'd) area indicated in Fig. 2. In support of this practice, a pod has been left exposed for one year and at the end of this period it showed no signs of deterioration.

When required, the pods will be taken to the fuzing building to be unpacked and prepared for firing. Preparation of the pods will consist of the following main operations:

(a) Checking the pods structurally.

(b) Checking the pods electrically.

(c) Fuzing the pods, i.e. inserting the rockets into the pods and installing the nose and tail cones.

These operations, along with the procedures for loading and arming the aircraft, are detailed in Avro Service Bulletin A-196 (soon to be superseded by RCAF EO 05-25E-2 and EO 05-25F-2).

4.3 2.75" Folding Fin Aircraft Rockets

The rockets which are being used currently with the CF-100 aircraft are the 2.75" diameter, folding-fin type. They are 48" long, weigh 18 1/2 lb. prior to firing, and are assembled from two components:

(1) A warhead weighing 6.47 lb. It contains a point-detonating fuze, an arming mechanism, and 1.4 lb. of high explosive.

(2) A tube containing the rocket motor, 5.9 lb. of propellant and the fins. The fins, when folded, fit inside the 2.75" diameter launching tubes, but are forced outward by the exhaust gases after firing and are locked mechanically in the extended position.

4.3 (Cont'd) The rocket heads are classed as Group 5, Category Z explosives when loose, and as Group 6, Category Z when boxed and must therefore be stored in the magazines. Standard explosive storehouse regulations must be observed whenever the heads are handled. They are shipped in sealed, steel containers with the fuze and head assembled; six heads to a container.

Rocket motors are classed as Group 6, Category Y explosives and must also be stored in the magazines. They are packed in watertight, steel containers with four motors to a container, and under normal storage temperatures they have a service life as below:

Mk. 1, Mod. 1 & 2 Motors - 21 months

Mk. 1, Mod. 3 Motors - 5 years

In handling and storing rocket motors, it should be noted that they are sensitive to temperatures below $0^{\circ}F$ and above $100^{\circ}F$, to direct sunlight, and to rough handling or jarring. In each case the main danger is in cracking the propellant charge, which could cause an explosion when the rocket is fired.

As rockets are needed for fitting into pods, heads and motors would be drawn from the magazines and taken to the fuzing building for unpacking, checking, and assembly. The checks would include a visual inspection of the rocket heads and motors for mechanical damage, cleaning to remove any protective grease from the screw threads which attack the heads to the motors, and an electrical continuity test of the motor firing circuit.

4.3 (Cont'd) These operations are detailed in the Description and Maintenance Instructions for 2.75" Aircraft Rockets, RCAF EO 30-100FF-2.

4.4 Storage Facilities

As mentioned earlier in this report, the pods are shipped to the armament facility fully assembled in plywood crates. They would be stored in the open in the area indicated in Fig. 2 and would be taken, as needed, to the fuzing building to be prepared for firing.

Two magazines, each 30'-6" wide x 60' long are provided for storing the rocket motors and heads. They must be sited and built in accordance with RCAF Magazine and Explosive Safety Orders and consequently, for some air bases, may have to be located some distance from the armament test facility so that the minimum specified distance from civilian property can be maintained. No temperature or humidity control is provided, although the magazines will be ventilated to keep dampness to a minimum. Internal walls or sandbag partitions will be required to separate the storage areas for rocket heads and motors and a light truck or a tractor and trailer will be needed for carrying these components to the fuzing building.

4.5 Fuzing Building

The fuzing building, which is shown in plan in Fig. 4, has been designed to permit unpacking, testing, and assembling of the rockets and pods with a high degree of safety and efficiency. Because of the quantity of

4.5 (Cont'd) explosives stored in it, the fuzing building must, like the magazines, be sited away from other air base buildings and civilian property in accordance with RCAF Magazine and Explosive Safety Orders. All of the walls and partitions in the fuzing building are constructed of 12" reinforced concrete and the rooms have been made big enough to handle other weapons much larger than the 2.75" rocket. The layout is such that, should an accident occur, the danger to personnel and to the rest of the armament supplies would be a minimum.

The crated pods are brought from the storage area to the "pod receiving" section of the fuzing building where they are unpacked and hoisted on to movable work stands. They are checked structurally and electrically and then are moved into the fuzing room where the rockets are fitted into the launching tubes and the noses and tail cones are installed. Following this, the fuzed pods are moved to the shipping area for transportation to the "ready-use" storage building.

The rocket motors are brought to the "explosives" entrance of the fuzing building and into a motor storage room which has space to store 480 rocket motors. The motors are unpacked here and then are passed through to motor test rooms where they are examined for damage and the motor firing circuit is tested for electrical continuity. After checking, the motors are passed through to assembly tables in the fuzing room for attachment of the rocket heads and for loading into pods.

A separate room is provided for unpacking, storing, and inspecting the

4.5 (Cont'd) high explosive rocket heads. It has space for storing 480 heads and for a bench on which they can be inspected and cleaned. Serviceable heads are carried from this room to the rocket assembly tables in the fuzing room where they are attached to the rocket motor.

It has been estimated that 3 pods per hour could be prepared in the fuzing building, using 2.75" rockets (29 per pod). Should 2" rockets be introduced (52 per pod), then only two pods per hour could be expected.

4.6 "Ready Use" Storage

From the fuzing building, the fuzed pods are taken to a "ready-use" storage building if they are not required immediately for loading an aircraft. In order that the ready-use storage will be readily accessible from the aircraft loading point, it is placed near the exit gate of the armament compound, as shown in Fig. 2. This building consists of ten compartments, each 15' wide and 25' deep and all partitions are constructed from 12" reinforced concrete. With suitable racks, each compartment is large enough to store 20 pods, so that a maximum of 200 pods may be stored ready for immediate use. If the "ready-use" stores building is to serve a single squadron, rather than two squadrons, then only 6 compartments will be built, giving space for 120 fuzed pods. These compartments will be ventilated, but no temperature or humidity control is contemplated at this time.

4.7 Handling and Test Equipment

A preliminary estimate of the handling and test equipment which will be

4.7 (Cont'd) required to operate this armament facility is given below:

- 1 trailer. This is required for transporting the rocket motors and heads from the magazines to the fuzing building and can be hauled by a fork-lift truck.

- 2 (minimum) fork-lift trucks. These are needed for unloading supplies for moving crated pods into the fuzing building, for putting fuzed pods into "ready-use" stores and for loading fuzed pods from the "ready-use" stores onto field trailers for transportation to the aircraft loading point. Overhead cranes might be used in both the fuzing building and the ready-use storage compartments, but it is felt that fork-lift trucks would be much faster and more flexible. Special tongs for the fork-lift trucks, or cradles for the pods would be needed.

- 6 (minimum) movable workstands for single pods. These would be used within the fuzing building to support the pods while they are being inspected, tested, and fuzed.

- 8 tractors and trailers fitted with cradles to carry 2 pods per trailer. These are required for hauling the pods from the armament test and storage facility to the aircraft loading point. This number is based on the assumption that eight aircraft would have to be reloaded during a fifteen minute period.

- 1 continuity, sequence, and insulation tester (1/U 22071). This is a portable, battery-operated test set which is required for the electrical tests on the pods prior to fuzing. (12 M/41 Safety Ohm meter)

- 2 rocket continuity test sets (RCAF Ref. 11C-69). These are

4.7 (Cont'd) portable, battery-operated units which are required for checking the continuity of the firing circuit of the rocket motors.

4.8 Power and Service

No electrical power is required in the preparation of wing-tip rocket pods other than for the heating plant for the fuzing building and for lighting. Water and sanitary drains are required to service the washroom in the fuzing building.

4.9 Personnel Required

Excluding supervision, it is estimated that at least 15 men are required to operate the armament facility in the manner described. They would be used as outlined below:

2 fork-lift operators. These men would be needed to take the crated pods and explosives to the fuzing building, and to transport fuzed pods in and out of the "ready-use" stores.

1 armourer to unpack the pods and to hoist them on to the movable workstands.

1 armourer to unpack rocket heads.

1 armourer to unpack rocket motors.

1 armourer to check the rocket pods.

1 armourer to check the rocket warheads.

2 armourers to check the rocket motors.

2 armourers to assemble rockets.

4.9 (Cont'd) 4 armourers to fit the rockets into the pods, and to attach the pod noses and tailcones.

8 drivers to haul fuzed pods from the "ready-use" stores to the aircraft at the loading point. However, these men would be members of the squadron servicing crews, rather than part of the staff for the armament facility. Therefore, they have not been included in the total number of men allocated to the facility.

5. ARMAMENT FACILITY FOR TWO CF-100 SQUADRONS ARMED WITH SPARROW II MISSILES

5.1 General Requirements

In this chapter, the armament facility is described as it would be used to serve two squadrons of CF-100 aircraft armed with Sparrow II guided missiles. Guided missiles, unlike the 2.75" rockets, are designed to manoeuver at supersonic speeds and to steer themselves to their target without human monitoring. To achieve these objectives, they contain highly refined mechanisms and complicated electronic components. Also, because of their size and the killing power of their warheads, only a few are launched at any one target. Thus, it is imperative to ensure that each missile is serviceable before it is launched, and its reliability must not be impaired by exposure or rough handling. Inspection and checking of the missile sub-systems (radar, auto-pilot, electrics, hydraulics, pneumatics) will be required when the missiles are prepared for firing, even though most of these systems cannot be tested realistically on the ground. However, excessive testing is to be avoided, since missiles are designed for use once only and some components are liable to be worn out by too much testing and servicing.

These characteristics have led to requirements for heated storage areas for the guidance and control assemblies, covered passages between the buildings, and air-conditioned, dust-free rooms for testing and assembling the hydraulic and electronic components. Thus, a missile test and assembly building is proposed for the area which was used previously

5.1 (Cont'd) for pod storage, and the "ready-use" storage building would be enlarged and heated. The missile building, fuzing building and "ready-use" storage building would be joined by covered passage ways. The layout of the armament facility, with these buildings added, is shown in Fig. 6.

The missile components would be brought to the compound by truck and taken to the designated buildings for storage. Explosives would be stored in the two magazines, and the guidance and control assemblies would be taken to the missile test and assembly building. When missiles were to be prepared for firing, the motors and warheads would be drawn from the magazines and taken to the fuzing building. There, they would be unpacked, checked, and assembled to serviceable guidance and control assemblies which would have been brought from the missile test and assembly building. Fully assembled missiles would be taken from the fuzing building and put into "ready-use" stores, unless they were needed at the aircraft loading point for installation on to an aircraft.

It is generally accepted at present that, when guided missiles are used, at least two should be fired at a target in order to achieve the required probability of kill. In keeping with this, the CF-100 installation is based on carrying four Sparrow II missiles, thereby giving the pilot the option of making two attacks by firing two missiles on each pass, or one attack firing all four missiles. On the CF-100 aircraft, the missiles will be mounted externally on fixed pylons under the wings. For jettisoning,

5.1 (Cont'd) the pylons and launchers remain with the aircraft and only the missiles are dropped.

In accordance with an RCAF draft report outlining the logistics, maintenance, and servicing policies for its squadrons armed with Sparrow II missiles, the present armament facility has been designed to serve two squadrons, each having 18 aircraft. Of these, 12 aircraft per squadron are assumed to be serviceable for combat operations, and it is specified that facilities must be available to turn around 4 aircraft per squadron in 15 minutes. Combat stocks of missiles have been specified at 256 missiles per squadron, of which at least 120 missiles per squadron are to be stored ready for immediate use.

5.2 Description of Sparrow II

5.2.1 General

Sparrow II is a boost-glide type of missile which is accelerated to high supersonic speeds by a solid-propellant rocket motor and then glides for the remainder of its flight to the target. Its wings are locked for 0.2 seconds after launch to prevent violent manoeuvring until the missile is clear of the launch aircraft, and an arming device keeps the fuze and warhead "safe" until the missile is well away from the launching aircraft.

Some of the particulars of Sparrow II are noted below:

Length	148"
Diameter	8"

5.2.1 (Cont'd)

Wing Span	40.12"
Weight	420 lbs.
Maximum Range	Up to 6 nautical miles
Max. Manoeuverability	2g
Maximum velocity	3000 ft/sec.
Operational Altitude	100 to 60,000'

A sketch of Sparrow II is presented in Fig. 5 to show the major components. These are described in the following sub-sections.

