SECURITY WARNING

This document is classified SECRET and must be handled in accordance with the existing regulations pertaining to information classified SECRET published by the Canadian Government.

The UNAUTHORIZED RETENTION OR DESTRUCTION OF THIS DOCUMENT IS PROHIBITED.

This brochure has been specially prepared for the Canadian Government and its attendant services. The information and data contained herein is the property of Avro Aircraft Limited and the recipient shall not transfer, copy, reprint, divulge or use any portion of it without the prior consent of Avro Aircraft Limited.

This is copy number.....14.....

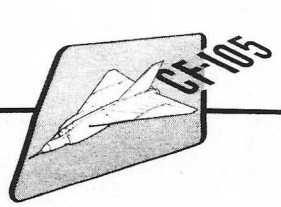
Issued to.....

Date.....

Classification cancelled/changed to.....

by authority of.....(date).....

Signature.....Rank.....



PROPOSED INSTALLATION OF FOUR INTERNALLY STOWED "SPARROW 2" MISSILES IN THE CF-105 AIRCRAFT

FEBRUARY 1955

AVRO AIRCRAFT LIMITED
MALTON — ONTARIO

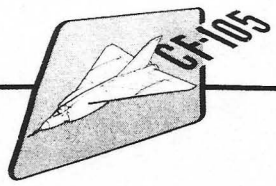


TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

PROPOSED INSTALLATION OF FOUR INTERNALLY STOWED SPARROW 2 MISSILES IN THE CF-105 AIRCRAFT

1.0 The CF-105

To achieve specification performance it was decided, early in the history of the CF-105, to stow missiles internally in the fuselage and to extend them clear of the skin line for launch.

Consideration of the possible evolution of armament during the service life of the CF-105 led to the adoption of a large armament bay extending from STN255 to STN485. The structure surrounding this region is stressed for air and other loads, resulting from the carriage of armament, without the assistance of any local structure which is peculiar to a particular installation.

The first armament installation considered for the aircraft was eight Falcon missiles. In this particular case it was found possible to keep the installation between STN292 and STN485. The space between STN255 and STN292 was therefore available for the carriage of missile auxiliaries and other components of the integrated electronics system.

Considerations of manufacture, maintenance and servicing, rearming and alternate armament led to the adoption of a package installation for Falcon missiles. The complete installation with the exception of missile auxiliaries, is contained in a quickly detachable package supported in the aircraft by quick "make and break" attachments at

either end of the bay.

It has been found possible to carry four Sparrow 2 missiles in a package of the same dimensions as the Falcon package without changing the aircraft lines. All connections between the package and the aircraft, with the exception of the cabling to the missiles, will be identical to the Falcon.

2.0 The Sparrow 2 Missile

The Sparrow 2 missile is a fully active air to air guided missile weighing ~~389~~ 403 lbs. prelaunch. It is 156.8" in length, has a body diameter of 8" and a wing span of 40". It has temperature limitations of -40°F to +130°F.

The missile is equipped with two hooks and a button for attachment to its launcher. The launcher is of the rail type and weighs approximately 36 lbs. A detent mechanism is contained within the launcher.

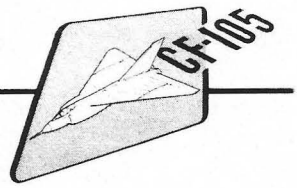
Missiles are normally ripple fired at intervals of approximately one half second.

The Sparrow 2 was designed for external carriage under the wings of aircraft flying at subsonic and ~~trans~~ supersonic speeds and for launch at altitudes up to 60,000 ft. Being fully active and guided from launch it is intended that it shall be locked on to the target prior to launch.

The problem of stowing four of these missiles internally in the CF-105

and extending them for launch has been investigated in detail. The most suitable method of making an attack still requires considerable investigation.

It ~~has, in the past~~ is, been considered necessary for the missile to actually see their target prior to launch. This necessitates extending the missiles to the launching position early in the final stages of the attack so that they may have time to lock on. This also means that the approach to the target must be made in a manner such that the aircraft fuselage does not blank off the missiles view of the target. Because of the length of fuselage ahead of the launchers it is necessary to lock the missile controls during the initial stages of free flight to ensure that the missile, in fact, clears the fuselage. ~~Further consideration of the launching problem~~ indicates that it may be possible to modify the missile in such a manner that it is not necessary for the missile to actually see the target prior to launch. The missile itself has no search capability and relies, for picking up its target, on slaving from the A.I. radar. It further relies on antenna stability for not losing its target during the initial stages of free flight with locked controls. It would therefore appear that if the missile were to be modified in such a manner as to delay radiation transmission until the missile was ahead of the aircraft fuselage and to utilise range rate memory we need not incur any degradation in the probability of a missile homing on to its target. By such a modification we would gain much greater attack, ~~flexibility, by eliminating the aircraft~~



fuselage as an obstruction to the missile line of sight, and by being able to prepare the missile inside the fuselage instead of outside. This possibility has yet to be discussed with the Douglas Aircraft Company.

The suitability of the missile for launch at speeds and altitudes in excess of the missile design limitations but within the aircraft design limitations still requires to be investigated.

3.0 Attack Modes

It is proposed to provide the capability for firing either two or four missiles on an attack. On a two missile attack it is necessary to extend missiles symmetrically about the aircraft centreline.

