PROGRESS REPORT

THE CF-105 SPARROW II

ARMAMENT INSTALLATION

Prologue
Tom Dugelby
Productions

Hawker
Sid
report

I N D E X

INDEX (Continued)

FIGURES (Continued)

PROGRESS REPORT ON THE CF-105 SPARROW II ARMAMENT INSTALLATION

1.0 INTRODUCTION

In February 1955, a proposal for the installation of four Sparrow II missiles was submitted to the R.C.A.F. In May 1955, conditional acceptance of the proposal was received by Avro Aircraft Limited.

During the intervening period until now, the Sparrow II missile has been undergoing development. This development, which has included changes to the external dimensions, is still proceeding and it is anticipated that it will be April 1956, before the missile stabilises sufficiently to justify the preparation of manufacturing drawings of the installation.

The proposed installation catered for both two and four missile attacks, with only two missiles being extended for firing in the case of the two missile attack. At the time of making the proposal there was a small wing to body clearance between adjacent missiles. The addition of blisters to the missile body during subsequent development has resulted in the disappearance of these clearances.

This matter has caused us to undertake a general re-examination of the proposed installation to determine what measures could be taken to give the flexibility originally proposed.

At the same time, in accordance with the R.C.A.F. letter of May 1955, the reduction of the weight of the installation was given prominent attention.

1.1 RE-EXAMINATION OF THE PROPOSED INSTALLATION

1.1.1 Structure

A large proportion of the weight of the original installation, less missiles, was structural weight. The reason for this was that the missiles themselves, plus the necessary clearances, occupied so much of the available space that the space left was inadequate and resulted in an inefficient structure. The original installation is illustrated diagrammatically in Fig. 1.1. Because of the space occupied by the missiles a good roof structure was not possible. The missiles, therefore, had to be spaced to give a heavy keel member down the centre of the installation with two side box members.

To obtain the extra space needed, to give the original performance, by spacing the missiles further apart in the original structure resulted in the virtual disappearance of the structure itself.

It was therefore apparent that a major repositioning of the missiles would be necessary. At the time of the

1.1.1 (Ctd.) re-examination of the installation the Company was conducting a general investigation into the carriage of missiles in a semi-submerged position instead of the more usual fully submerged position, and had been impressed by some of the advantages which could accrue from such an installation. We therefore considered semi-submerged carriage in our re-examination of the Sparrow II installation.

By lowering the missiles until their centrelines were on the aircraft skin line it was found possible to obtain a good top structure which did away with the necessity for a keel member. The missiles could thus be spaced further apart without encroaching on the size of the side beams and adequate clearances could be obtained. The revised installation is shown diagrammatically in Fig. 1.2.

The resulting structural scheme, which is shown in Fig. 1.3, is considerably more efficient than the originally proposed scheme and should result in a weight saving of around 500 lbs.

1.1.2 Doors

Perhaps the major uncertainty of the original installation was with regard to the integrity of the doors, which opened

1.1.2 (Ctd.) outwards to permit missile extension. These doors were large and, because of space limitations, very thin. By installing the missiles with their centrelines at the aircraft skin line it is no longer necessary to have doors to permit the missile body to be extended for firing.

Doors are still required in the region of the wings and fins to permit them to pass through the skin line on extension. As a result of the reshuffle in missile position these doors no longer need to be outward opening.

It will, however, still be necessary to seal the hole left by a missile after firing. For this purpose small chord flap doors can be used. These doors open inwards and only come into operation after retraction of an empty launcher. It is not at present intended to close the doors during launch. Ample space is available to make them of suitable thickness. The required arrangement of doors is shown in Fig. 1.4.

The exposed part of the missile body will still require the protection which was previously provided by internal carriage. We understand from the Douglas Aircraft Company

1.1.2 (Ctd.) that the model of the Sparrow II, subsequent to the present one, will be suitable for exposed carriage throughout the CF-105 flight envelope. However, as this model may not be available in time, we propose to cover the exposed portions of the missile with a light fairing which can be jettisoned prior to firing. The outline of this fairing is shown in Fig. 1.5. Cooling air will be passed through the annulus between the missile and the fairing and will be exhausted to atmosphere at the rear of the fairing. The fairing will be jettisoned by releasing the forward end, allowing it to rotate through a fixed angle, and then releasing the rear end.

Even with the improved version of the missile a fairing over the radome will be required to prevent damage or deterioration from mud, stones, ice, etc. A small fairing over the radome will, therefore, be a part of the installation. This small fairing will not be jettisonable and will be used to hold the forward end of the large fairing in position (when it is fitted).

1.1.3 Extension Linkage

The original installation imposed severe restrictions on the type of extension mechanism which could be used, because of the small space above the missile in the retracted position.

1.1.3 (Ctd.) When the missiles were lowered to the semi-submerged position considerably more space was available for the retracted linkage, and it became possible to consider other types of extension mechanism. Several alternatives were fully investigated and one showed up head and shoulders above all the others. This was the 'two jack with drag link' scheme illustrated in Fig. 1.6. As will readily be seen from the diagram this scheme only begins to score when adequate room is available in the retracted position.

1.2 MISSILE 'LOOK ANGLE'

1.2.1 General

The present Sparrow II requires to 'see' its target prior to launch. Unless an aircraft is designed specifically to give this facility prominence above all other considerations there must be regions where the missiles cannot 'see' because portions of the aircraft or other missiles obstruct its view. This, in turn, leads to limitations on attack configurations. The CF-105 installation, being under the fuselage is, in general, restricted in its view upwards, relative to the plane of the wings. Fig. 1.7. shows the restriction imposed on the original installation, by the CF-105 fuselage.

1.2.1 (Ctd.) We understand that it would be possible to develop a Sparrow II guidance system that did not require to see the target before launch. If this were to be done there would be no 'look angle' limitation. Until the time that such a missile is developed we must, however, live with the restriction and try to evaluate its importance.

1.2.2 Co-altitude Attacks

For a perfect lead collision attack against a co-altitude target the interceptor's wings would be level and the necessary look angle of the missile, as shown in Fig.1.8.1, would theoretically be a straight line. In practice, because of speed variations causing changes in interceptor angle of attack, and because of other random variations, the necessary look angle would become a narrow horizontal band of the order shown in Fig. 1.8.2. Additionally, even in a nominal 'wing level' attacksthere would probably be some transient banking over small angles to correct small heading errors, so that the actual required 'look angle' for the missile is somewhat as shown in Fig. 1.8.3.

Hence, for a 'wings level' co-altitude attack the original installation gives more than adequate view to the missiles.

1.2.2 (Ctd.) The Fire Control System which will be fitted to the CF-105 is not yet known to us in sufficient detail to enable us to evaluate its capabilities. It is quite probable that in the final attack phase it will have inherent limitations which make it necessary for this phase to be carried out with wings level. However, if we assume that a fully versatile Fire Control System is fitted to the CF-105, in theory, attacks could be pressed home from positions which necessitated banking right up to the moment of firing. The missile 'look angle' necessary to permit these extreme attacks is shown in Fig. 1.9. Comparison with Fig. 1.7. will show that sufficient 'look angle' to permit these curved attacks up to the moment of firing cannot be provided on the CF-105. The restriction applies, for example, when the interceptor has been positioned by G.C.I. on the beam too far ahead of the target and in a condition where he cannot reduce his speed in time. It would therefore appear that, on a curved attack, the interceptor should level its wings for about two seconds to permit lock on and launch.

In the absence of data on the accuracy of G.C.I. positioning and data on probability versus distance from optimum position, we are not able to evaluate the percentage of attacks which would be penalised by the proposal to fire with wings level. It is our opinion, however, that the percentage should be small.

1.2.2 (Ctd.) We are unable to say what difficulties would be involved in incorporating the wing levelling feature in a Fire Contril System, but are inclined to the opinion that it should not prove too difficult.

For co-altitude attacks we therefore submit that the R.C.A.F. should accept that the final phase of an attack should be conducted with the wings level.

1.2.3 Attacks against a Target with Altitude Superiority

Conditions may arise when it is desired to attack a target from an inferior altitude. This state of affairs could occur principally at the higher altitudes where it was desired to use the interceptor's higher manoeuvrability at a lower altitude than the target and the missile's climb capability.