5.2.2 Radar and Guidance Assembly

Sparrow II is an active missile, having a small powerful K-band radar set to obtain its own guidance information. This information is used to steer the missile and also to assist the fuze in detonating the warhead at the point where it will do the most damage.

The radar and guidance computers are located in the nose section of the missile, and form a self-contained unit except for primary power. An aerodynamically fair, electrically transparent radome shields the antenna assembly.

5.2.3 Hydraulics and Power Supply

The wings of Sparrow II are movable and are actuated by an hydraulic system consisting of three electrically controlled transfer valves, each operating a ram. An accumulator, charged with nitrogen to 3500 p.s.i. pressure, supplies hydraulic fluid at an operating pressure regulated between 1700 and 2500 p.s.i. On later versions of the Sparrow, this

5.2.3 (Cont'd) accumulator may be deleted and a turbine-driven hydraulic pump may be fitted in its place.

Primary electrical power is obtained from a turbine-driven alternator which gives 750 VA at 4000 cps and 500 VA at 400 cps. D.C. voltages are obtained by means of a transformer and rectifier unit. A charge of ethylene oxide liquid fuel propellant generates the gas which drives the turbine. Prior to launch, power and the antenna slaving signals are obtained from the launching aircraft through an umilical plug.

5.2.4 Auto-Pilot

Fast, accurate response to guidance commands is achieved by means of an acceleration command auto-pilot governing hydraulic actuators. Also, the auto-pilot provides automatic flight stabilization and keeps the rate of roll within acceptable limits. It contains only 10 electronic tubes, which is a significant feature regarding reliability of the missile.

5.2.5 Armament System

The armament system consists of three elements; a fragmentation-type warhead which contains a 14 lb. high-explosive charge and which weighs approximately 49 lb.; a proximity fuze to burst the warhead at the point for maximum damage; and a safety and arming device which prevents detonation and delays arming the warhead until the missile is well away from the launching aircraft.

5.2.6 Propulsion System

The Sparrow II rocket motor is a solid-propellant, internal-burning

5.2.6 (Cont'd) charge contained within a thin-walled cylindrical chamber assembly. It weighs 117 lb. before burning, including 70 lb. of propellant, and produces approximately 8000 lb. thrust (at 60°F) for 1.85 seconds. Burning is initiated by a small, low-shock igniter equipped with a safety switch. The motor is designed for operations in temperatures from -75°F to +150°F, so that no external temperature control is required.

5.2.7 Wings and Fins

Fixed cruciform tail surfaces provide aerodynamic stability for the Sparrow II and control is achieved by moving the wings. All of the surfaces are of plug-in type and may be attached or removed quickly from the body of the missile. Because of this, a minimum of "ready-use" storage space is required, since the missiles can be stored with the fins and wings removed.

5.3 Missile Handling and Preparation

It is expected that the Sparrow II will be shipped to the air bases in seven packages, broken down as below in order to comply with RCAF explosive orders:

1. Radome, guidance, auto-pilot, power supply, fuze, and control assemblies.
2. Motor assembly (Group 6, Category Y explosive).
3. Warhead assembly (Group 7, Category Z explosive).
4. Wings and tail fins.
5. Motor igniters (Group 6, Category X explosive).

5.3 (Cont'd)

6. Warhead detonators (Group 10, Category Z explosive).

7. Safety and arming mechanism.

Packages 2, 3, 5, 6 would be stored in the magazines and would have to be handled in accordance with RCAF Magazine and Explosive Safety Orders. Items 1, 4, 7 would be taken to the missile test and assembly building and stored there until they were needed.

Package #1, which contains the electronic, instrument, and control section of the missile, will be a hermetically sealed container fitted with a desiccator and a humidity indicator. When packaged in this manner and protected from extremes of temperature, this assembly should have a shelf life of at least two years. It is assumed that the other components of the missile would also be packaged for long-term storage.

The two magazines in the armament facility would be adequate for storing the explosive components of the 512 missiles that are required to support two squadrons at the air base. The warheads (Group 7, Category Z explosive) would be stored in one magazine, and the motors (Group 6, Category Y), ignitors (Group 6, Categroy X), and detonators (Group 10, Category Z) would be stored in the second magazine. However, internal walls or sandbag partitions would be required in the second magazine to separate the different types of explosive. All of the explosive items would be taken to the fuzing building for unpacking, testing, and assembly with the non-explosive components of the missile.

To prepare the Sparrow II for firing, the non-explosive components would

5.3 (Cont'd) be unpacked, inspected for damage, and tested in the missile test and assembly building. The guidance and control sections of the missile would be checked in the air-conditioned, dust-free rooms on a "go-no go" type of automatic test rig. Details of the tests are not known at this time, but they would include at least function checks of the radar (transmitter, antenna, and receiver), the auto-pilot, and the control systems. It is estimated that such a check-out will require about 20 minutes per missile.

After checking, the non-explosive components would be taken to the fuzing building for assembly with the explosive items, or would be stored in the missile test building if they were not needed immediately. From the fuzing building, the assembled missiles would be transferred to the "ready-use" stores, and, to conserve space, stored with the wings and fins detached. As the missiles are drawn from the "ready-use" stores, a final servicing check might be required.

No servicing instructions for the Sparrow II are available at this time, but it is expected that the operations would include fitting the wings and fins, and charging the hydraulic system and the accumulator. The shelf life of "ready-use" missiles has been set at 30 days initially, but will be increased to 90 days when experience warrants it. For missiles on aircraft, or with the accumulator charged, the estimated shelf life is 4 days. Thus, the armament facility will have to provide for considerable

5.3 (Cont'd) recycling of missiles as well as for storage and for initial testing and assembling.

5.4 Missile Test and Assembly Building

It was pointed out earlier in this report that the characteristics of air-to-air guided missiles led to a requirement for a special building in the armament facility in which the guidance and control sections of the missiles could be stored and tested. A sketch of a typical building for this purpose is shown in Fig. 7 of this report. It is a reinforced concrete structure divided into two main areas; one for receiving, storing, and shipping the packaged items, and the other, an air-conditioned, dust-free zone for testing and repairing the electronic and instrument components and for storing them after they have been checked. Access to this zone is through a locker room, and since female help may be used in the building, provision is made for separate washrooms.

The missiles would be brought by truck to the receiving area of the building and stored in their shipping container. Since the guidance and control assemblies weigh over 400 lb. in the containers, an overhead conveyor system is recommended for moving them about and for lifting the containers on to tables for unpacking. The missiles would be lifted from the containers by a crane and passed through to the air conditioned testing section of the building on a monorail system. Here they would be lowered on to movable workstands and taken to the special test rigs which are in separate rooms. Serviceable components would be stored in racks

5.4 (Cont'd) near the exit leading to the fuzing building and any rejected missiles would be moved into the faults isolation room where defective items would be replaced. Adjacent to this is a pressurized instrument room with equipment for repairing and testing delicate parts such as gyros and hydraulic components. Storage rooms for spare parts and rejected parts are located so that they are accessible from the faults isolation room. Office space is provided in the building, since it will be necessary to maintain records of serviceability and failures of individual parts, particularly in the early days of using missiles.

It should be noted that the facilities for this missile test and assembly building could be provided in the squadron electronics maintenance hangar, since the equipment and trades which are required are similar in nature. This would mean that fewer personnel and less equipment would be needed inside the explosives danger area, although it would of course imply hauling serviceable guidance and control assemblies long distances to the fuzing building by truck or trailer.

5.5 Fuzing Building

In the proposed armament facility for squadrons armed with air-to-air guided missiles, the fuzing building would be joined to the missile test and assembly building and to the "ready-use" storage building by covered passages. This would permit the use of light, movable work-stands on which the missiles could be assembled and transported readily from one area to another.

5.5 (Cont'd) As with the 2.75" rockets, the explosive items (motors, igniters, warheads, and detonators) would be brought to the explosives receiving area of the fuzing building for unpacking and checking. Although no details are available at this time about any tests which might be required on these items, it is assumed that only visual inspections and electrical continuity checks will be needed. Serviceable items would be transferred to the fuzing room for assembly with the guidance and control components of the missile. The fuzing building is shown in Fig. 8, as it would be used to handle Sparrow II missiles. It is expected that only one rocket motor test room would be required when Sparrow II missiles are being used.

5.6 "Ready-Use" Stores

For use with Sparrow II missiles, the existing "ready-use" storage building would have to be enlarged to provide covered access to all of the storage compartments and it would have to be heated. The ten compartments, each 15' wide and 25' deep, would have space for up to 200 Sparrow II missiles, if they were stored with the wings and fins detached. It is assumed that they would be stored sideways in the compartments on racks, and would be lifted in and out by fork-lift trucks.

Just prior to sending missiles to the loading point for installation on to aircraft, a final servicing operation may be required. While not known in detail, it will probably involve fitting the wings and fins and charging the hydraulic system and the nitrogen accumulator. A small, portable,

5.6 (Cont'd) servicing rig may be required in the "ready-use" storage building for this work.

5.7 Handling and Test Equipment

An estimated list of equipment for the armament facility for use with the Sparrow II missile is given below:

- 1 trailer. This would be required for carrying explosives from the magazines to the fuzing building. It was also needed for the faciliyt handling 2.75" rockets.

-1 (possibly 2) overhead, travelling cranes in the missile building. These would be required for handling incoming and outgoing missile containers, and for tranferring missiles to the test area.

- 8 (minimum) missile assembly dollies. These would be used for moving the missiles around in the test and fuzing areas and to support the missiles during the test and assembly operations.

- 2 electric fork-lift trucks. These would be needed in the missile building and in "ready-use" stores for lifting missiles into and out from storage racks, and for loading them on to trailers for transportation to the aircraft loading point.

- 8 trailers per squadron. These would be used for hauling missiles to the aircraft loading point. Racks, to carry two missiles per trailer, would also be needed. They would be squadron equipment, and the number is based on serving 4 aircraft per squadron in a 15 minute period.

- 2 guidance and control system test rigs. These would be of an automatic "go-no go" type, probably developed by the missile contractor.

5.7 (Cont'd) No details are available at present, although it is assumed that the unit would supply electrical power, electronic signals, hydraulic fluid, and high-pressure nitrogen to the missile for the tests. Although one test rig could handle initial testing of missiles at a rate high enough to support two squadrons (since a full test requires only 20 minutes), two rigs would be desirable because missiles would require recycling at frequent intervals. The services required might include 4 KVA of electrical power and cooling means for the hydraulic system.

- 2 radar target simulators. These would be chambers, approximately 4' x 4' x 4' for absorbing the radar energy which is radiated during the tests.

- miscellaneous test meters and special tools for testing and repairing defective electronic and mechanical parts of the missile.

- 1 missile servicing rig. This might be required in the "ready-use" storage building for charging the missile hydraulic system with fluid and the accumulator with nitrogen just before the missiles would be taken to the aircraft loading point. It is assumed that nitrogen bottles would be used on the rig and that no hydraulic pumps would be required.

- no major changes would be required for the fixed equipment in the fuzing building. It is probable that benches would be re-located and that a different test set for the rocket motors would be needed.

5.8 Power and Services

In converting the armament facility to handle Sparrow II missiles in place of 2.75" rockets and pods, no major changes would be required in the

5.8 (Cont'd) necessary services. Water and sanitary sewers would already have been supplied for the fuzing building and would have to be extended to the missile building to handle the washrooms, air conditioning unit and possibly cooling for the hydraulic systems on the missile test rigs. Heating and lighting would be available for the fuzing building, but would also be required for the missile test and assembly building and for the "ready-use" storage building. Additional power would be needed in the missile test building for the test rigs, but since no details of the test rig are available, the amount is not known. It is estimated that about 8 KVA might be required for the two rigs.

5.9 Personnel Required

It is estimated that, excluding supervision and clerical staff, at least 18 men will be required to operate the armament facility for two squadrons of CF-100 aircraft armed with Sparrow II missiles. They would be used as below:

- 2 fork-lift operators. These men would be needed to transport explosives from the magazines to the fuzing building, and to lift missiles into and out of storage racks.

- 3 men to handle and unpack the missiles and containers coming into the missile building, and to load the missiles on movable workstands.

- 5 armament systems men to test the guidance and control systems, and to correct faults.

- 1 man to transport missiles on dollies from one area to another in the buildings.