4.0 The Internal Installation of Four Sparrow 2 Missiles

Any difficulty associated with the internal stowage of Sparrow missiles arises from their large wing span, Figure 1, page 5. It is apparent that if we are not to increase the size of the fuselage the wings must protrude through the underside of the aircraft. Whereas three Sparrow missiles can just be fitted into the fuselage in line abreast, when four missiles are fitted they must be staggered fore and aft in order that their centerlines may be moved sufficiently close together.

In the extended position, in order that fins on adjacent missiles do not collide, the inner and outer two missiles must extend, by different distances.

It has been possible, in the proposed design, to maintain clearances

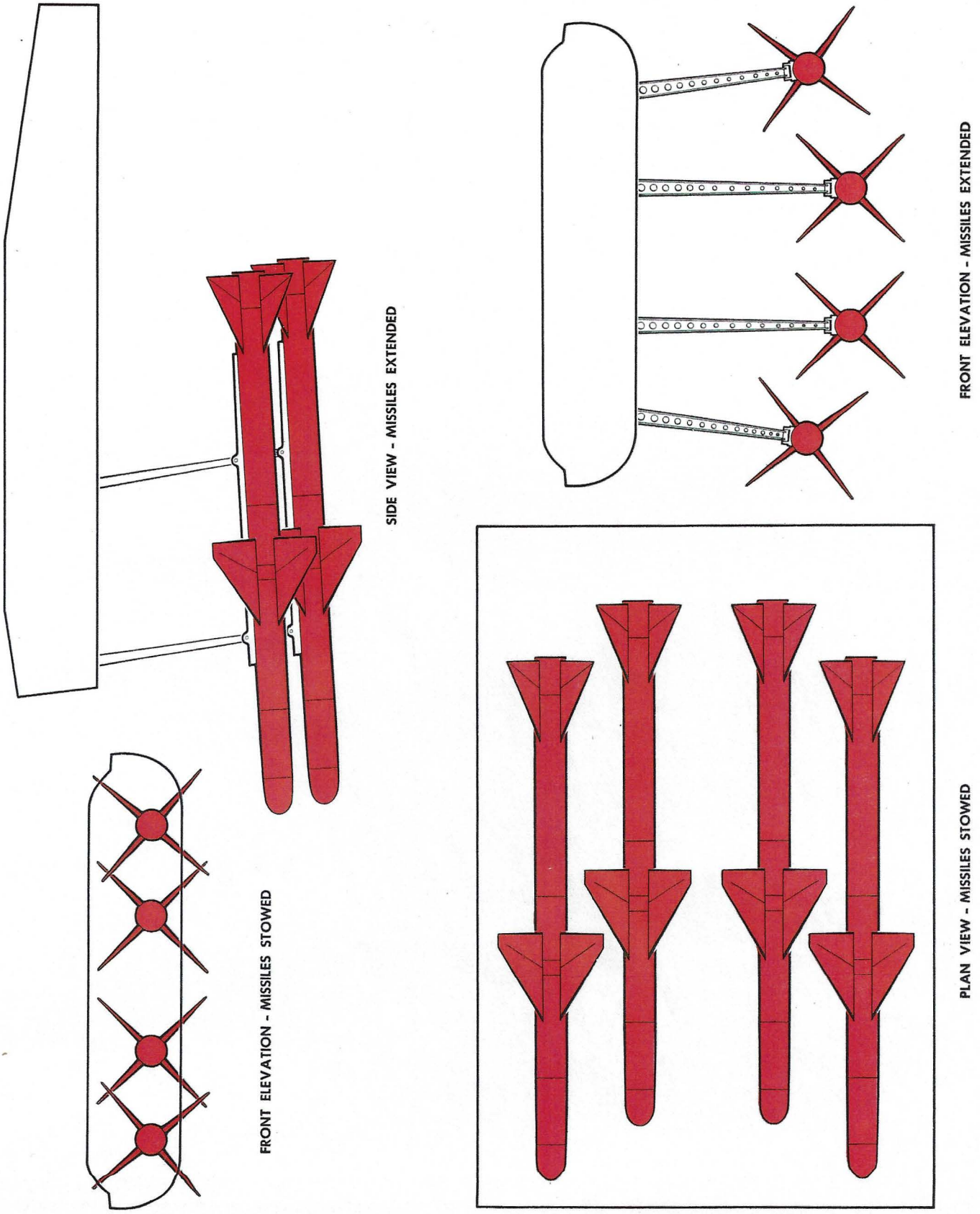
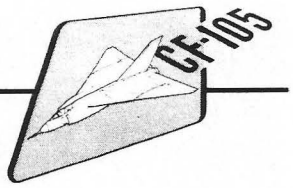