Due to the 'look angle' restriction caused by the nose of the CF-105, very little non co-altitude ability can be obtained from level flight off the tail of the target. A somewhat better, although still far from good, condition exists for attacks on the nose of the target. Even on the beam, where the missile is not looking past the aircraft nose, adequate look angle to use the full missile capability is not available against some targets.

1.2.3 (Ctd.) A vertical look angle versus aspect angle plot, such as Fig.1.10, shows the very rapid fall off of non co-altitude capability of the CF-105 in level flight at the smaller and larger aspect angles and that, even on a beam attack, the full missile climb capability cannot be used. In the light of the limited information available to us we do not think that non-co-altitude attacks from level flight are practical.

The extended distance of the missile below the fuselage on the original proposal was as large as is practical. Further extension, even though impractical, was investigated, but did little to improve the situation. To obtain effective non-co-altitude capability with the CF-105 and Sparrow II missiles, attacks would appear to have to be made from other than a level flight attitude.

The Douglas Aircraft Company have informed us that on installations similar to the CF-105 installation it is proposed to manually fly an attack at constant altitude until the computor indicates to the pilot that he is in an area from which he can fire. At this stage the pilot is required to pull up the nose of the aircraft to centre the steering dot. As soon as the missiles lock on they

1.2.3 (Ctd.) will automatically fire. Using this technique, added altitude capability is given to the missile as is shown in Fig. 1.11. We understand that it is possible to mechanise such an attack in the Fire Control System, but do not know the cost in dollars or complexity.

We suggest that the solution to the 'look angle' problem in non-co-altitude attacks probably lies in this direction and that provided the missile is at a reasonable distance below the aircraft skin line the exact distance is a secondary consideration.

1.3 CURRENT SPARROW II INSTALLATION

As a result of the work previously outlined in this report, we are now investigating in detail the installation outlined in this section of the report. The missiles will be carried with their centrelines on the aircraft skin line.

1.3.1 Structure

We consider that the value of a package installation has been proved by the recent change in weapons requirement, and that flexibility in choice of weapon is a feature to be maintained. The practicability of a rapidly replaceable

1.3.1 (Ctd.) package has, in our opinion, also been proved by recent demonstrations with a partially developed mock-up package.

Structural investigation is therefore along the lines of a quickly replaceable package constructed as shown in Fig.1.3

1.3.2 Extension Linkage

A detailed investigation into the linkage described in para. 1.1.3, and shown in Fig. 1.6. is proceeding.

As a result of the investigation outlined in Section 1.2. (look angle), we considered that the extended length of the linkage required further examination.

Further lengthening of the linkage was impractical from consideration of stiffness, tolerances and clearance on landing with extended missiles. A certain amount of shortening could be carried out before wing collisions were encountered. The small amount of shortening, though helpful, did not materially improve the weight of the installation or stiffness and clearance. Further investigation showed that if the extension distance was

1.3.2 (Ctd.) to be considerably reduced, we once again entered a region where adequate clearances were available. A 'look angle' plot of this configuration was made and is shown in Fig. 1.12. This plot appeared to us to give adequate look angle in line with the thinking of section 1.2. and hence we have investigated it further.

For reasons of aircraft response we consider it inadvisable to exceed a missile lowering time of 1 second. Using the output of the two 20 g.p.m. pumps fitted to the Utility Hydraulic System we find that, with the short links, we can achieve a 1 second extension without the need for hydraulic accumulators.

The long linkage, as originally proposed, would require more than twice the quantity of hydraulic oil. If supplied by accumulators the added oil requirements would cost about 150 lbs. in weight. The links themselves would be about 60 lbs. heavier than the short links for comparable stiffness. To take care of the added drag loads and the higher moment loads, we woild expect that the package structure would be about 40 lbs. heavier with the long links than with the short links.

1.3.2 (Ctd.) Balancing the concrete weight saving of 250 lbs. against the small loss in 'look angle', we decided to concentrate our investigation on the shorter links giving the 'look angle' illustrated in Fig. 1.12.

In this linkage, single extension jacks are used and side and end loads are taken out by the jacks. Drag load is catered for by the drag link.

Up locks will be used to hold the missile firmly against way pads in the retracted position.

Fig. 1.13 shows the hydraulic 'hook up' to the mechanism. Fig. 1.14 shows the missiles mounted on their links in the launch position.

1.3.3 Missile Body Doors

After a missile has been fired, and the launchers retracted, it is necessary to seal the slot which was previously occupied by the missile body. For this purpose we propose to use small chord inward opening doors, which are actuated to the closed position only after the retraction of the empty launcher. Should it be proved necessary, it can be

1.3.3. (Ctd.) arranged for these doors to be closed during launch and opened for launcher retraction.

Because of the position of the empty launcher it is not possible to seal the slot with a simple hinged door. The type of door chosen is shown in Fig.1.15. Hydraulic actuation will be used.

1.3.4 Wing and Fin Doors

In order to extend the missile for launch it is necessary to first open doors to allow the missile wings and fins to pass through the skin line. Several types of door were investigated in detail and the multi-element sliding door shown in Fig. 1.16 proved to be the most suitable. There are rollers at each end of the door which run in tracks. Hydraulic actuation will be used.

Prior to lowering the selected missiles the wing and fin doors will be fully opened in about 0.50 seconds. After the missiles have been lowered the doors will then be closed to the position they occupied prior to missile lowering, thus leaving long narrow open slots on the underside of the aircraft.

1.3.4 (Ctd.) After retraction of the empty launcher the wing and fin doors, together with the body, will be actuated to close the slots.

Electro-hydraulic sequencing will be provided to open the doors during retraction of hangfire missiles on training missions.

1.3.5 Hydraulic System

All actuation will be hydraulic from the Hydraulic Utility System. This system contains two 20 g.p.m. pumps and oil will be delivered to the package through quick disconnect fittings at the rear.

No accumulators will be fitted and actuation will be from pump delivery. The output of both pumps will be used on a four missile attack while on a two missile attack the output from one pump only will be used. In this manner we expect to obtain roughly constant extension times for both two and four missile attacks.

Electrical sequencing of doors and missile linkage via limit switches will be used.

1.3.5 (Ctd.) Provision will be made, either in the package or in the aircraft for connecting a ground hydraulic supply to the system for actuating doors and linkage. In this way, facility for individual reloading missiles, as opposed to package interchange, will be provided.

1.3.6 Electrical Connections to Package Firing Circuit Safety, etc.

Electrical connections to the package, firing circuit safety plug, access to hydraulic disconnects etc., will be similar to those demonstrated at the CF-105 Mock-up Evaluation Conference. Suggested improvements will be incorporated.

1.3.7 Missile Bay Cooling

The missile bay will be maintained within the limits of 0°F and +160°F by cockpit discharge air as described in Air Conditioning System Report P/EQUIP/62/1.

1.3.8 Electrical Supply

The principal power requirements of the missiles will be provided by the main aircraft electrical system. Small quantities of special voltage or special frequency power

1.3.8 (Ctd.) may be supplied by the Fire Control System Power Sub System. On failure of an alternator the pilot shall have the opportunity to retain missile firing capability by electing to do without engine intake de-icing.

The provision of power for optical firing of Sparrow II missiles after a failure of the Power Sub System will be investigated.

1.3.9 Operating Envelope

The installation will be designed to permit carriage of the missiles in the stowed position at all speeds and accelerations within the flight envelope.

For lowering and carriage in the extended position, the system will be designed for all speeds within the flight envelope, and for normal acceleration of between -1 and +4g. Considerable weight penalties would be incurred to extend the normal acceleration range. As it is possible that this range may be exceeded during breakaway in actual combat, we propose to automatically jettison hangfire missiles immediately upon the completion of the firing phase of the attack. In peacetime operations this jettison feature could be disabled provided flight with extended missiles was limited to the range -1 to +4g.

1.3.9 (Ctd.) For retraction of empty launchers the system will be designed for all speeds and accelerations within the flight envelope. For the retraction of hangfire missiles on peacetime operations the system will be designed for all speeds within the flight envelope and for normal accelerations of between -1 and +2g. If the +2g limit is to be exceeded during retraction the missile would pause in its motion until the acceleration is reduced below +2g. No other effect beyond prolonging the extension time would result.

1.3.10 Attack Modes

Provision will be made to attack either automatically under the control of the F.C.S., or manually. Either two or four missile attacks can be carried out.