5.9 (Cont'd)

- 1 armourer to unpack explosives.
- 1 armourer to inspect the warheads and detonators.
- 1 armourer to inspect the rocket motors and igniters.
- 4 armourers to assemble missiles.
- 8 drivers to haul missiles to the aircraft loading point.

Since the latter would be squadron personnel, they have not been included in the total number of people required to staff the facility.

6. ARMAMENT FACILITY FOR ONE CF-105 SQUADRON ARMED WITH SPARROW II MISSILES

6.1 General Requirements

In this section of the report, the armament storage and test facility is described as it might be developed to serve one squadron of CF-105 interceptor aircraft armed with Sparrow II guided missiles. The armament installation of the CF-105 aircraft differs from that of the CF-100 in that the missiles are carried in a semi-submerged position in a removable weapon pack which fits into the bottom of the fuselage. The procedure which is proposed for reloading the aircraft is to remove the empty pack and to replace it with one that is loaded. The implications of this concept are important with respect to the armament storage and test facility and it would therefore be helpful to review the reasons for adopting the weapon pack concept. These are:

(a) Internal or semi-submerged stowage has been chosen for the missiles because it causes less drag than an external installation and consequently it improves the performance of the aircraft. However, the missiles must be lowered clear of the fuselage skin line just prior to launching and this requires a system of mechanical links, doors, hydraulic actuators, and electrical signals and switches. It was considered advisable to have all this equipment in a self-contained removable pack so that, should any component become unserviceable, a serviceable pack could be quickly substituted rather than making the entire aircraft unserviceable.

(b) By making the aircraft primary structure independent of the

6.1 (Cont'd) armament bay structure, any changes in the type of armament to be carried could be accommodated with the least amount of change to the aircraft. This greatly expedites the incorporation of such changes and saves money. It has already paid a significant divident in this respect, before the aircraft has even flown.

(c) It makes it feasible to contemplate the possibility of interchangeable armament packs carrying different weapons or stores. This makes the aircraft more versatile from a tactical point of view.

(d) Reloading the aircraft by changing armament packs permits the specified "turn-around" period of 10 minutes to be met comfortably, as far as the armament is concerned. This has already been demonstrated during the aircraft mock-up conference. It is extremely doubtful whether the "turn-around" requirement can be met any other way with the armament which is contemplated at present.

To load, maintain and store these armament packs, an additional building, approximately 96' wide and 172' long, is proposed inside the armament compound. It would consist of two main sections: one for storing, repairing and maintaining unloaded packs and dollies; the other for servicing and reloading packs and for storing them in the loaded condition. As shown in Fig. 9, this "pack" building would be located between the missile "ready-use" stores and the gate leading to the aircraft loading point.

The missiles would be prepared as outlined in the previous chapter of this

6.1 (Cont'd) armament bay structure, any changes in the type of armament to be carried could be accommodated with the least amount of change to the aircraft. This greatly expedites the incorporation of such changes and saves money. It has already paid a significant divident in this respect, before the aircraft has even flown.

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The missiles would be prepared as outlined in the previous chapter of this

6.1 (Cont'd) report, so that no alterations to the armament facility would be required in this respect. In assembling the missiles, however, it may be necessary to check the rigging of the wings and fins, since on the CF-105 installation the clearances will be small between the missiles and the armament pack structure. When required, serviceable missiles would be drawn from the missile "ready-use" stores and loaded into armament packs in the "pack" building. After loading, the packs would be taken to the aircraft loading point and hoisted into aircraft, or, if not required immediately, they would be stored in stalls in the pack building. The packs would be transported and stored on dollies similar to that shown in Fig. 10. These dollies also serve as hoists for lifting the packs into or out of aircraft and pack servicing stands.

It should be noted that the removable armament pack concept does not preclude loading missiles directly into the aircraft. If this were done, the missiles would be taken from the "ready-use" missiles stores through the pack building to the aircraft loading point on missile transport dollies and would be fitted to the launcher rails while the pack was in the aircraft. However, it is presently felt that this procedure would adversely affect the aircraft turn-around time and this is discussed further in Para. 6.2.2 of this report.

It is understood that, with the CF-105 aircraft, a single squadron consisting of 12 fighter and 2 trainer aircraft is to be stationed at each all-weather air base. Of these aircraft, 6 fighters are considered to be

6.1 (Cont'd) serviceable for combat operations and the squadron facilities are to be capable of turning around 4 aircraft in any 15-minute period. With this decrease in the number of active aircraft at each base, the number of missiles to be stored and handled could be reduced to 250 (say) so that the magazines, missile building, fuzing building, and other buildings as planned for the CF-100 would be more than adequate. However, to meet the turn-around requirement, a serviceable loaded pack must be available for each aircraft as it returns from a mission, so that at least 12 packs are required to support the 6 active aircraft. The number of spare packs required over and above this number depends on the total number of sorties likely to be required and on the serviceability of the packs after firing. For this preliminary report, it is assumed that 18 packs are allocated to each squadron and that initially 6 would be installed in serviceable aircraft, 6 would be stored serviceable and loaded, and 6 would be stored serviceable and empty, or would be undergoing routine maintenance or repair work. In addition, if it is assumed that the duration of each sortie is 1 hour, the pack servicing facility should probably have 3 "pack servicing stands", since servicing and reloading a pack will require about 30 minutes. While it might be argued that 2 "pack servicing stands" would be adequate, since some packs may be unserviceable after firing and therefore could not be reloaded, the additional capacity would permit some minor pack repairs and adjustments to be made. Further information is required concerning the total number of sorties and the serviceability of the armament pack after firing,

6.1 (Cont'd) before the design of a pack servicing facility can be finalized.

6.2 CF-105 Armament Package

6.2.1 Description

The armament pack which is being designed for the CF-105 aircraft at the present time will stow four Sparrow II guided missiles in a semi-submerged position and lower them clear of the fuselage skin line just before they are launched. This pack will be approximately 16 ft. long, 10 ft. wide, and will weigh about 3800 lb. when loaded. During an attack, either two or four missiles may be fired, and if only two are selected, the outboard missiles will be fired first. Only those missiles which are selected for firing will be lowered during the attack phase.

When the missiles are in the stowed position, the openings where the wings and fins pass through the skin line will be sealed by roll-type doors. These will open inwardly while the missiles are being lowered and after the missiles have been fired the launchers will be retracted part way so that they will cover the openings which had been filled previously by the missile bodies. Jettisonable fairings may be required over the exposed portions of the missile bodies to permit temperature control and to provide protection from stones, mud, or ice thrown up during take-off. Extension of the missiles, including operation of the doors, will be accomplished by means of a system of mechanical links. These will be powered by hydraulic actuators which will be controlled by electrical signals and switches and hydraulic power is obtained from

6.2.1 (Cont'd) the aircraft utility hydraulic system which can supply 40 U. S. gallons of fluid per minute at a pressure of 4000 p. s. i. One accumulator is fitted in this system, but it is not large enough to permit any functioning of the pack without the pumps running or, alternatively, an external supply of fluid. All hydraulic and electrical connections between the pack and the aircraft will be through "quick-disconnect" couplings, and for safety, all missile firing signals will be brought through one electrical connector which will be mounted at one side of the pack. Making this connection will constitute arming the aircraft. "Hangfire" missiles will be jettisoned automatically in combat operations, but for training missions provision will be made to retract the missiles if they fail to fire.

The CF-105 armament packs are designed to be fully interchangeable between aircraft and will be attached to the aircraft at four pick-up points, one at each corner of the pack. Of these, only the rear attachments will be jigged, and precise jigging will only be required for their distance apart. The two front pick-ups will mate with self-aligning fittings in the aircraft and therefore they will not require careful jigging. All attachments will be locked and unlocked individually and will be operated manually from outside the package without removing any panels.

6.2.2 Reloading the CF-105 Aircraft

With the CF-105 aircraft, it will be possible to reload in two ways.

6.2.2 (Cont'd) These are:

A. By removing the used armament pack and replacing it with another that has been serviced and loaded away from the aircraft.

B. By servicing the pack and loading missiles into it while it is fitted to the aircraft.

However, if the specified turn-around time of 10 minutes for the aircraft is to be met, only the first of these methods seems feasible at the moment.

The design of the Sparrow II pack has not yet progressed to a state where detailed servicing instructions can be specified, but for the purpose of this preliminary report, schedules have been assumed for servicing the pack and for each method of reloading the aircraft. These are given below:

(a) To reload the aircraft by changing packs, it is believed that the following operations will be necessary:

1. Disarm the pack by disconnecting the missile firing circuits.
2. Depressurize the aircraft utility hydraulic system.
3. Disconnect the hydraulic and electrical couplings between the pack and the aircraft.
4. Remove the used pack from the aircraft.
5. Check the missile auxiliary circuits using a special test set.
6. Override the ground safety switches and check the missile firing circuits for stray voltages.
7. Reset all safety switches.

6.2.2 (Cont'd)

8. Install a serviceable, loaded pack into the aircraft.
9. Make the hydraulic and electrical connections between the pack and the aircraft.
10. Reset the depressurizing valve in the utility hydraulic system.
11. Arm the pack by connecting the firing circuits

It has been demonstrated on the CF-105 mock-up that an armament pack can be removed and re-installed in about 4 to 5 minutes. Since the checks on the aircraft circuits should not exceed 5 minutes, the specified 10-minute turn-around for the aircraft can be met by this method.

The used pack would be taken to the "pack" building in the armament storage and test facility and hoisted into a servicing stand for reloading. A preliminary schedule for reloading the armament pack is offered below.

1. Connect the hydraulic and electrical couplings between the pack and the servicing stand.
2. Lower the launchers.
3. Remove any unfired missiles so that the pack may be tested without risk of firing any missiles.
4. Clean the pack to remove any corrosive deposits left by the exhaust gases from the rocket motors.
5. Inspect the pack for damage.
6. Test the pack in its various firing modes. This would also include electrical and electronic tests using dummy missiles and dummy missile auxiliaries.

6.2.2 (Cont'd)

7. Reload the pack with serviceable missiles from the "ready-use" missile stores.
8. Retract the missiles and launchers.
9. Disconnect the hydraulic and electrical services.
10. Remove the loaded pack from the servicing stand and transport it to the aircraft loading point for installation into an aircraft, or put it into "ready-use" pack stores.

It is estimated that a pack would have to be in a servicing stand for 25 to 30 minutes to complete this work. This would include 5 minutes to unload unfired missiles, 10 minutes to clean and inspect the pack, 5 minutes to test the pack, and 10 minutes to load missiles.

(b) To load missiles directly into the aircraft, the sequence of operations is believed to be:

1. With one engine still idling in order to provide hydraulic and electric power, disarm the pack by disconnecting the missile firing circuits and lower the missile launchers.
2. Shut down the engine.
3. Unload unfired missiles to permit testing the pack without risk.
4. Connect external hydraulic and electrical power supplies to the aircraft.
5. Clean the pack to remove any corrosive deposits left by the exhaust gases from the rocket motors.
6. Inspect the pack for damage.
7. Check the pack and missile auxiliaries for correct functioning.

6.2.2 (Cont'd)

8. Override the ground safety switches and check the missile firing circuits for stray voltages.
9. Load missiles on to the launchers.
10. Retract the launchers.
11. Disconnect the hydraulic and electrical external power supplies.
12. Check the compensator level in the aircraft utility hydraulic system and top up with fluid if necessary.
13. Arm the aircraft by connecting the missile firing circuits.

Using this technique, the aircraft turn-around time would probably be 25 to 35 minutes, allowing 5 minutes for unloading unfired missiles, 10 minutes for cleaning and inspecting the pack, 5 minutes for testing, 10 minutes for loading missiles, and 5 minutes for servicing the utility hydraulic system. If fairings should be required over the missiles, they would be fitted after the missiles were retracted and while the utility hydraulic system was being serviced.

6.2.3 Handling the CF-105 Armament Pack

It has been explained that the presently preferred procedure for reloading the CF-105 aircraft is to remove the "used" armament pack and to replace it with another one that has been serviced and loaded. Also, the "used" pack would be taken to a building in the armament storage and test facility and would be hoisted into a rig for servicing and reloading. When it is considered that the pack is approximately 16 ft. long, 10 ft. wide, and weighs about 3800 lb. when loaded, it is readily

6.2.3 (Cont'd) appreciated that power equipment is required for all handling operations.