FIG. 1 CF-105 SPARROW 2 MISSILE PACK – TYPICAL VIEWS



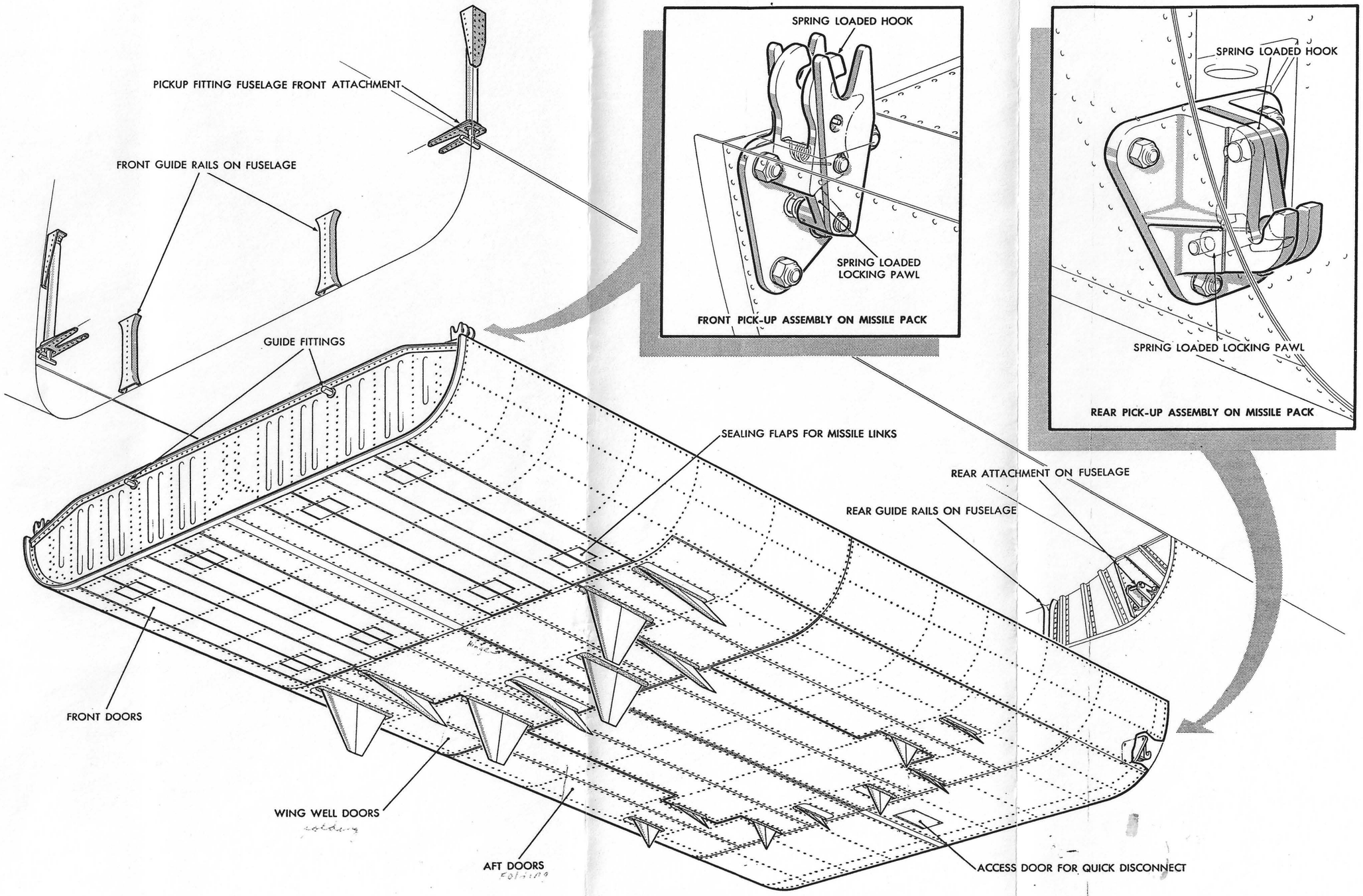
between adjacent missiles to a minimum of one and one half inches and between the missile fins and package structure to a minimum of one inch. These are considered practical tolerances to work to.

5.0 Missile Extension Gear

Because the missile fins extend through the doors beneath the missiles, Figure 2, page 7, it is not possible to integrate door operation and missile lowering into one linkage. It is essential that missile lowering begins only after the doors have been fully opened.

The missile operating linkage adopted, Figure 3, page 8, is on the swinging link semi parallel motion principle, actuated by a hydraulic jack. The missiles are parallel to the aircraft datum in the stowed position and the geometry of the linkage is arranged such that they are pointed 4^{o} down in the launching position. Because Sparrow 2 missiles are ripple fired there is no requirement for angular separation of adjacent missiles and consequently it is proposed that missiles will be parallel to the aircraft centerline in both the stowed and the extended positions.