1.3.11 Cockpit Controls

The following cockpit controls will be provided :-

(a) A two position arming switch labelled SAFE-ARM.

(b) A selector switch labelled MANUAL TWO, MANUAL FOUR, A.I. TWO AND A.I. FOUR.

(c) A hangfire indicator light. To retract a hangfire on peacetime operations this light should be depressed.

(d) A SPENT-AVAILABLE indicator.

1.3.11 (Ctd.) (e) An emergency jettison button on the pilot's main panel.

(f) A trigger with which firing is enabled.

1.3.12 Attack Sequence

The armament electrical busbar will be energised when the undercarriage is retracted. Power is then available for energising missile extension etc. Upon entering the combat area the SAFE-ARM switch can be put to ARM.

After acquisition of a target the number of missiles to be fired and the type of attack (manual or automatic) can be selected on the multi position selector switch. The trigger should then be depressed and kept depressed until the missiles have been fired or it is wished to break off the attack.

While the trigger is depressed missiles are being readied for firing, and on a manual attack the fairings will be jettisoned and missiles will then be extended. On an automatic attack the missiles remain retracted until the Fire Control System indicates that about two seconds remain until the missiles can be fired. The wing and fin doors then open, the fairings are jettisoned, the missiles are extended and the doors partially closed.

1.3.12 (Ctd.) When the selected missiles reach the extended position their transmitters are switched on and limited search for the target commences. As the missiles reach the extended position an intervalometer commences operation and generates firing pulses at half second intervals. The first missile to lock on receives the first firing pulse. In a four missile attack the second pulse is routed to the first missile on the opposite side of the aircraft to lock on. Thereafter, missiles receive pulses in the order of lock on. Simultaneous lock on is catered for by a system of arbitrary priorities. Two seconds after the first missile has left the launcher on a 'two missile' attack, (or three seconds on a 'four missile' attack) an automatic jettison signal will be routed to hangfires. These hangfires will be jettisoned by dropping (the Douglas launcher contains this provision). Immediately after jettison the launcher will be automatically retracted and the doors will be closed. The SPENT-AVAILABLE indicator will then indicate the stores remaining. At any time the attack may be aborted by releasing the trigger. In the event that extension has commenced when the trigger is released the missiles will move to the launching position and will be jettisoned after two or three seconds in wartime operations.

1.3.12 (Ctd.) The jettison feature can be disabled for training missions and in this case launchers will remain extended after firing if a hangfire is present. The launchers, including the hangfire, can be retracted by depressing the hangfire indicator in the cockpit. In this case the wing and fin doors will open prior to missile and launcher retraction.

1.4 DEVELOPMENT PROGRAMME

The timing of the various phases of the development programme is based on two key dates:-

(1) The availability of a weapons test CF-105 in December 1957.

(2) The requirement to have a Weapons Installation available for evaluation in conjunction with a Fire Control System in, about, March 1959.

The development programme is, therefore, aimed at providing a Sparrow II installation for flight work by the end of 1957, and at completing flight development in the following fifteen months.

The programme outlined hereafter is our best estimate of the amount of work required to complete development. As the installation is still in the formative stage it can only be considered tentative.

1.4.1 Extension Mechanism Test Rig

This test rig will be a ground static rig consisting of the missile extension gear only. It is proposed to get this rig into operation, in a rough and ready form, as quickly as possible, and to refine it as the design progresses. Initially, we expect to commence operation with two jacks, a drag link, and a dummy launcher on which weights can be hung. All components would be sized on preliminary loading data. At a later date these preliminary test items will be replaced with items of the final design and simulated air loading will be applied to the rig.

1.4.2 Door Test Rig

This rig will be handled in a similar manner to the extension mechanism test rig in that we would first commence with a preliminary specimen and arbitrary loading, and later refine both the specimen and the means of loading. The specimen will consist of two wing and four body doors with tracks and linkage. Simulated air loads will be applied and the doors functioned until all components are proved to have a satisfactory service life.

1.4.3 Mock-up

It is not anticipated that we will build a mock up of the Sparrow II installation. Because of the 'tight' programme for developing this installation we do not consider that a mock-up could be completed in time to be of value in the design of the installation. A suitable vehicle for package evaluation is available in the original Falcon package. It is proposed to weight the package to the full loaded weight of a Sparrow package and to continue development of pick-ups, seals, hoist, dolly, etc. Small mock-ups of details such as fairings, etc, may be made where they will be of assistance in the design.

1.4.4 Wind Tunnel Tests

Wind tunnel testing will be required to obtain data on:

(1) Forces acting on the missiles during lowering, launch and during the initial stages of free flight.

(2) Effects on aircraft of extended linkage, open doors, etc.

(3) Fairing jettison.

(4) Missile jettison.

These tests will be carried out late in 1956.

1.4.5 Test Package

In order to complete our preflight development programme before the end of 1957, we consider it essential to have a complete airworthy Sparrow Package Installation by May 1957. This means that the design must be complete, and the drawings issued, by September 1956. The implications are that the drawings will be released prior to Wind Tunnel testing and that we may have to face up to considerable modification of the installation prior to flight test.

All test packages will be built with preliminary tooling and using hand methods where possible.

The test package will be functioned, fired, transported on the dolly and generally carried through a development programme aimed at determining the necessary modifications which, combined with the results of the wind tunnel test programme, will give us an airworthy installation for flight testing.

Four launchers plus one spare will be required in March 1957, for this package. These launchers will differ from the standard Douglas launcher.

Four non-fireable dummy missiles will be required in April 1957.

1.4.5 (Ctd.) Twelve fireable dummy missiles, plus eight spares, will be required in May/June, 1957, for ground firing tests which we propose to conduct at Pt. Petre.

These missiles will be used as follows:-

Two shoots of one missile

One shoot of two missiles

Two shoots of four missiles.

1.4.6 Preflight Testing of the Installation on a CF.105

Prior to flight of the installation in a CF-105, we would like to conduct ground firing trials. These trials would take place in December 1957/January 1958, at some place where the aircraft could be flown close to a firing range and towed to the range without dismantling the aircraft. Twelve fireable dummy missiles would be required for this stage of the development.

These missiles will be used as follows:-

Two shoots of two missiles.

Two shots of four missiles.

1.4.7 Flight Development of the CF-105 Sparrow Installation

It is the Company's opinion that its responsibilities under the present contract extend to the provision of a sound installation for the carriage, launch and jettison of Sparrow missiles, and for ensuring safe clearance of the fuselage on launch and jettison. Under the present contract the Company does not consider itself responsible for any action of the missile after the moment at which guidance should commence.

1.4.7 (Ctd.) The flight development programme will therefore be confined to demonstrating that the Company has satisfactorily met its responsibilities as defined above.

The programme will be divided into three parts, subsonic, transonic, and supersonic. In each of these three regions the structural integrity of the installation for retracted carriage, extended carriage and extension and retraction will be proved. For this purpose an additional six non-fireable dummy missiles will be required in December 1957. During this stage of the testing, as in all stages, the handling, performance and response of the aircraft will be measured and any changes to the aircraft or any of its systems made. The jettison of fairings will be carried out immediately after the structural integrity has been proved. This will be followed by jettisons of non-fireable dummy missiles, a further twelve of which will be required in May 1958.

Firing trials will be carried out in each of the three regions. In each region the first firings will be at the low end of the speed range and at medium altitude. We propose to commence with single shots followed by firings of two and then four missiles. The speed will then be increased in increments to the point at which

1.4.7
(Ctd.) four missiles will be fired at the upper end of the speed range. Approximately twenty fireable dummy missiles will be required for each of the three regions. We anticipate that our requirements for these missiles will be 20 in May 1958, 20 in July 1958, and 20 in September 1958.

In each region two single shots will be fired at the lowest convenient speed in the range. These shoots will be followed, at the same speed, by a shoot of two missiles and then a shoot of four missiles. The speed will then be increased in three increments to the speed which gives maximum 'q' for the region. At each of these speed increments a four missile shoot will be carried out.

Preliminary jettison trials will be carried out at low speed with two and four missiles. Thereafter jettisons of four missiles will be carried out at the maximum speeds in each region.