For transporting the pack and lifting it in and out of an aircraft or a servicing stand, a "weapon pack hoisting dolly" has been designed by Avro Aircraft Ltd. It will be fitted with a towing bar and steering gear to permit rapid towing behind a tractor. It should be noted that the dolly has been designed for towing the pack sideways only, since the pack must be towed under the aircraft from the side. Provision has been made to unlock and castor the wheels to permit limited movement in the fore-and-aft direction, but no towing bar has been provided for this.

To install a weapon pack in an aircraft (or servicing stand), the pack is towed on its dolly to a point underneath the armament bay and four cables are attached from the dolly to lifting points on the aircraft structure. By means of these cables, pneumatic actuators in the dolly raise the dolly with its pack until the four attachment fittings between the pack and the aircraft are engaged and can be locked. The advantage of hoisting the pack by means of cables is that it will align itself automatically with the aircraft pick-up points and therefore no accurate positioning of the pack underneath the aircraft is required. The dolly is then lowered to the ground and the cables are detached from the aircraft. Pack removal is accomplished by the reverse process. To illustrate this hoisting operation, Fig. 10 shows an early CF-105 armament pack being lifted into the aircraft mock-up on a hoisting dolly. The power for the pneumatic actuators is obtained from air bottles which are mounted on the

6.2.3 (Cont'd) dolly and charged to 1800 p. s. i. These bottles are adequate to hoist a loaded pack into an aircraft six times without recharging. In addition to using the dollies for transporting and hoisting the packs, it is proposed that they be used for supporting the packs whenever they are being stored, either loaded or unloaded. On this basis one dolly would be required for each armament pack, or a total of 18 per squadron of 12 aircraft, based on the considerations discussed in Para. 6.1.

6.3 Missile Pack Building

In line with current thinking to keep all the armament functions and equipment in one area, a building approximately 96' wide and 172' long is proposed for the armament compound with facilities for handling, testing, and storing CF-105 weapon packs. As shown in Fig. 9, it would be attached to the "ready-use" missile storage building, and would have a door near the gate leading to the aircraft loading point. Thus, missiles could be brought easily to the packs for loading, and the loaded packs could be taken directly to the aircraft loading point. A typical Missile Pack Building is shown in Fig 11.

The pack must be mounted in a servicing stand for reloading and, because of its size and weight, it is considered advisable to hoist it once only and to carry out all servicing operations - unloading, cleaning, inspecting, testing, and reloading in one location.

To sustain 6 aircraft that are flying one hour combat missions, three servicing stands will probably be required since about 25 to 30 minutes

6.3 (Cont'd) will be needed for servicing each pack. While no detailed design is submitted for the servicing stands as yet, it is suggested that, for safety, they be in the form of compartments approximately 24' wide and 20' deep with all partitions made from reinforced concrete. Pack attachment fittings and hoisting fittings could be suspended from the roof of each compartment so that the pack could be hoisted and mounted in the same way as on the aircraft. Each loading compartment would require an hydraulic supply of 40 U S. gallons per minute at 4000 p. s. i. for 2 to 3 seconds for each operation of the missile lowering mechanism, and electrical power for operating the pack and any test equipment. In addition, water and drains would be needed for cleaning the pack after firing.

Opposite the pack loading compartments would be four "loaded pack" storage stalls, each with space for two loaded packs on hoisting dollies. In between, sufficient space would be left open to enable tractors to manoeuver easily while towing packs on dollies.

In the maintenance part of the building, one pack maintenance compartment would be provided. It would be identical to those used for servicing and reloading, and could be used for reloading packs if necessary. Storage areas would be included for serviceable unloaded packs, hoisting dollies, spare parts, and tools. Unserviceable packs would be left outside the building until the maintenance stand was free.

Space would also be provided for a washroom, a staff room, and an equipment room. This latter would house the hydraulic pumps and generators

6.3 (Cont'd) which are needed for operating and testing the pack mechanisms and an air compressor to supply air for the bottles and tires on the hoisting dollies.

6.4 Handling and Test Equipment

The equipment which is required for handling and preparing the Sparrow II missiles has been outlined in Section 5.7 of this report and is not repeated here. The only change that might be needed would be in the missile transporter, since the height and spacing of the missile launchers is not the same on CF-100 and CF-105 aircraft.

For the CF-105 armament packages, a preliminary list of equipment is offered below:

- 18 armament pack hoisting dollies, based on having a dolly for each armament pack.

- 8 tractors. Two would be required for moving packs in the pack building, and one to serve each of the six active aircraft.

- 1 crane (overhead or mobile) with at least 3 ton capacity. This would be needed for lifting a pack if a dolly became unserviceable and had to be replaced.

- 4 armament pack test sets. Although not yet designed, the test sets would be required to simulate the missiles and the aircraft fire control system to the extent that each pack could be tested fully prior to loading.

6.4 (Cont'd) - Miscellaneous tools for making repairs, and adjustments, to the weapon packs.

6.5 Power and Service

If CF-100/Sparrow II squadrons were re-equipped with CF-105 aircraft, it has been suggested that a weapon pack building be added to the armament facility. This building would require heat, water, and sanitary sewers, which might be extended from the other buildings in the armament compound. The power requirements cannot be specified firmly, since the design of the weapon pack is not complete, but preliminary estimates, excluding lighting requirements, are given below:

Weapon Pack Building

Hydraulic: Each operation of the pack takes about 2 seconds and requires fluid at 4000 p. s. i. pressure at a rate of 40 U. S. gallons per minute, so that about 125 H. P. is required for testing each pack, or 600 H. P. total, if all of the fluid is supplied directly from pumps. However, by using accumulators and by staggering the testing in the four pack servicing compartments, the total power required could be reduced considerably.

Electric: In order to test the pack and missile circuits completely, it is estimated that up to 15 KVA per pack would be needed, but if the pack circuits are checked for electrical continuity only, the requirement is practically nil. It is assumed that 15 KVA would be needed for the pack maintenance stand.

6.5 (Cont'd) Compressed Air: Air is required at 1800 p. s. i. for charging the bottles on the missile pack hoisting dollies. In addition, air may be required for charging accumulators, if they should be used in the test hydraulic system, and for air driven tools which might be used for repair work on the packs. A 10 H. P. compressor such as the Ingersoll-Rand #P3310E (RCAF Ref. 4G/1578) would be adequate for these services. Thus, excluding lighting, at least 25 KVA would be required for the pack building but no total power requirement is given, since this is governed by the number of packs which must be functioned at any one time and by the design of the hydraulic test system.

6.6 Personnel Required

For an air base operating a single squadron of CF-105 aircraft, there would be fewer aircraft to supply and a smaller stock of missiles to maintain, so that fewer people would be required for testing and assembling missiles than in the CF-100/Sparrow II case outlined in Chapter 5. However, additional men are needed for servicing the CF-105 weapon pack and it is estimated that, excluding supervision and clerical staff, at least 30 men will be required to operate the armament facility for one CF-105 squadron. This number is broken down as follows:

- 2 fork lift operators. These men would be needed for transporting explosives from the magazines to the fuzing building, for lifting missiles in and out of storage racks and for hauling packs and dollies about in the missile pack building.

6.6 (Cont'd)

- 2 men to unpack missiles, to handle missile containers and to transport missiles on dollies from one area to another in the missile test and fuzing buildings.

- 3 armament systems men to test the missile guidance and control systems, and to correct faults.

- 1 armourer to unpack and inspect the warheads, detonators, rocket motors and igniters.

- 2 armourers to assemble missiles.

- 3 men to inspect and test the missile packs prior to reloading and to operate the hoisting dollies. (One man would be required to each pack servicing rig).

- 12 armourers to bring missiles from ready-use stores, service them, load them on packs and assist while the packs are being hoisted in and out of the servicing rigs. (Three crews of four men would be needed).

- 1 man to service the hoisting dollies and to supervise the stores for spare parts and tools.

- 4 men for missile pack maintenance, including structural, hydraulic, and electrical aspects of the work.

- 6 drivers (squadron personnel) for transporting the missile packages between the armament compound and the aircraft arming point.

7. DISCUSSION

This report has outlined the general requirements for an armament facility which could be installed at air bases for all-weather interceptor aircraft. The facility has been designed so that it could be built initially to store and prepare small, simple weapons such as the 2.75" rockets and pods which are being used at present with the CF-100 aircraft and developed later to handle larger, more complex weapons, such as the Sparrow II air-to-air guided missile, either individually, or in complete aircraft loads as proposed for the CF-105 aircraft. The initial stage of the facility has already been planned by the RCAF to store and prepare 2.75" rockets and pods for its CF-100 squadrons and this installation should be completely satisfactory for the requirements that were specified.

The introduction of air-to-air guided missiles, such as the Sparrow II, brings requirements for additional facilities because of the complex and delicate mechanisms that are necessary for their guidance and control. In particular, these components will require heated storage areas and air-conditioned, dust-free rooms for assembling and testing.

In the design of the buildings and the fixed installations, it is felt that allowance should be made for handling missiles larger than Sparrow II, since it would be feasible to install missiles up to 15 ft. in length and 1200 lb. in weight on either the CF-100 or CF-105 aircraft. Also, it should be pointed out that the guidance and control parts of the missiles could be stored and tested outside of the explosives area, possibly in an

7. (Cont'd) electronics maintenance hangar. However, this would require transporting the components long distances to the fuzing building for final assembly with the parts of the missile which contain explosives.

Detailed descriptions for equipment to handle and test the Sparrow II missile could not be included in this report, because complete information is not available at the present time about the assembly, test, and servicing operations for this missile. Moreover, the concept of the operations for the CF-100/Sparrow II squadrons has been based on an RCAF draft report which might be subject to change. Thus, the estimates for the quantities of equipment and manpower must also be considered as preliminary. However, for the conditions that were outlined for the CF-100/Sparrow II squadrons, the armament test and storage facility as described in Chapter 5 is considered to be adequate.

In Chapter 6 it was shown that the introduction of the armament pack concept as used on the CF-105 aircraft, would probably impose further requirements on the armament storage and test facility. These would in the main consist of a large building and equipment for storing, servicing and maintaining the armament packs. Because of the size and weight of the pack, power equipment would be required for all handling operations and to this end a hoisting dolly has been designed by Avro for transporting the pack and for lifting it in and out of aircraft or servicing rigs. Also, considerably more power is required to permit functioning and testing the packs and more men are needed to staff the facility in spite of a sharp

7. (Cont'd) reduction in the number of aircraft that are served by it. These factors must be weighed against the longer turn-around time that would be required if missiles were loaded directly on to the aircraft. At the moment, there is not sufficient information available concerning the installation and post-installation checking of the Sparrow II missiles to permit a rational comparison of the loading times by the two alternative methods. Also, the Sparrow II armament pack for the CF-105 aircraft is still in an early stage of design so that servicing instructions, test equipment, and power requirements cannot be given in detail. Again, the concept of the operations for the CF-105/Sparrow II squadron has been based on an RCAF draft report which might be subject to change, so that the quantities of equipment and manpower that are given must be considered as preliminary estimates only.

Table 1 shows a summary of quantitative information contained in the text of the previous chapters.

It is appreciated that many equipment details are missing in this preliminary study, but this is because full information concerning the assembly, test, and servicing procedures for the Sparrow II missile is not available to the Company at the present time. However, it is felt that this report may be of use to acquaint members of the CF-105 development team with the problem and to form a basis for discussion between the RCAF and the Company.

8. CONCLUSIONS AND RECOMMENDATIONS

1. An armament storage and test facility is considered essential for each all-weather interceptor air base and it should be located as close as possible to the aircraft loading or turn-around point.
2. All buildings and fixed equipment should be designed for handling the largest weapons that are likely to be carried on CF-100 or CF-105 aircraft. This could include ordnance of up to 15 ft. in length and 1200 lb. in weight.
3. The Armament Storage and Test Facility as planned by the RCAF for handling 2.75" rockets and pods is considered to be adequate for the concept of operations that was specified.
4. When air-to-air guided missiles are introduced, special installations will be required, and will probably include air-conditioned, dust-free rooms for testing and assembling the guidance and control systems, and heated areas for storing these components. These facilities could be provided in a special building inside the armament compound.
5. The Armament Storage and Test Facility as proposed by the RCAF for supporting two CF-100/Sparrow II squadrons is considered to be adequate for the concept of operations that was outlined.
6. If a requirement were introduced for combined armament, such as arming CF-100 aircraft with 4 Sparrow II missiles and 2.75" rockets in pods, then additional storage buildings and possibly another fuzing building would be needed. Explosives Regulations would probably necessitate building an additional Armament Storage and Test Facility.