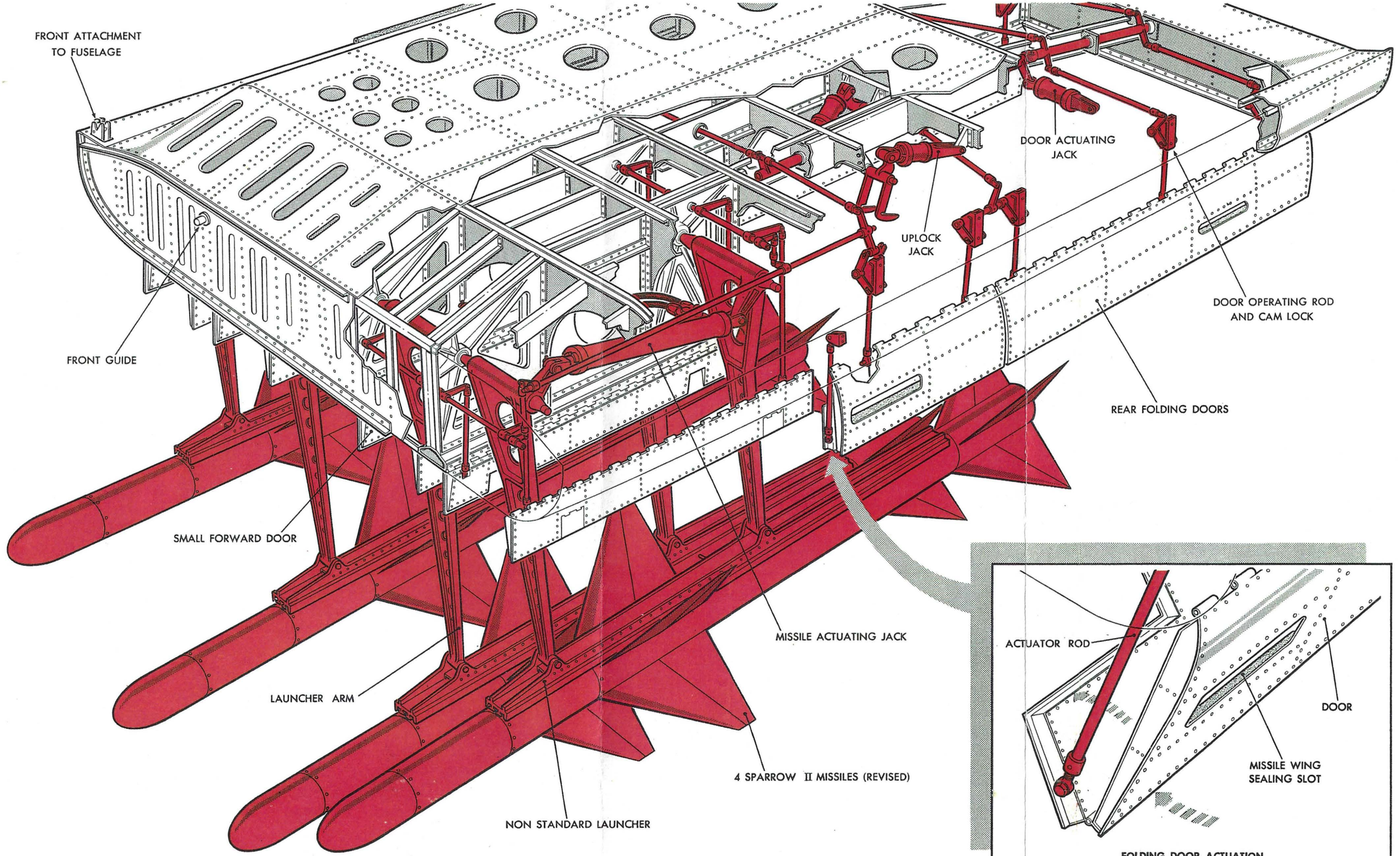
Preliminary analysis of the dynamics of missile lowering indicate that if we take approximately 0.7 seconds to lower the missile from the stowed position to the launching position it is possible to adopt a means of fixed geometry damping which will eliminate the need for "programmed" extension. Accordingly we propose hydraulic actuation of the extension gear with variable area orifice damping during the last 30% of jack stroke.



FRONT PICK-UP ASSEMBLY ON MISSILE PACK

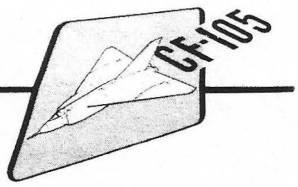
REAR PICK-UP ASSEMBLY ON MISSILE PACK

FIG. 2 CF-105 SPARROW 2 MISSILE PACK – DOOR PATTERN AND ATTACHMENT



FOLDING DOOR ACTUATION

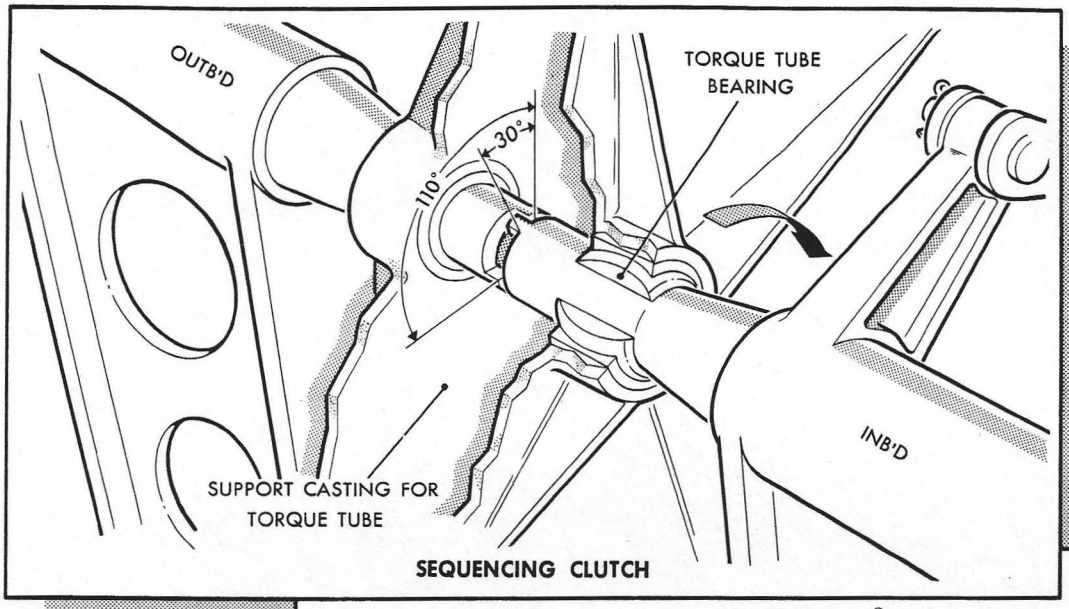
FIG. 3 CF-105 SPARROW 2 MISSILE PACK – DOOR AND MISSILE MECHANISM



Because of the close proximity of missiles to one another the mechanism arms will be designed for maximum stiffness under side loading. It is essential that in the stowed position the missiles should not sag under normal acceleration loading or the fins would be damaged. In the space available it would be extremely difficult and very heavy to make the mechanism arms sufficiently stiff to be adequate for both normal and side loads. It is therefore proposed to incorporate a hydraulically operated up lock over the CG of each missile. These up locks will have considerable "lead" on the hooks to pick up a missile which is being retracted under normal acceleration and which is therefore sagging.