The firing integrity trials will be followed by further firings at high altitude to investigate 'flame out' and fuselage clearance on launch. A further 30 missiles are estimated as necessary for this phase and will be required in December 1958. As eight of these will be already in stock a delivery of twenty-two missiles is, infact, required.

1.4.7 (Ctd.) All integrity shoots will have been carried out at medium altitudes where maximum 'q' can be obtained. As the majority of the CF-105's combat will be at 50,000 ft. at least three shoots at this altitude and at various speeds will be required to ensure satisfactory launch of the missiles under simulated combat conditions.

At least three more four missile shoots should be carried out at maximum aircraft altitude to determine whether or not 'flame out' occurs.

It is probable that this programme will be carried out at RCAF Station, Cold Lake. No special facilities other than hangarage, living quarters and assistance in servicing, photography etc., are expected to be required.

1.4.8 Requirements for Missiles and Launchers

From the previous paragraphs our anticipated requirements for missiles and launchers are :-

1.4.8.1 Non-Fireable Dummy Missiles

A total of twenty two non fireable dummies are required; four in March 1957, six in December 1957, and twelve in May 1958.

1.4.8 Requirements for Missiles and Launchers (Ctd.)

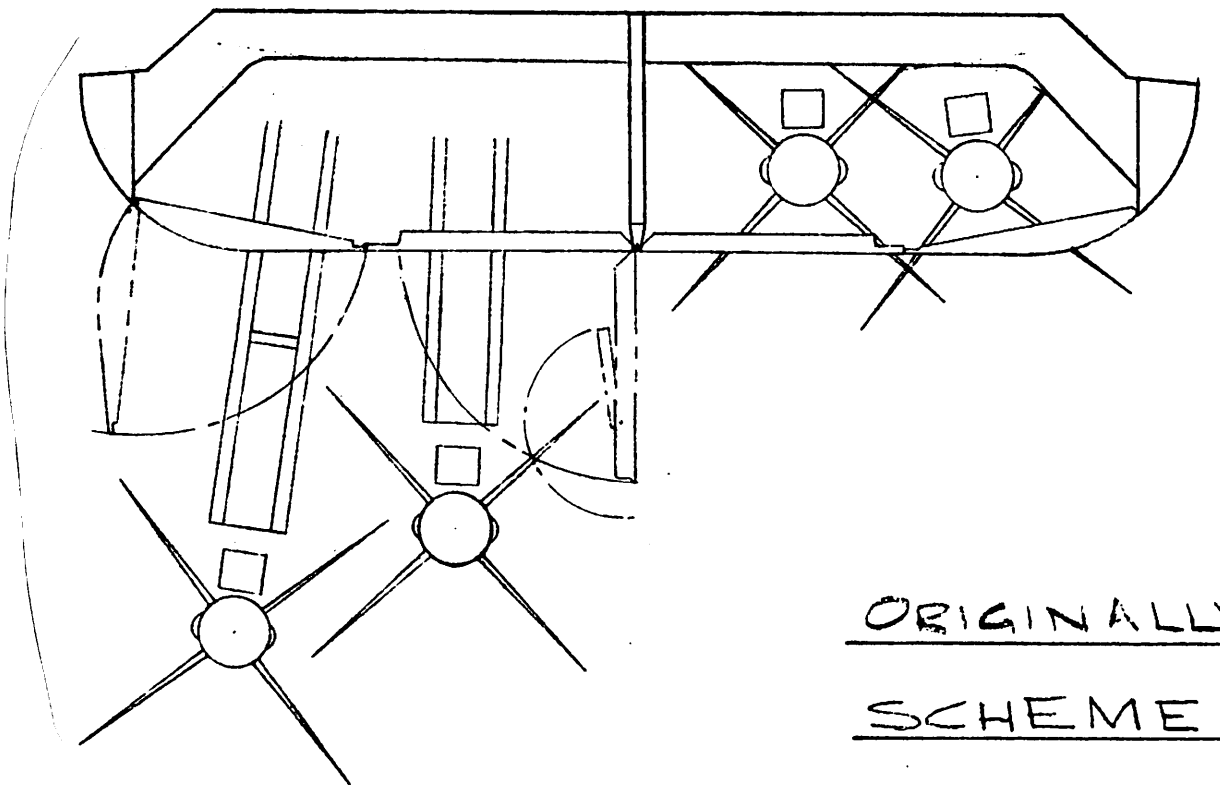
1.4.8.2 Fireable Dummy Missiles

114 fireable dummy missiles will be required as follows :-

20	in May	1957
12	in November	1957
20	in May	1958
20	in July	1958
20	in September	1958
22	in December	1958

1.4.8.3 Launchers

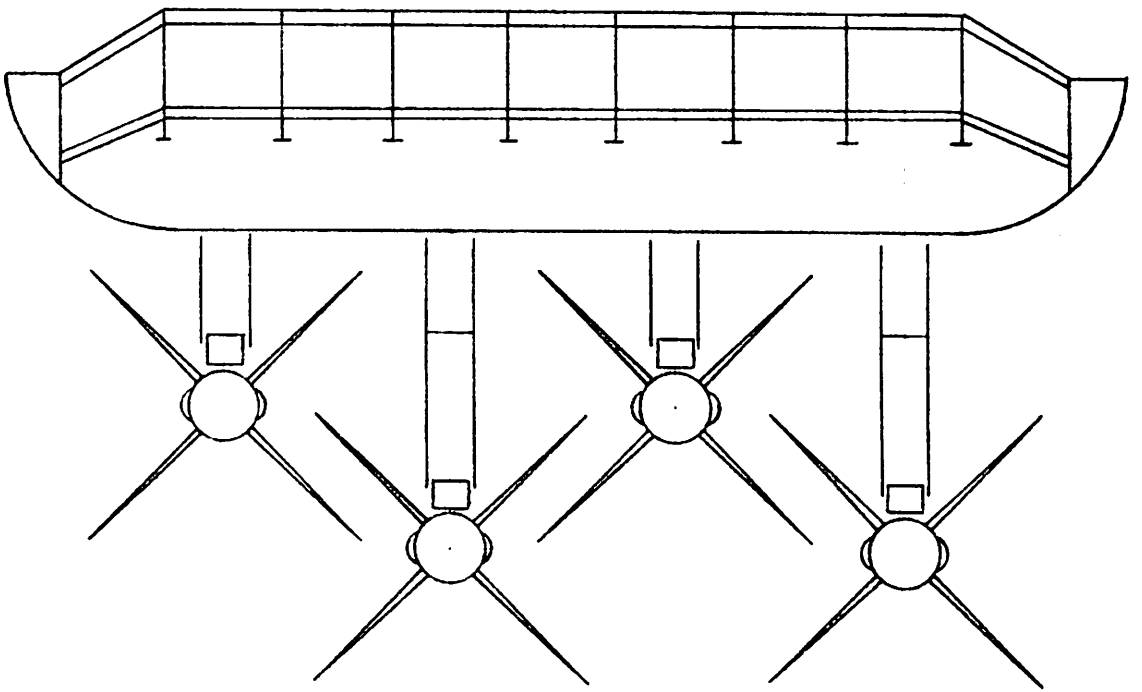
It is expected that at least fifteen launchers will be required to service the three packages which we expect to use in the development programme. Five will be required in March 1957, a further five in October 1957, and the final five in February 1958.