7. Reloading the CF-105 aircraft by changing the armament pack appears at this time to be the best way of meeting the specified aircraft turn-around time of 10 minutes, as far as the armament is concerned.

8. With the introduction of armament packs, an additional building will probably be required in the armament compound with facilities for storing, servicing, and maintaining the weapon packs.

9. The water mains, sanitary sewers and power lines to the armament compound should be made adequate to serve the facility in its final stage of development.

10. Detailed requirements for the test and handling equipment cannot be specified at this time, since information is not available concerning the assembly, testing and servicing procedures for the Sparrow II missile. Also, testing and servicing instructions for the CF-105/Sparrow II armament pack cannot be given yet since design of the pack is still in an early stage.

APPENDIX 'A'

REFERENCES

1. General RCAF Magazine and Explosive Safety Orders, EO 30-1-10.

2. Test Equipment for Rocket Systems - Arming and Disarming the Wing-tip Rocket Pods, Avro Service Bulletin A-196 (To be superseded by EO 25E-2 and EO 35F-2).

3. Description and Maintenance Instructions for 2.75" Folding Fin Aircraft Rocket, EO 30-100FF-2.

4. RCAF Logistics, Maintenance, and Servicing Policy for the Sparrow II Air-to-Air Guided Missile on the CF-100 Aircraft (Draft Report).

5. CF-105 Aircraft - Concept of Base Operations, Issue 1 (Draft Report).

6. Sparrow II (Douglas Aircraft Co. Brochure).

7. The Armament Package Concept, Avro report dated February 1956 and issued at the CF-105 Mock-up Conference.

8. CF-105 Progress Report - Sparrow II.

TABLE 1

SUMMARY OF ARMAMENT FACILITY DATA FOR ALL-WE

	2 CF-100 SQUADRONS ARMED WITH 58 - 2.75" F.F.A. ROCKETS IN WING TIP PODS	2 CF- A 4 SPAI
AIRCRAFT PER SQUADRON	18 INTERCEPTORS, 2 TRAINERS	18 INTERCEP
INTERCEPTORS SERVICEABLE (Total)	24	
ARMAMENT COMPONENTS IN BASE STORAGE	CF-100 Rocket Pods - 600 (Approx) (Non-Explosive) Rocket Motors - 17,000 (Approx) (Gr. 6 Cat. Z Explosive) Rocket Warheads - 17,000 (Approx) (Gr. 6 Cat. Y Explosive)	Guidance & Co (Non-Exp Wings & Fins - (Non-Exp Safety & Armin (Non-Exp Solid Propellar (Gr. 6 Ca Warheads - 51 (Gr. 7 Ca Motor Ignitors (Gr. 6 Ca Warhead Deton (Gr. 10 C
ITEMS STORED READY FOR IMMEDIATE USE	Fuzed Pods.....96 Min. .....200 Max. = 72 Aircraft Loads (Min) including those on serviceable aircraft.	Loaded Missile Loads (Min) i serviceable a
BUILDING AND SPECIAL PROVISIONS REQUIRED	Magazines (2) (Ventilated) Fuzing Building (Heated) "Ready-Use" Storage Building (Unheated)	Magazines (2) Missile Test & (Heated and w Fuzing Building "Ready-Use" S Covered Passa

TABLE 1

CILITY DATA FOR ALL-WEATHER INTERCEPTOR AIR BASES LOG/105/36

NS . ROCKETS S	2 CF-100 SQUADRONS ARMED WITH 4 SPARROW II MISSILES	1 CF-105 SQUADRON ARMED WITH 4 SPARROW II MISSILES
ERS	18 INTERCEPTORS, 2 TRAINERS	12 INTERCEPTORS, 2 TRAINERS
	24	6
pprox) ox) pprox)	Guidance & Control Assemblies - 512 (Non-Explosive) Wings & Fins - 512 - sets (Non-Explosive) Safety & Arming Mechanism - 512 (Non-Explosive) Solid Propellant Motors - 512 (Gr. 6 Cat. Y Explosive) Warheads - 512 (Gr. 7 Cat. Z Explosive) Motor Ignitors - 512 (Gr. 6 Cat. X Explosive) Warhead Detonators - 512 (Gr. 10 Cat. Z Explosive)	Guidance & Control Assemblies - 250 (Non-Explosive) Wings & Fins - 250 sets (Non-Explosive) Safety & Arming Mechanisms - 250 (Non-Explosive) Solid Propellant Motors - 250 (Gr. 6 Cat. Y Explosive) Warheads - 250 (Gr. 7 Cat. Z Explosive) Motor Ignitors - 250 (Gr. 6 Cat. X Explosive) Warhead Detonators - 250 (Gr. 10 Cat. Z Explosive) CF-105 Armament Packs - 18 (Non-Explosive)
ft Loads iceable	Loaded Missiles.....144 Min. .....240 Max. = 60 Aircraft Loads (Min) including those on serviceable aircraft.	Loaded Packs - 6 (+6 on aircraft) Serviceable Unloaded Packs - 6 Loaded Missiles - 202 (max.) This would give 12 Aircraft Loads Ready and 6 Aircraft Loads per hour by reloading packs.
Ventilated) (Heated) (Unheated)	Magazines (2) (Ventilated) Missile Test & Assembly Building (Heated and with parts Air Conditioned) Fuzing Building (Heatcd) "Ready-Use" Storage Building (Heated) Covered Passage Ways	Magazines (2) Missile Test & Assembly Building (Heated and with parts Air Conditioned) Fuzing Building (Heated) "Ready-Use" Storage Building (Heated) Covered Passage Ways Missile Pack Servicing Building (Heated)

TABLE 1 (Cont'd)

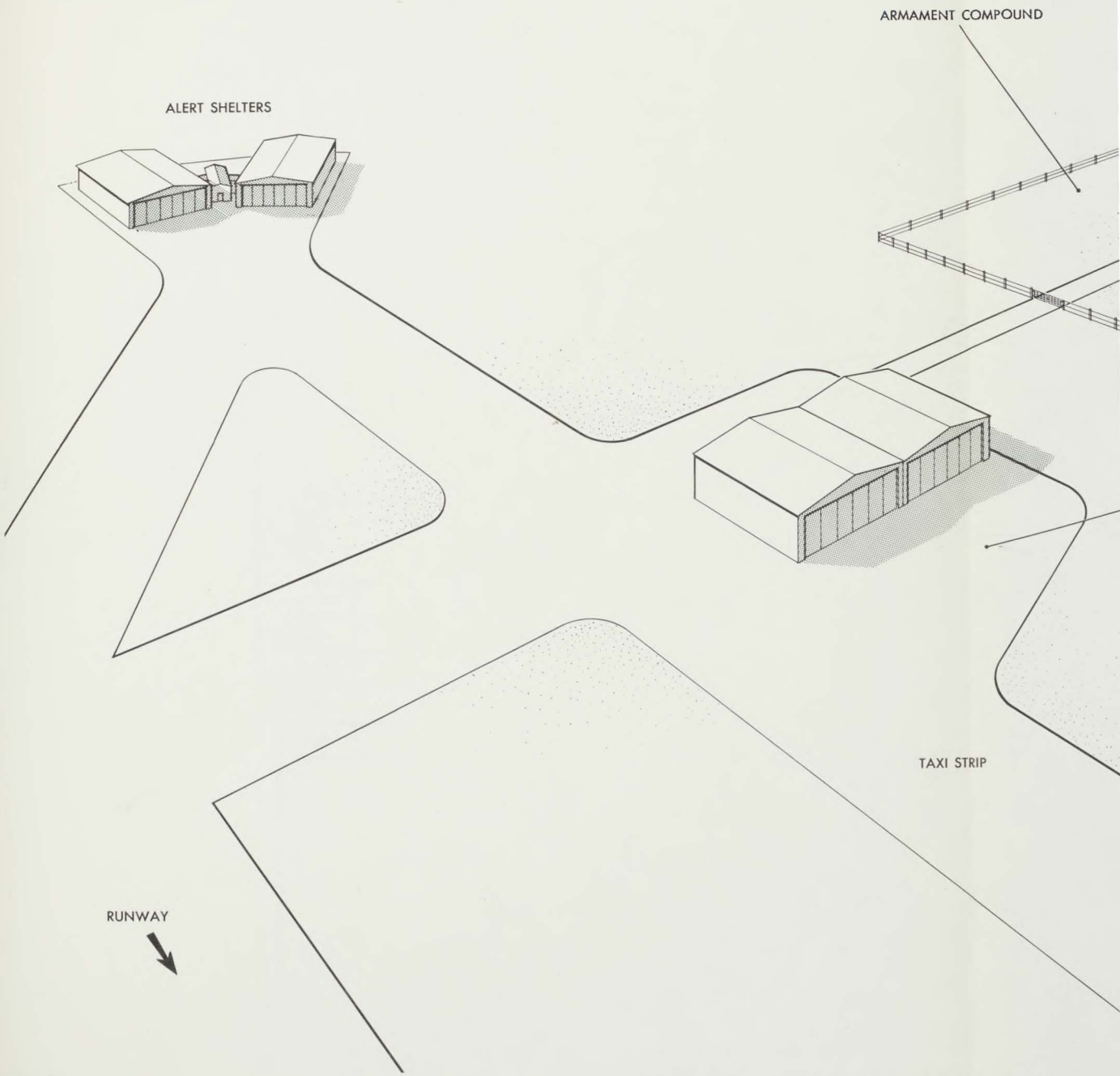
SUMMARY OF ARMAMENT FACILITY DATA FOR ALL-WEAT

	2 CF-100 SQUADRONS ARMED WITH 58 - 2.75" F.F.A. ROCKETS IN WING TIP PODS	2 CF-100 ARMI 4 SPARRO
TEST EQUIPMENT	1 Pod Test Set 2 Rocket Motor Test Sets (Portable, Battery Operated)	2 Missile Test Rig 1 Motor Test Set 2 Radar Target Sin 1 Missile Servicing
HANDLING EQUIPMENT	2 Fork-Lift Trucks 1 Trailer for Transporting Explosives 6 Pod Workstands 8 Tractors & Trailers (Field Equipment)	2 Fork-Lift Trucks 1 Trailer for Tran 8 Missile Assembl 8 Tractors (Field 16 Missile Loading
POWER REQUIRED FOR TESTING AND SERVICING (HEATING & LIGHTING ARE EXCLUDED)	None	8 KVA.
DIRECT MANPOWER REQUIRED	2 Fork-Lift Operators 1 Armourer to Unpack Pods 1 Armourer to Unpack Rocket Heads 1 Armourer to Unpack Rocket Motors 1 Armourer to Check Pods 1 Armourer to Check Rocket Head 2 Armourers to Check Rocket Motors 2 Armourers to Assemble Rockets 4 Armourers to put the Rockets into the Pods and Attach the Noses & Tailcones 15	2 Fork-Lift Operat 3 Men to Unpack N 5 Armament Syste Repair Missi 1 Man to Transpor 1 Armourer to Unp 1 Armourer to Insp Detonators 1 Armourer to Insp Igniters 4 Armourers to As 8 Drivers for 18
DESIGN FLOW RATE OF ASSEMBLED WEAPONS	3 Pods per Hour	6 Missiles per Hou

TABLE 1 (Cont'd)