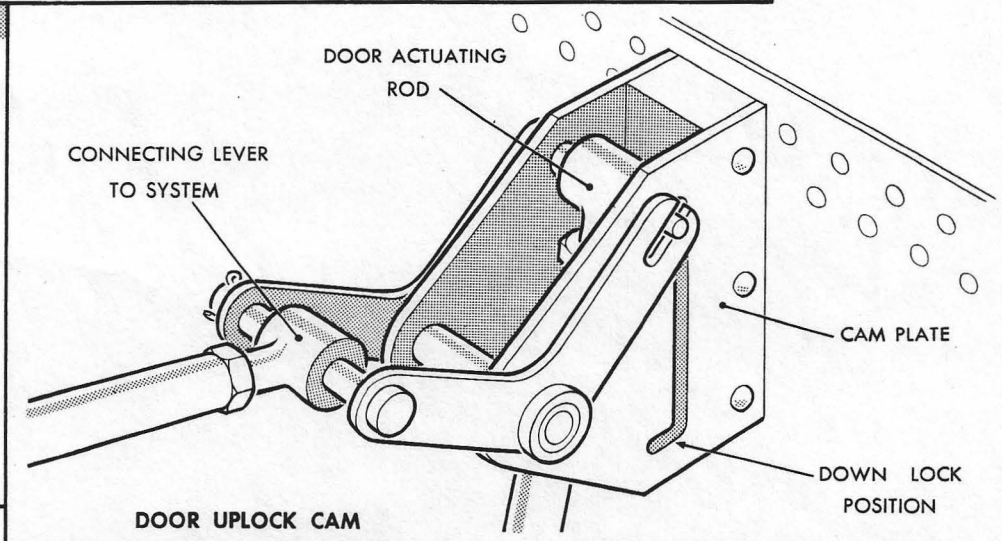
In order to stow the missiles within the confines of the fuselage it has been necessary to stagger them fore and aft when they are retracted. In order to ensure wing and fin clearance at launch it is necessary to stagger adjacent missiles vertically. The adoption of common linkage pivot points has meant that in the extended position all four missiles are practically in line abreast.

During lowering of missiles it is essential that the inboard missiles do not overtake the outboard missiles or wing collisions can result. The design therefore incorporates a clutch, Figure 4, page 10, between adjacent inboard and outboard missiles to ensure that wing collisions can not occur. On a two missile attack this clutch provides that if the outboard missiles are selected only these two missiles need be extended, If the inboard missiles are selected all four missiles must be extended



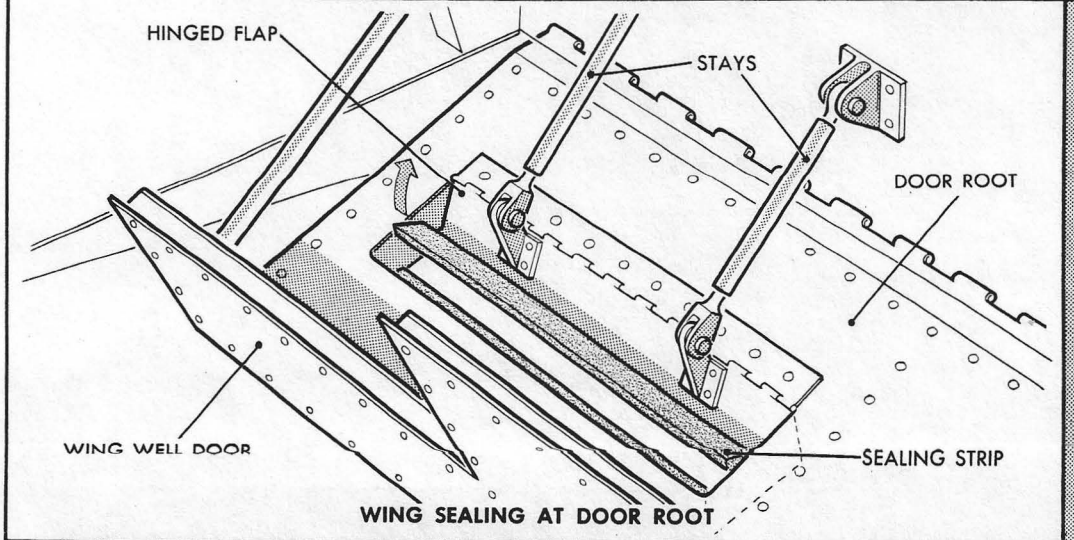
SEQUENCING CLUTCH

FIG. 4



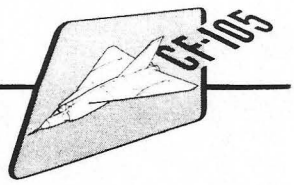
DOOR UPLOCK CAM

FIG. 5



WING SEALING AT DOOR ROOT

FIG. 6



before, the inner missiles are fired. If this restriction on the inboard missiles is not acceptable programming similar to that proposed for the Falcon installation can be used in place of the clutch. This will permit extension of only the two selected missiles when it is desired to fire two missiles. Programming if adopted, could incorporate damping and would eliminate the need for the proposed variable area orifice.