ORIGINALLY PROPOSED

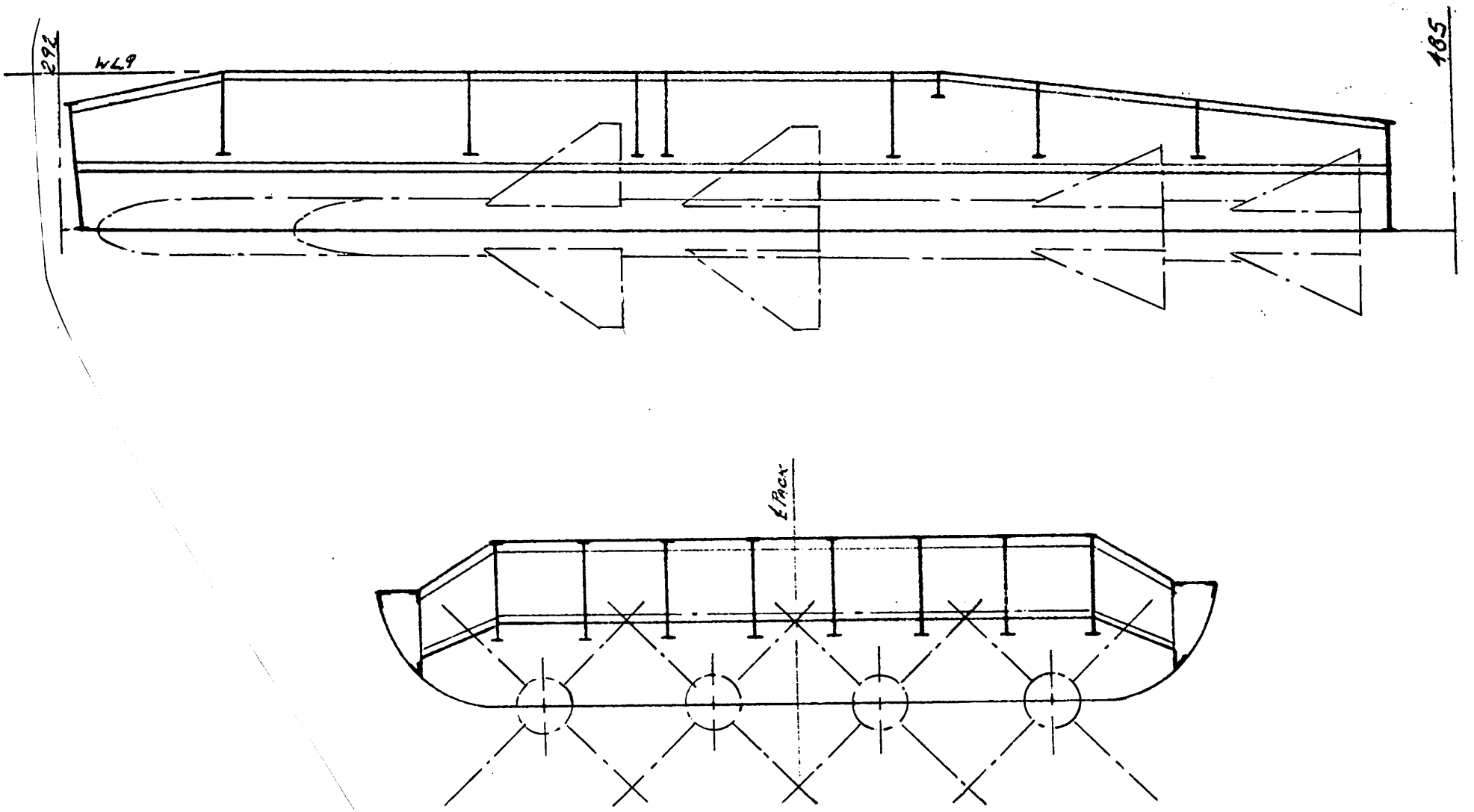
SCHEME MODIFIED

FIG 1:1



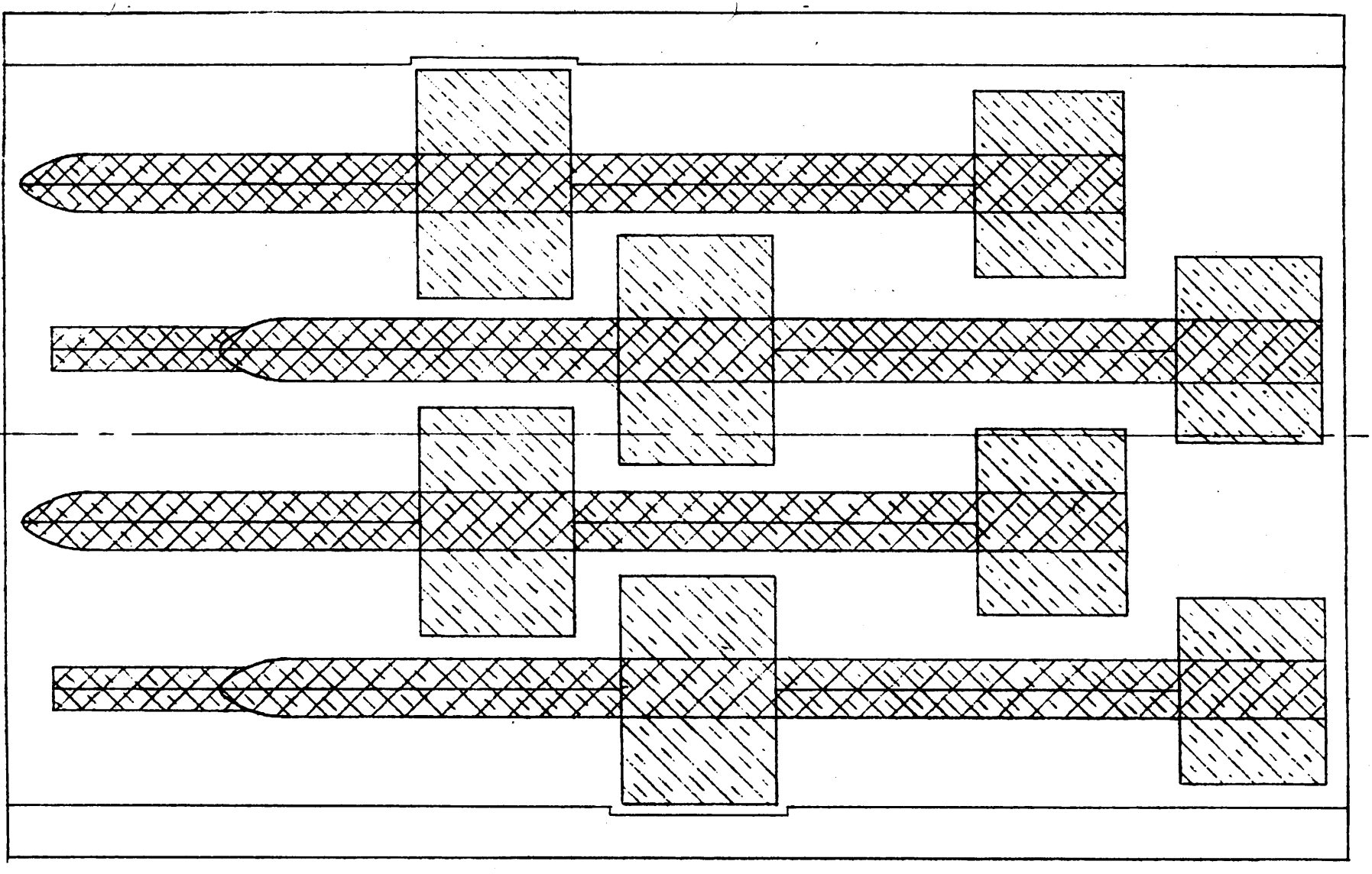
REVISED SCHEME

Fig 1:2



REVISED SCHEME — STRUCTURE

FIG. 1:3

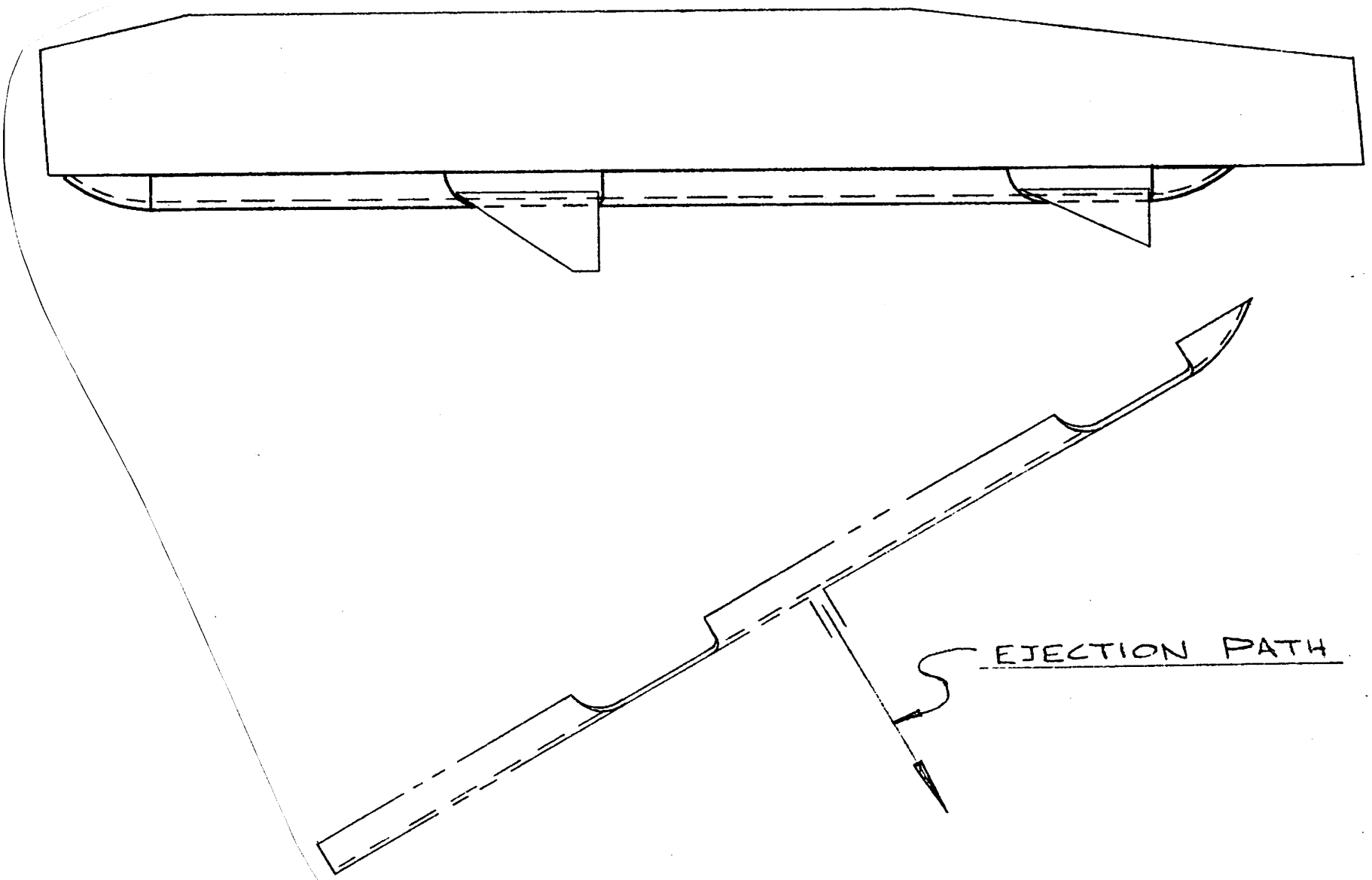


DOORS OPEN DURING FIRING

DOORS OPEN DURING EXTENSION