CILITY DATA FOR ALL-WEATHER INTERCEPTOR AIR BASES LOG/105/36

S ROCKETS	2 CF-100 SQUADRONS ARMED WITH 4 SPARROW II MISSILES	1 CF-105 SQUADRON ARMED WITH 4 SPARROW II MISSILES
)	2 Missile Test Rigs (Fixed Installation) 1 Motor Test Set 2 Radar Target Simulators 1 Missile Servicing Rig	2 Missile Test Rigs (Fixed Installation) 1 Motor Test Set 2 Radar Target Simulators 1 Missile Servicing Rig 3 Pack Servicing Rigs (Fixed Installation) 1 Pack Maintenance Rig (Fixed Installation)
plosives Equipment)	2 Fork-Lift Trucks 1 Trailer for Transporting Explosives 8 Missile Assembly Dollies 8 Tractors (Field Equipment) 16 Missile Loading Dollies	2 Fork-Lift Trucks 1 Trailer for Transporting Explosives 8 Missile Assembly Dollies 18 Armament Pack Hoisting Dollies 6 Tractors (Field Equipment) 12 Missile Loading Dollies
	8 KVA.	25 KVA (Minimum)
Heads Motors Head Motors kets ts into Noses	2 Fork-Lift Operators 3 Men to Unpack Non-Explosives 5 Armament Systems Men to Test and Repair Missiles 1 Man to Transport Assemblies on Dollies 1 Armourer to Unpack Explosives 1 Armourer to Inspect Warheads, Detonators 1 Armourer to Inspect Motors, Igniters 4 Armourers to Assemble Missiles & 8 Drivers for Field Equipment 18	2 Fork-Lift Operators 2 Men to Unpack Non-Explosives 3 Armament Systems Men to Test and Repair Missiles 1 Armourer to Unpack & Inspect Explosives 2 Armourers to Assemble Missiles 3 Men to Hoist, Inspect, Test Missile Packs (1 for each Servicing Rig) 12 Armourers to Load Packs (3 Crews of 4 Men) 1 Man for Stores & Servicing Dollies 4 Men for Pack Maintenance & Repair & 6 Drivers for Field Equipment 30
	6 Missiles per Hour	Test & Assemble 3 Missiles per Hour Test & Load 6 Packs per Hour



1714-105-1

FIG. 1 TYPICAL AIR BASE LAYOUT

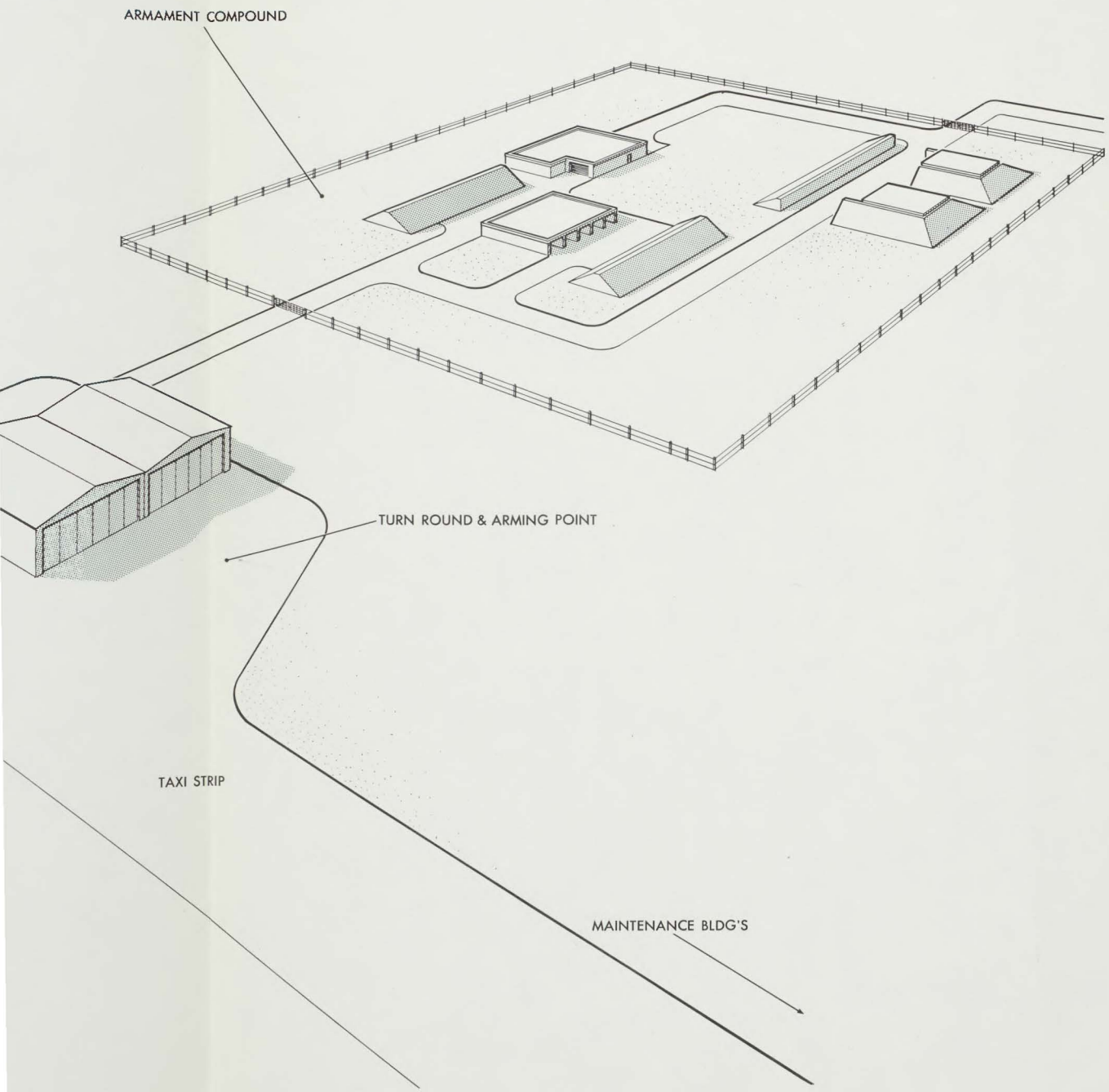
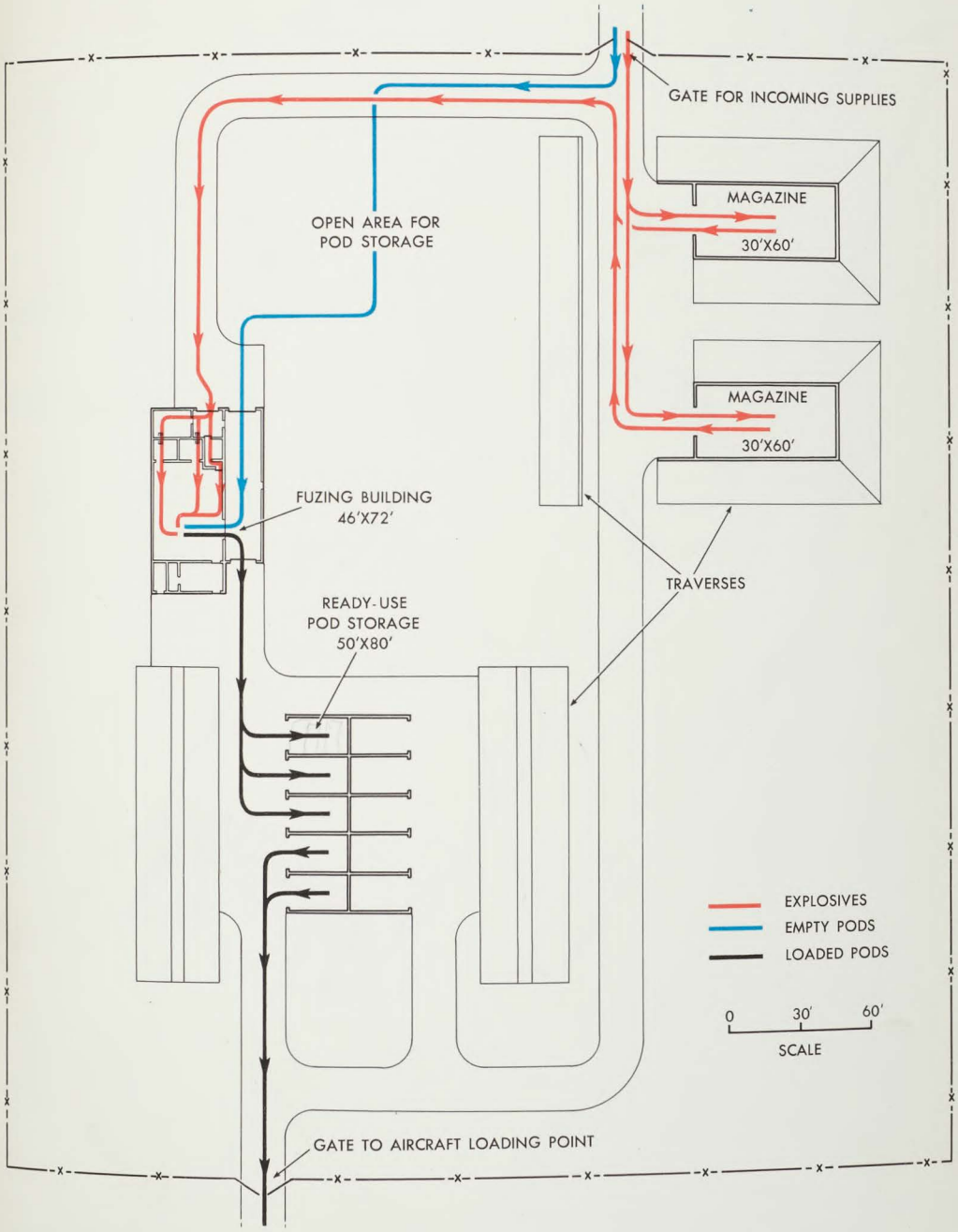