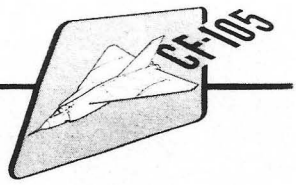
Once in the extended position missiles can be fired in any order.

6.0 Door Arrangement and Operation

Because of the proximity of adjacent inboard and outboard missiles it is not possible to get a door hinge member between them in the region of the wings and fins. In this area therefore, it is necessary to have pairs of doors beneath each pair of missiles. These doors are hinged at the aircraft centerline and at the outboard edge of the package.

Due to the high airloading on the aircraft when the armament bay doors are open we wish to have them open for the shortest possible time. This means that we have to close these doors when the missiles are fully extended.

The fact that when the missiles are extended there are missile extension arms passing through the skin line means that if the large span doors were to be carried forward into the region of the arms we would be in difficulty with door stiffness, strength and sealing. Consequently, forward of the missile wings, we have run a door hinge member between adjacent



inboard and outboard missiles and placed a pair of doors under each missile. Thus when the missiles are extended and doors closed the extension arms pass through the forward doors at the gap line between the small doors and present no insoluble problem.

The missile wings and fins extend through the large span doors and present a sealing problem. This will be solved by contouring the gap line of the doors such that one wing and one fin of each missile passes through the skin at the gap and by providing small mechanically operated sealing doors, Figure 6, page 10, for the other wing and fin. These sealing doors are linked to the structure in such a manner that on opening the main doors these small doors will automatically open to clear the missile.

All doors will have piano type hinges. Because of a change in fuselage section midway along the armament bay it has been necessary to split each large span door into two.

On extension the missile wings pass close to the open doors. It is therefore necessary to ensure that door deflections due to airloading are kept to an absolute minimum. The large span of the rear doors made this a difficult problem. It was therefore decided to make these doors of the folding type such that not only is our stiffness problem made easier but we do not present such an undesirably large side area to the airstream.

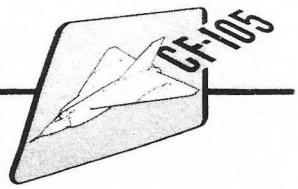
Having to open so many doors simultaneously to extend missiles and

having small clearances accentuates the importance of stiffness in the door actuating gear. Multiple door pick ups are advisable to cut deflections when doors are either fully open or fully closed and yet a single source of power is essential. The proposed solution is to operate the doors through cam plates, Figure 5, page 10, in such a manner that stiffness of the actuating linkage between the jack and the final operating rods is of no consequence. In the proposed installation there is one door actuating jack to each pair of missiles. Because of pressure loads in the armament bay, whenever doors are opened, it is essential in order to avoid overstressing to open all doors whenever missiles are to be extended. It is proposed that the door operating time will be 0.4 seconds.

7.0 Missile Extension Gear and Door Operating Sequence

When a four missile attack is selected, on receipt by the weapons control of a fire control system signal, all doors will open. Limit switches operated by the doors reaching the fully open position will result in the unlocking of the mechanism up locks and in the application of hydraulic pressure to the missile lowering jacks. When the missiles are fully extended the mechanism will operate further limit switches to close the doors. Once the doors are fully closed firing pulses can be applied to the missiles. After firing, the process described above is carried out in reverse order.

When firing two missiles a similar process is gone through. In the case of the inboard missiles, after all the doors are open the up locks on the



two inboard missiles only are released and these missiles alone are extended. The remainder of the process is as described previously. In the case of the outboard missiles the process is exactly as in a four missile attack except that firing pulses are applied to only the two selected missiles.

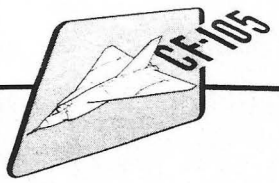
8.0 Hydraulic System

Hydraulic power for missile actuation and door operation will be stored in return flow accumulators which are carried in the rear of the missile package. Hydraulic pressure is derived from the aircraft utility system which includes two 20 gpm pumps. Only two lines will connect the package to the aircraft and these will be of the quick disconnect type. Valves for regulating flow to the missile jacks, up locks and door jacks will be electrically sequenced.

Pneumatic actuation will be investigated in detail and if any significant weight reduction can be derived consideration will be given to using this type of energy source.

9.0 Electric Power Supply

Sparrow 2 missiles each require about 2.5 KVA of ~~closely regulated A.C.~~ fixed frequency AC power for 1 minute prior to launch. As Sparrow missiles are not the only armament proposed for the CF-105 it was decided that to size the main aircraft electrical system for this load would be to penalise other versions of the aircraft with different armament. It is therefore proposed to fit an entirely separate alternator for Sparrow missiles only.



This alternator would be driven by an air turbine motor; the complete assembly including controls to be carried in the rear of the package. The air supply for the turbine can be obtained from the main air conditioning trunk line which runs close to this position. A quick disconnect flexible hose will connect the air supply between the package and the aircraft structure. On production versions of the Sparrow installation the capacity of the A16 electrical system will be increased to eliminate a turbine driven source.