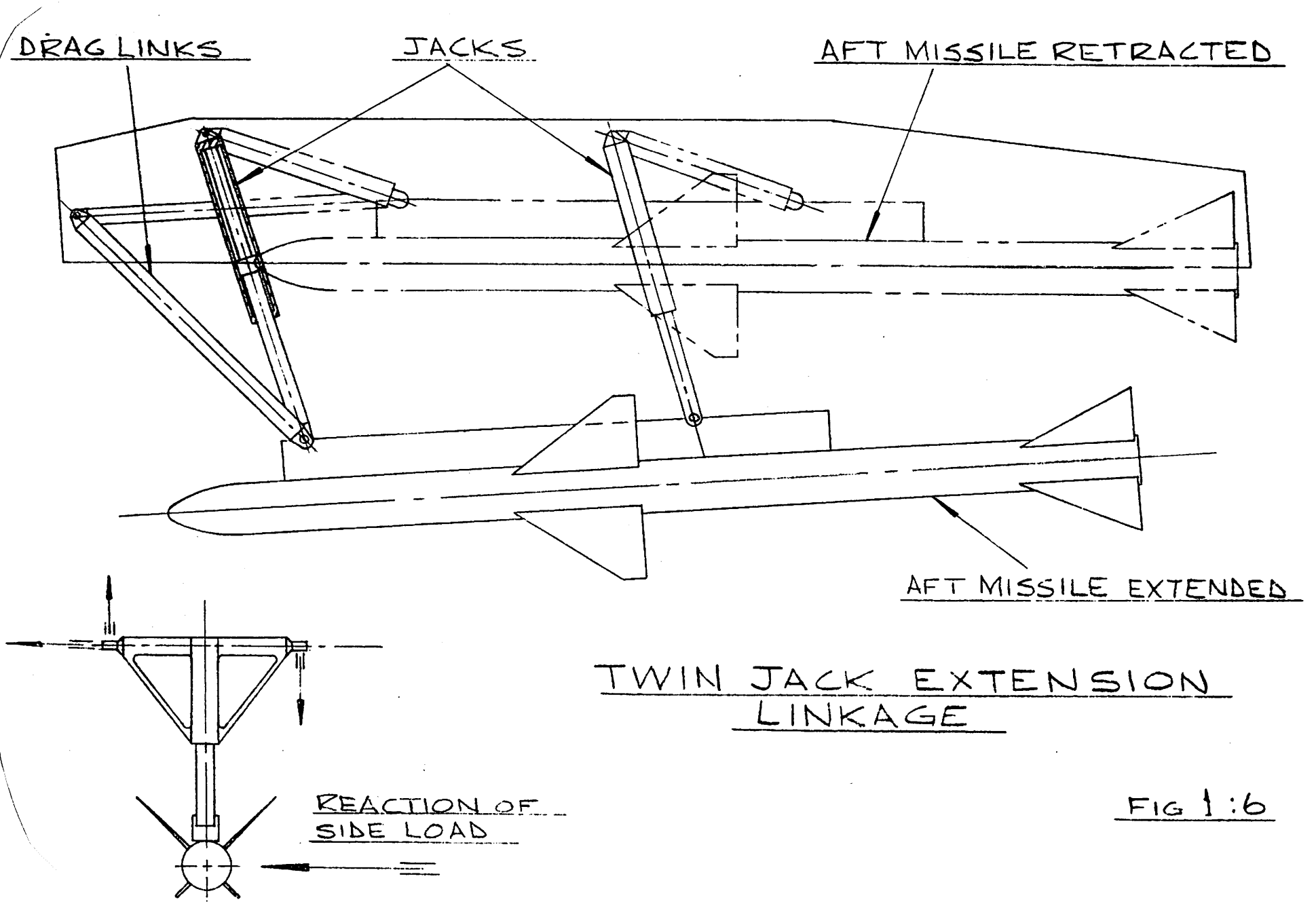
REVISED SCHEME DOOR AREAS

FIG 1:4



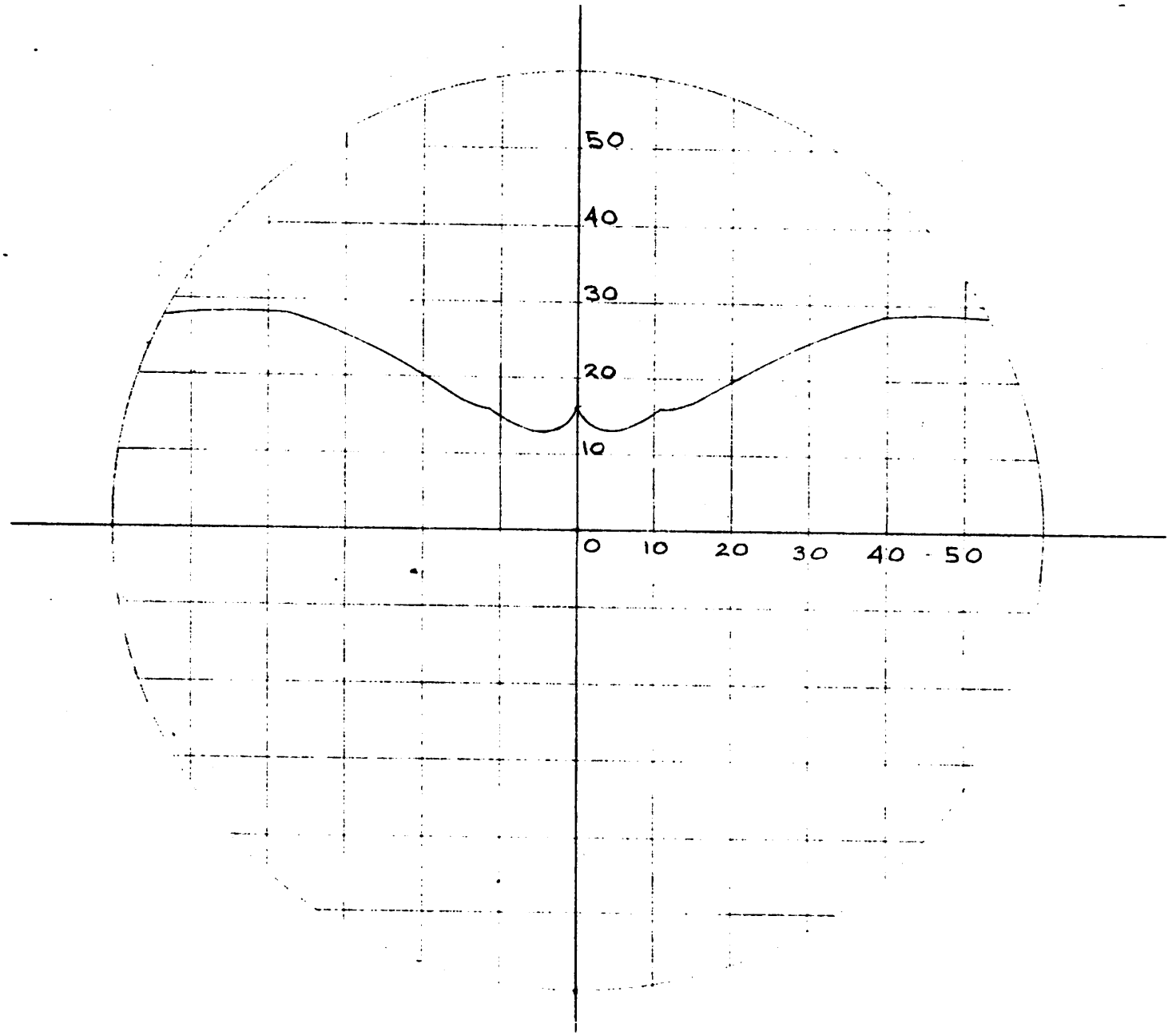
JETTISONABLE FAIRING

FIG 1:5



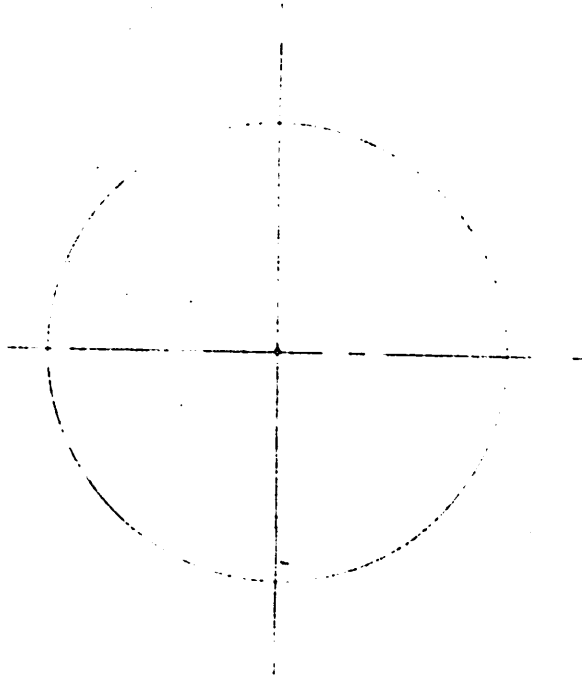
TWIN JACK EXTENSION LINKAGE

FIG 1:6



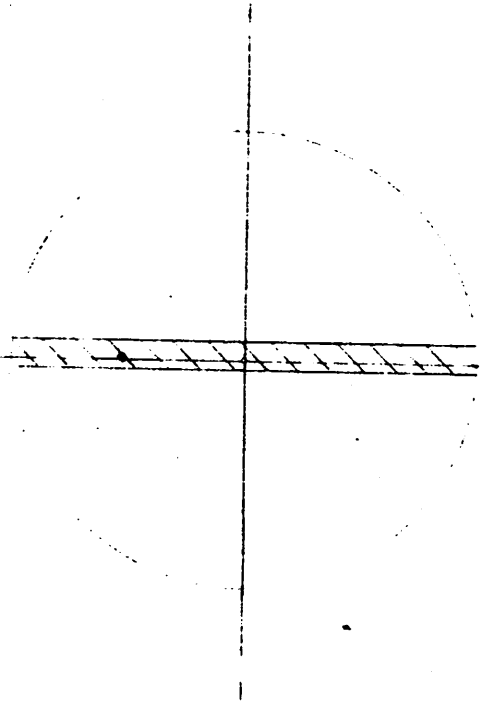