FIG. 1 TYPICAL AIR BASE LAYOUT



1715-105-1

FIG. 2 ARMAMENT COMPOUND FOR USE WITH CF-100 ROCKET POD SQUADRONS

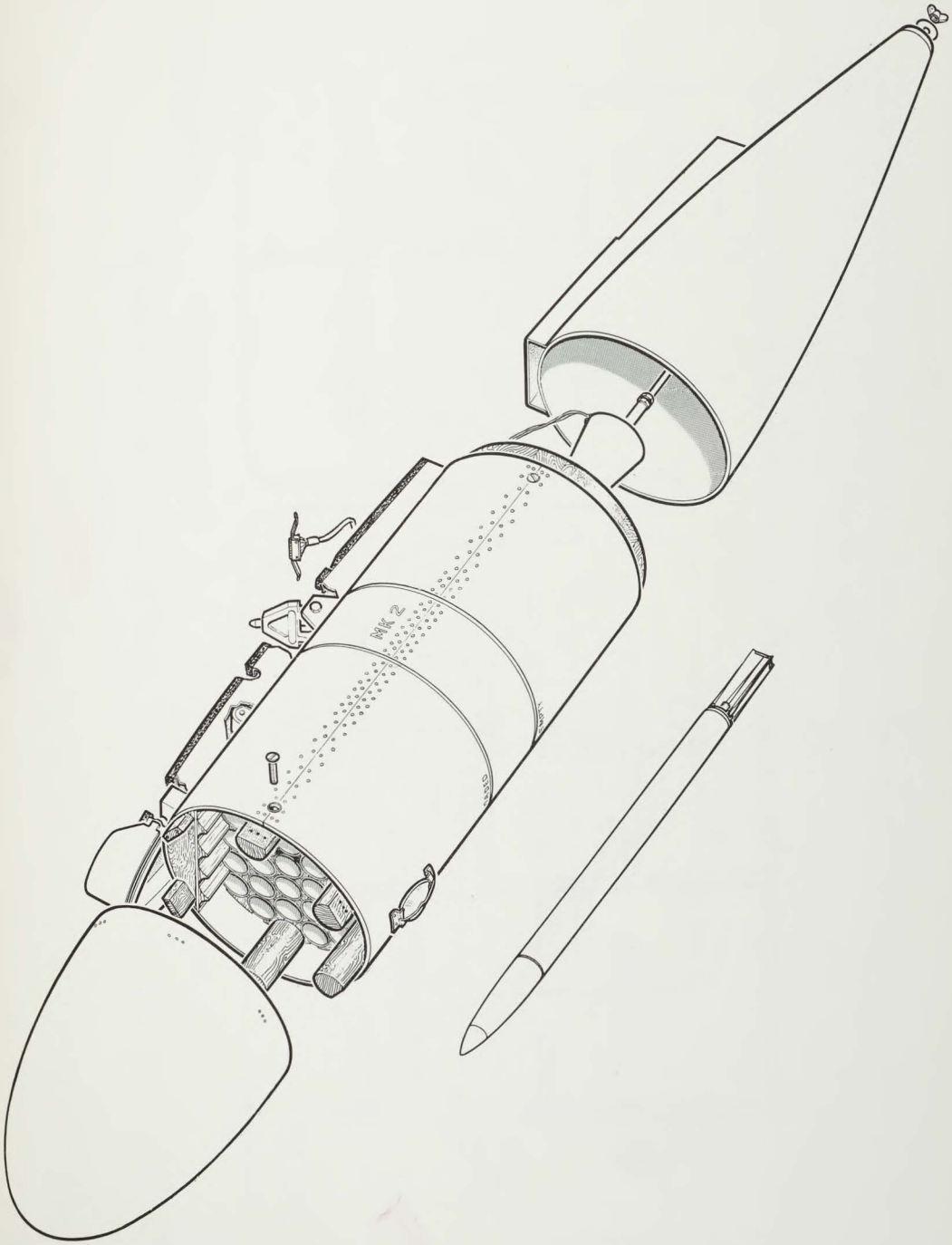


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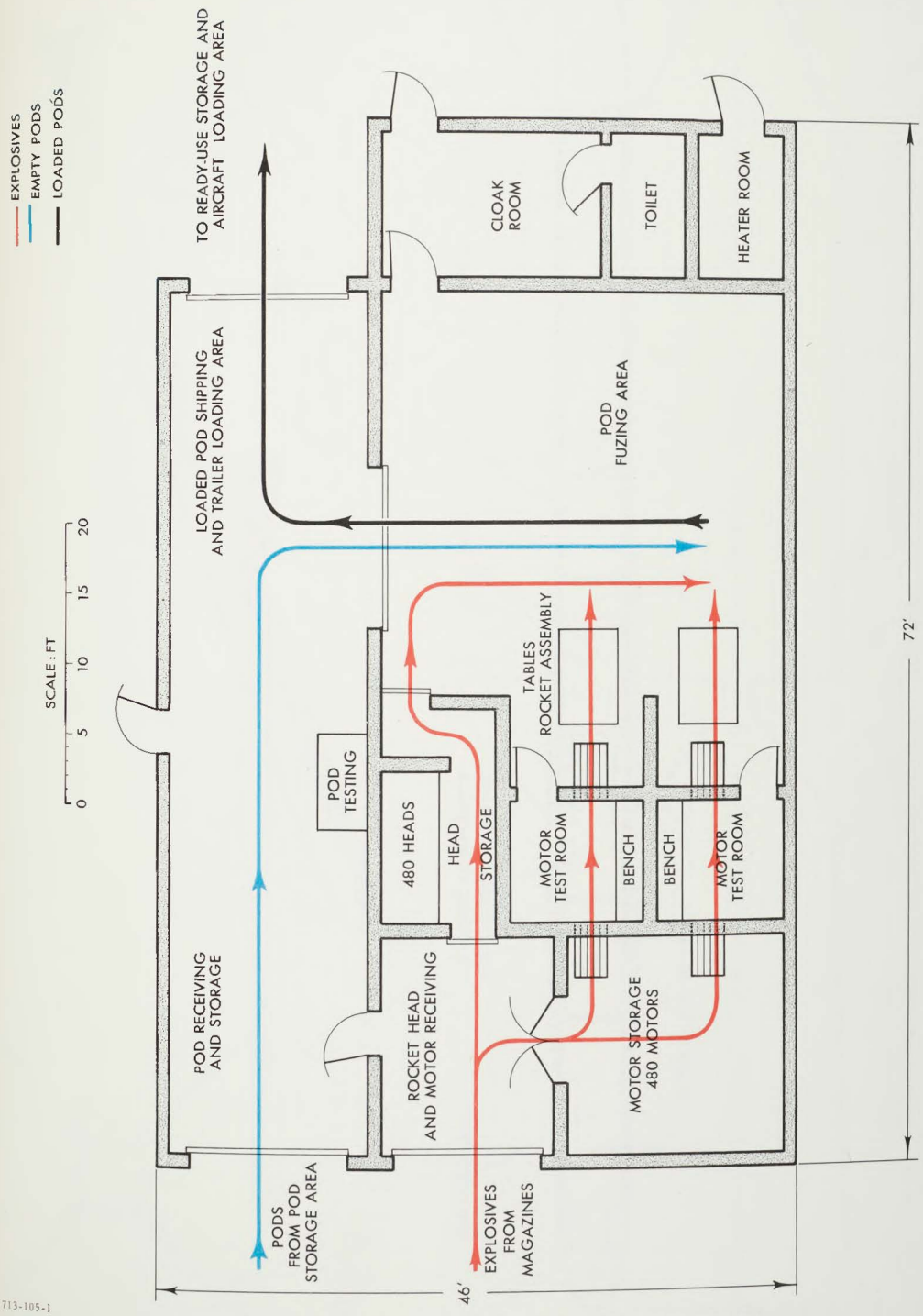
FIG. 3 CF-100 ROCKET POD EXPLODED VIEW ALSO 2.75" F.F.A.R.



1713-105-1

FIG. 4 FUZING BUILDING, AS USED FOR CF-100 ROCKET PODS

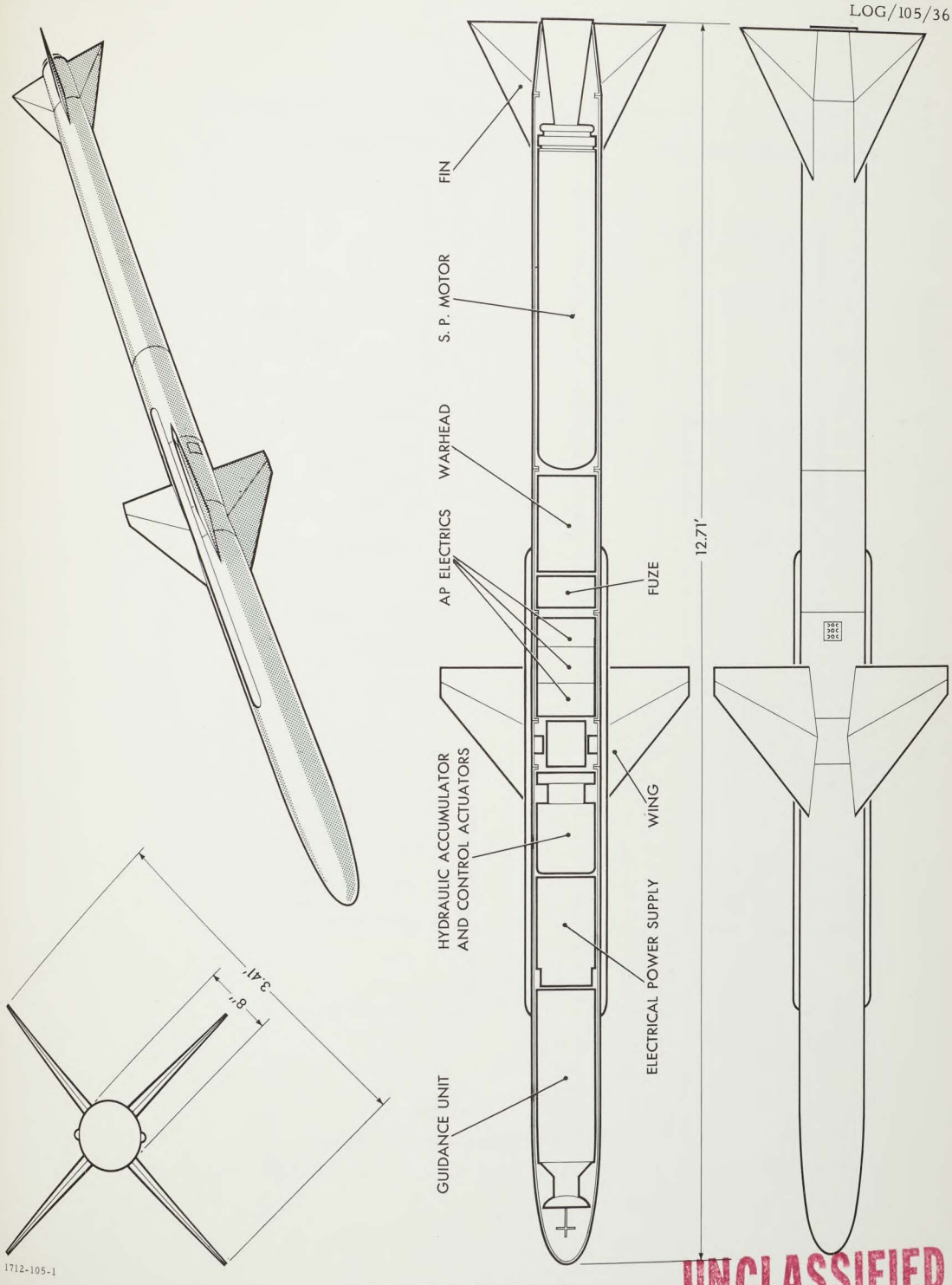
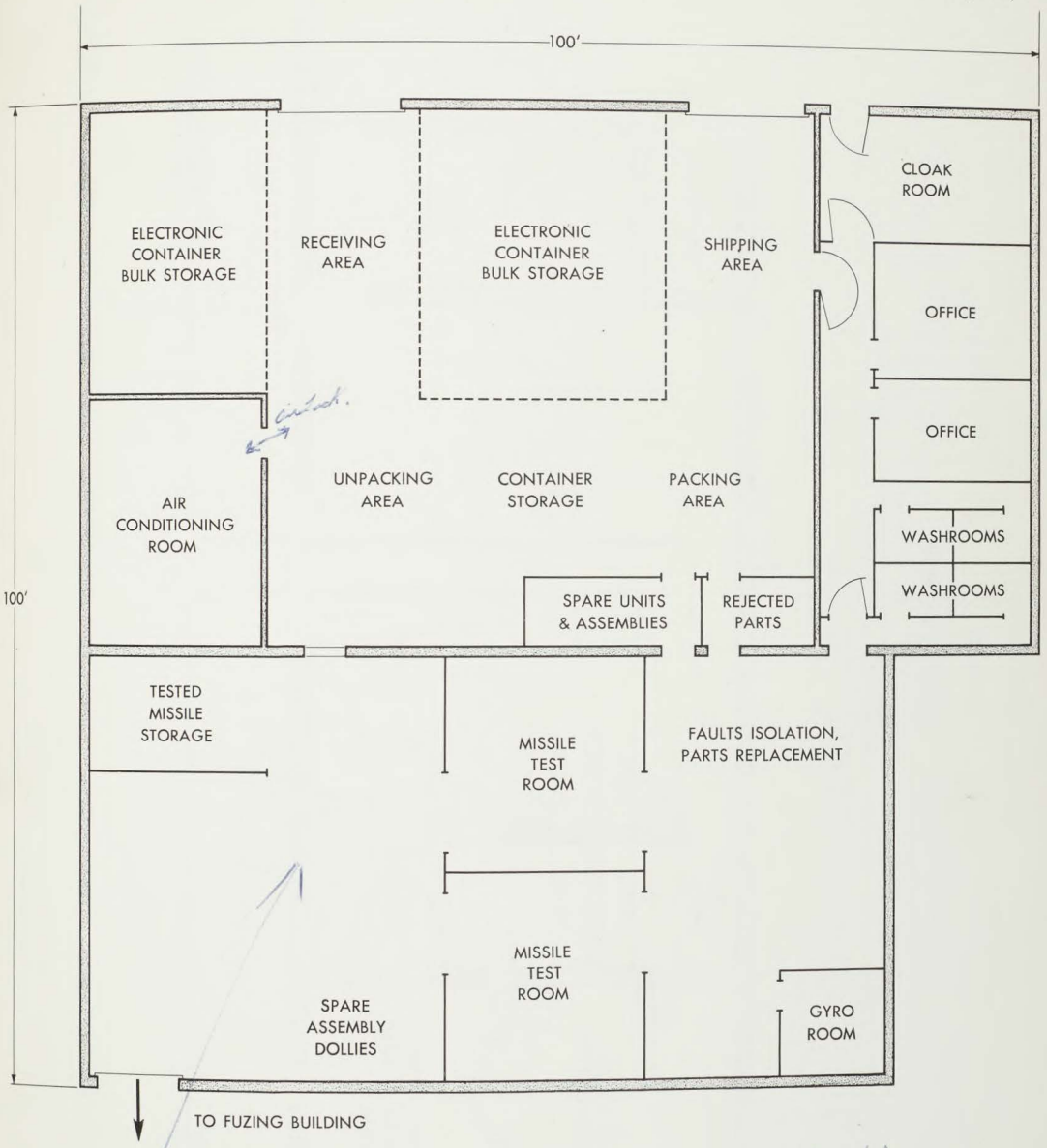