10.0 The Package

The package concept Figure 7, page 16, postulated in the Falcon proposal will be adhered to for the Sparrow 2. The package will pick up on the same fittings, will use the same hydraulic lines and will utilise the same ground equipment for hoisting, servicing etc. The concept of quick removal and replacement will be adhered to with the target being the replacement of packages as a normal rearming procedure within the specified turn round time.

When removed from the aircraft the package will be entirely self contained.

11.0 Servicing Re-Arming etc.

All ground operating controls, hydraulic depressurising valve, accumulator charging points, firing circuit safety plug, hydraulic and air quick release couplings will be grouped together at the rear of the package and access will be through a hinged door. The door will be held closed by a minimum number of quick release fasteners. All firing leads will pass through the safety plug which when disconnected will hang below the skin

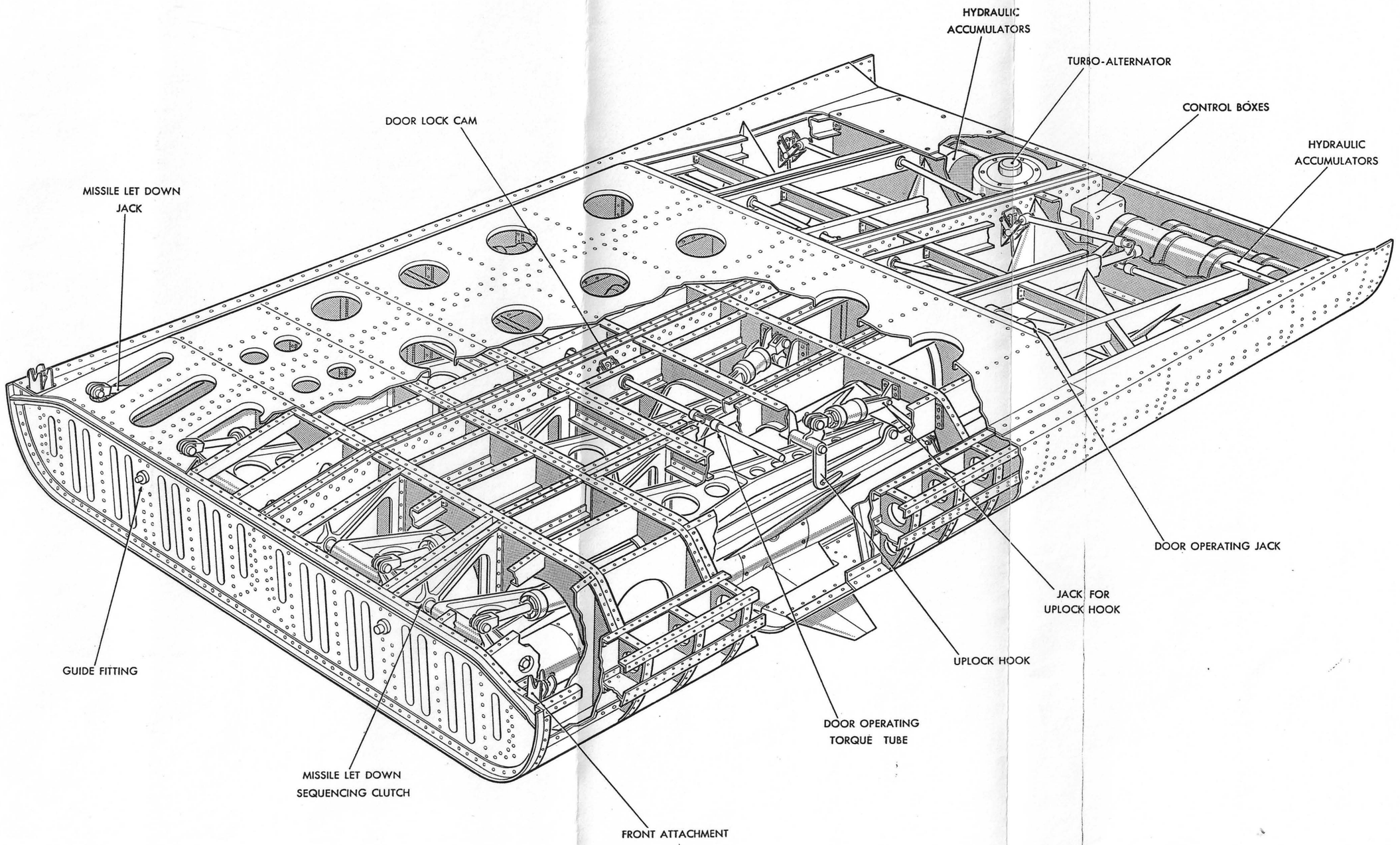
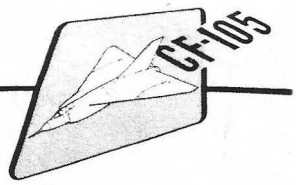


FIG. 7 CF-105 SPARROW 2 MISSILE PACK



line as visual evidence of safety. Additional safeguards will be provided at the nose wheel and the external fuel tank. An override for test purposes will be provided at the rear of the package.

Buttons for raising and lowering missiles will be provided. The raising and lowering sequence can be stopped at any time by releasing the button. Normal ground operation will be at one third the speed used in flight. Flight operating times can be achieved on the ground by using the firing circuit safety override. An external hydraulic supply is required for ground functioning.

Both front attachments can be made or broken simultaneously by one man at the front of the package. A similar set up exists at the rear of the package.