ORIGINAL SCHEME - AVAILABLE LOOK ANGLE

FIG 1.7



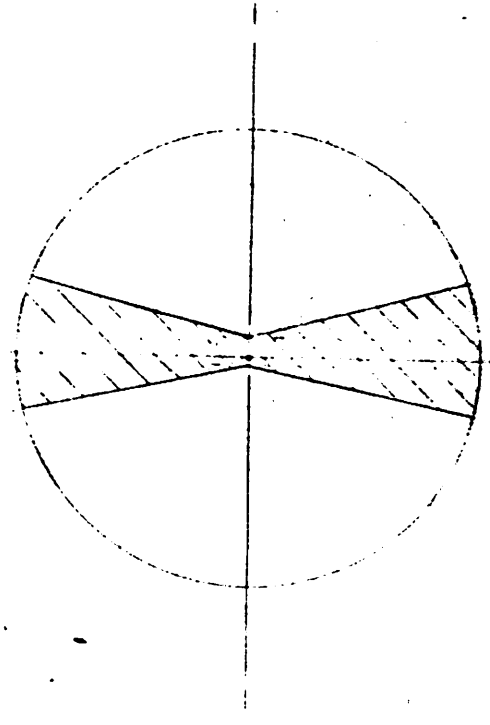
THEORETICAL LOOK ANGLE REQUIREMENT. WINGS LEVEL CO-ALTITUDE ATTACK

FIG 1:8-1



LOOK ANGLE REQUIREMENT. WINGS LEVEL CO-ALTITUDE ATTACK

FIG 1:8-2



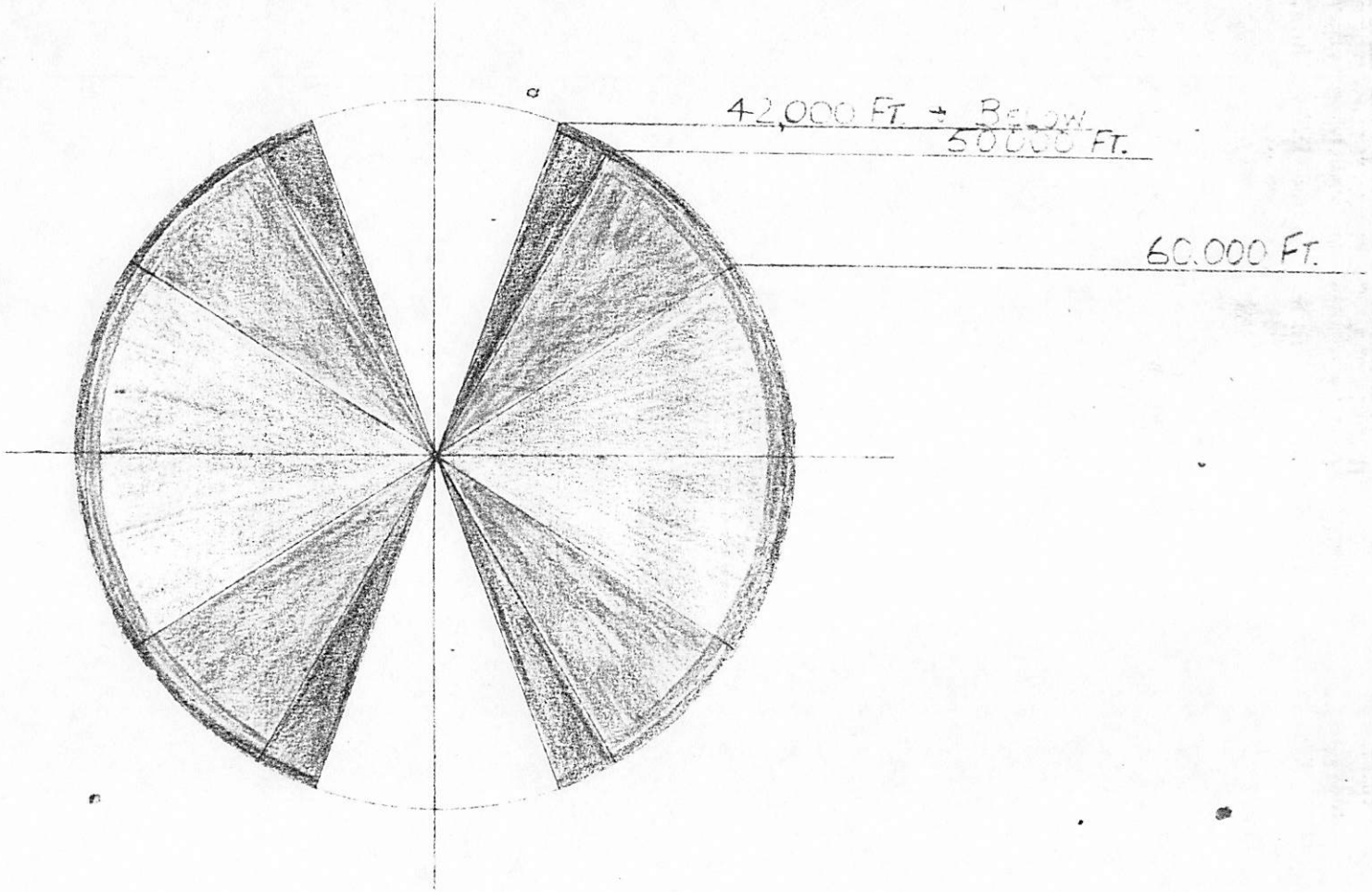