FIG. 5 SPARROW 2 MISSILE

UNCLASSIFIED



1710-105-1

FIG. 7 MISSILE TEST AND ASSEMBLY BUILDING

UNCLASSIFIED

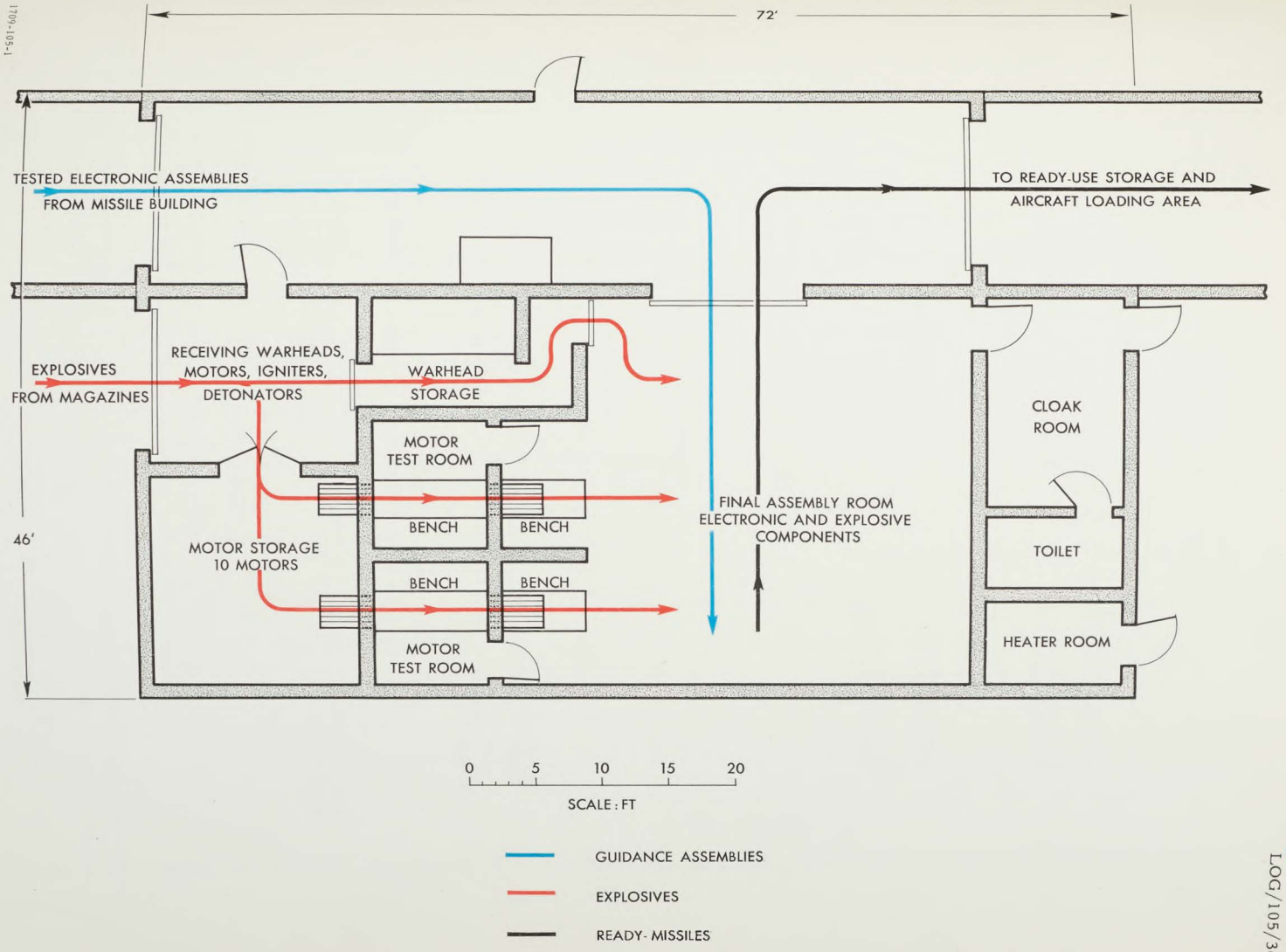
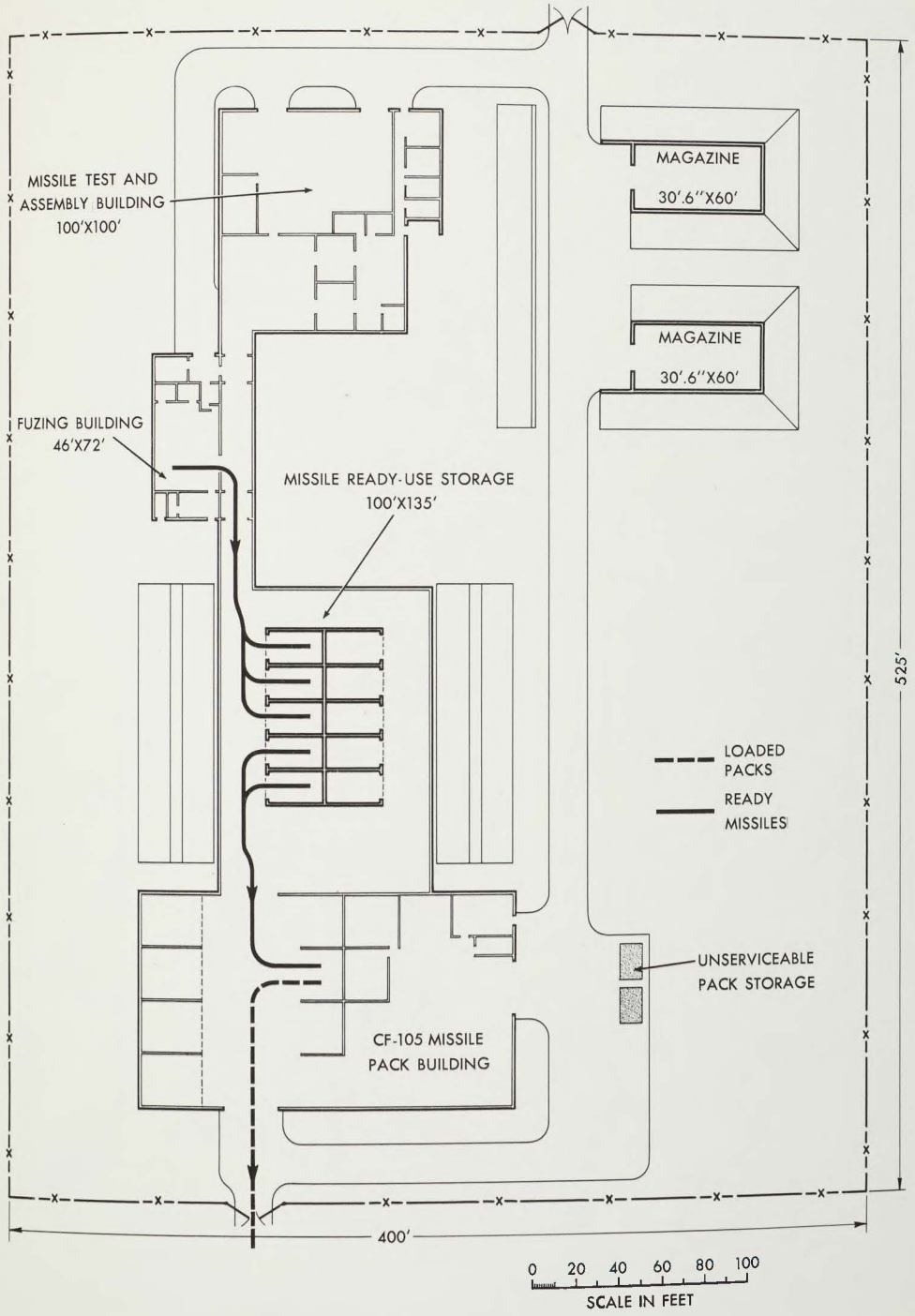


FIG. 8 FUZING BUILDING, AS USED FOR SPARROW 2 MISSILES



1708-105-1

FIG. 9 ARMAMENT COMPOUND FOR USE WITH CF-105 AIRCRAFT AND MISSILE PACKS

1707-105-1

FIG. 10 CF-105 MISSILE PACK AND DOLLY DURING HOISTING

1706-105-1

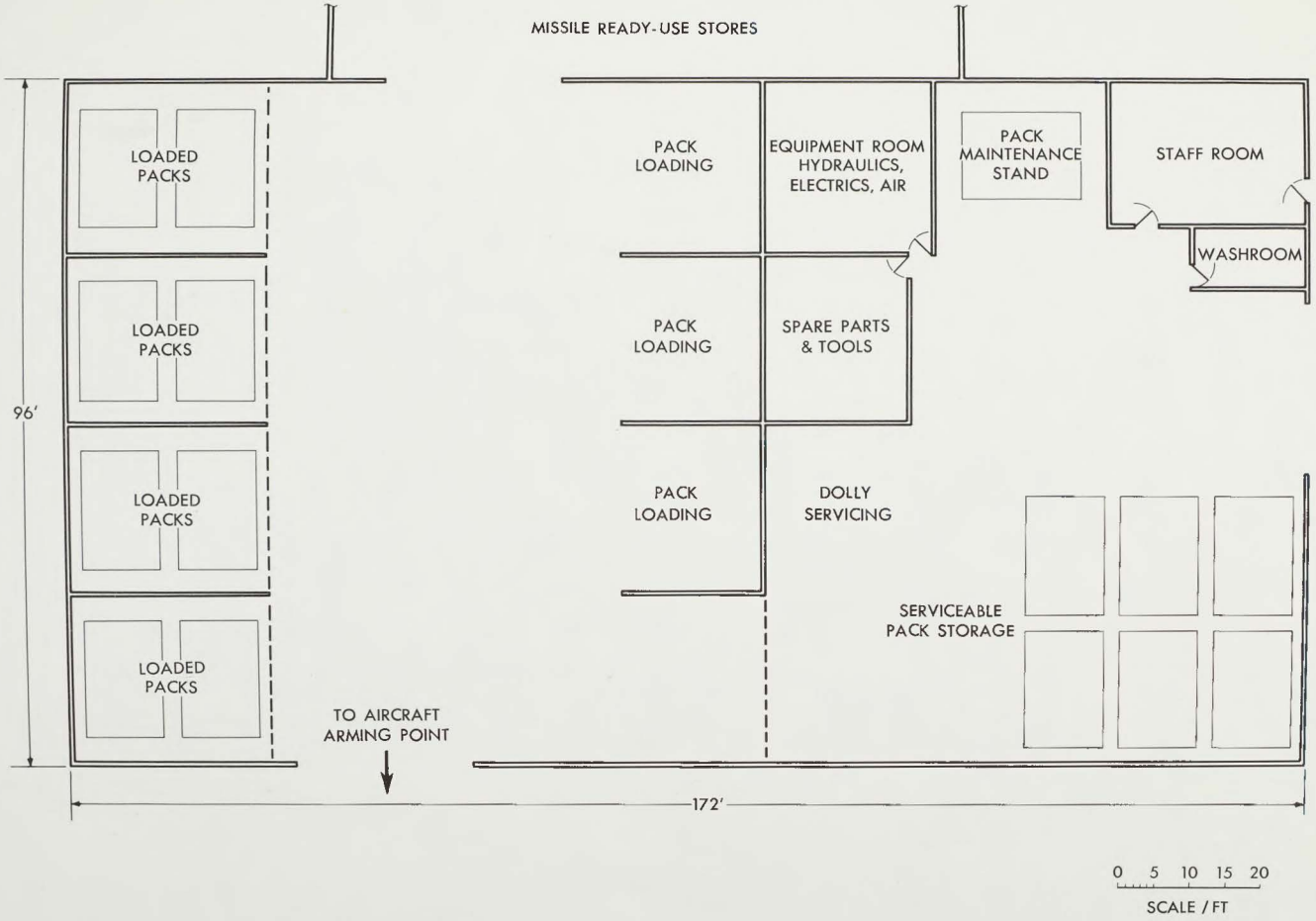


FIG. 1 MISSILE PACK-BUILDING