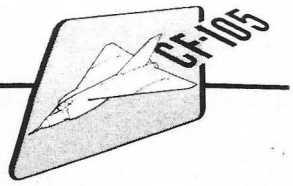
Rearming can be carried out by loading individual missiles or by replacing packages.

12.0 Missile Auxiliaries

The exact nature of the auxiliaries has yet to be determined. They will however be carried in the electronics compartment immediately forward of the armament bay and will be accessible through a quickly detachable hinged panel.

13.0 Attack Sequence

~~The sequence of operations to be carried out on an attack will depend on whether or not it is really necessary for the missiles to lock on to~~

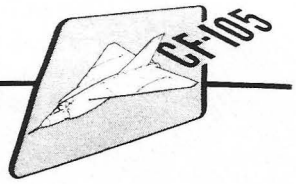


their target pre-launch.

13.1 If Missile Does Not Require to Lock on to Target Pre-Launch

In this eventuality servoing of the antenna and servoing into coincidence of range gates etc., could be carried out inside the aircraft with minor corrections being made during extension and in the launching position prior to launch.

If four missiles are to be fired on an attack a "2.6 seconds to go" signal will be taken from the fire control system to initiate the extension cycle. This signal will simultaneously start the firing intervalometer and energise the door opening valves, causing the doors to open in 0.4 seconds. When fully open, the doors will energise the missile up locks to release. These will in turn energise the missile actuation jacks to extend the missiles to the launching position in a further 0.7 seconds. As the missiles reach the extended position the retraction side of the door jacks will be energised and the doors will close in a further 0.4 seconds. This operation will be completed 1.55 seconds after the "2.6 seconds to go" signal. In a further 0.05 seconds the intervalometer will commence to supply firing signals at 0.5 seconds intervals. Interlocks will be provided to ensure that the missiles are all fully extended and the doors closed prior to the commencement of the generation of firing pulses. Missiles will be fired alternately from port and starboard sides. After launch and when clear of the nose of the aircraft time delays in the missiles will energise their transmitters and unlock the



controls. 0.5 seconds after the last missile has left its launcher the intervalometer will generate a retract signal which will cause the doors to be opened, the launchers retracted and locked home and the doors to be closed.

If only two missiles are to be fired the same process will be gone through except that the sequence will be started one half second later to put the CG of the attack at the right point in time.

In the event of a hangfire all launchers will remain extended to allow for the subsequent disposal of the hangfire by the pilot.

13.2 If Missile Does Require to Lock on to Target Pre-Launch

In this eventuality antenna and range gate servoing can start before extension but the missile transmitters can be turned on only after extension. The slaving process takes about 3 seconds.

The lowering sequence will commence at 2.6 seconds to go in the case of an attack with all four missiles. The missiles will reach the extended position in the same manner as previously outlined. At 1 second to go the intervalometer will generate the first firing signal. A system of priorities will be arranged whereby the first firing signal is routed to the first missile to lock on. The second signal will be routed to the first missile on the opposite side of the aircraft to lock on and so on. If at any time a firing signal is available and no missile is ready the signal will be held until a missile is prepared and the next signal will

follow one half second later. Simultaneous lock on of adjacent missiles will be catered for in the firing circuit. One half second after the last missile has been launched the retraction sequence will commence and will be identical with that previously outlined.

When only two missiles are to be launched the same process will be gone through except that the sequence will be started one half second later.

In the event of a hangfire all launchers will remain extended for subsequent disposal of the hangfire by the pilot.

14.0 Jettisoning

~~Provided jettisoning without firing is confirmed as an RCAF requirement for all types of missiles~~ Provision will be made for jettisoning.

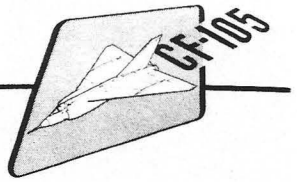
15.0 Cockpit Controls

The proposed cockpit controls are:-

The trigger
An Arm-Safe switch
A Mode selector switch
A Manual retract switch
A Jettison switch

To complete an attack it is proposed that the trigger must be kept depressed. Releasing the trigger will abort the attack at the time of trigger release.

The mode selector switch will permit the selection of either automatic or manual firing of either two or four missiles. When a two missile attack



is selected the outboard missiles will be fired on the first pass. When manual attack is selected the attack sequence will commence when the trigger is depressed.

The manual retract switch will permit the retraction of hangfire missiles at the discretion of the pilot.

The jettison switch will jettison a hangfire if any launchers are extended or will jettison all missiles if jettison is selected at a time when all launchers are retracted. Missiles will be jettisoned one at a time,

16.0 Development Programme

Although the CF-100 MK. 4 Rocket Pack and the CF-105 Falcon installations differ radically from the proposed Sparrow installation it is considered that sufficient basic data will have been derived from them to safely permit the Sparrow development programme to be less extensive than that proposed for the Falcon.

Initially we propose a mock up of a complete package to gain experience with the complete installation. Simultaneously we would propose to construct a ground test rig of one half of a package for mechanism development tests. This rig would later be used for rocket sled tests under representative conditions of air loading. Prior to commencing manufacture of the flight test packages we would construct an experimental package for ground firing and intensive ground functioning.

17.0 Summary

A package installation of four Sparrow 2 missiles in the fuselage of the CF-105 is proposed. The proposed details of this scheme are outlined. Firing sequences for the missile when locked on before launch and for a proposed modification of the missile to permit launch prior to lock on are presented. The package complete with missiles is estimated to weigh approximately 4,470 lbs.