PRACTICAL LOOK ANGLE REQUIREMENT

FIG 1:8-3

— LOOK ANGLE REQUIREMENTS

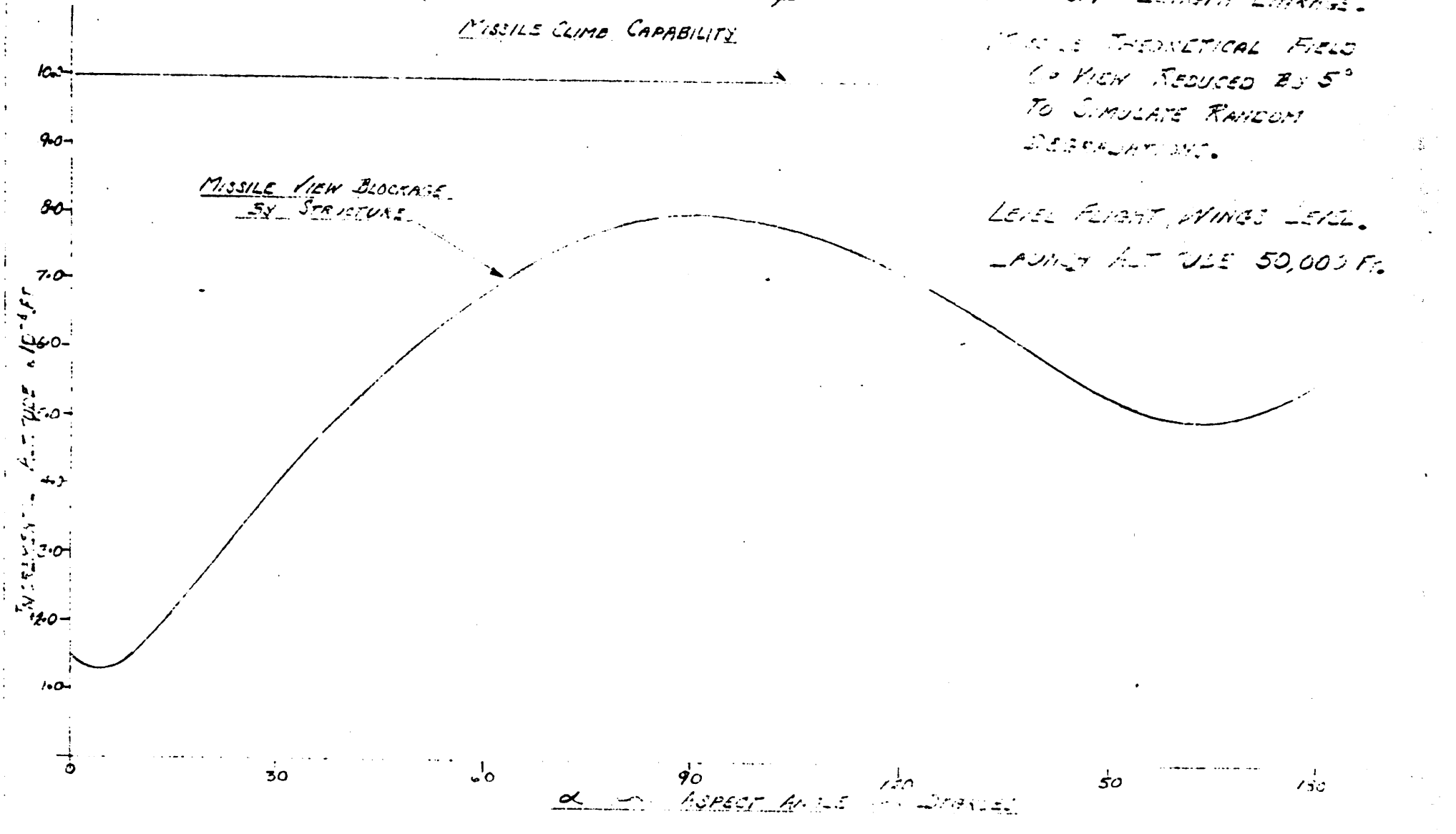
M=1.5

POWER LIMITED



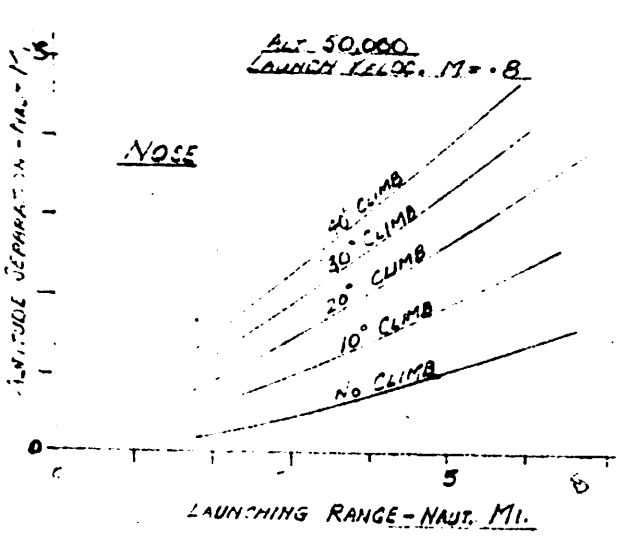
VIEW ALONG MISSILE ℄ FROM MISSILE EYE

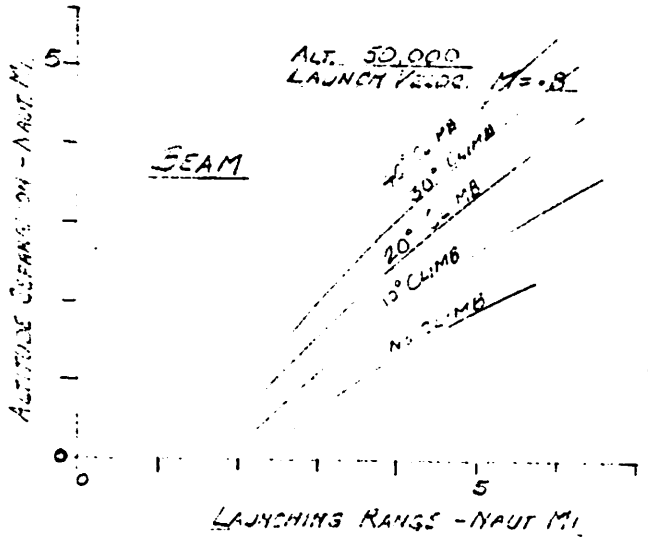
FIG. 1:9

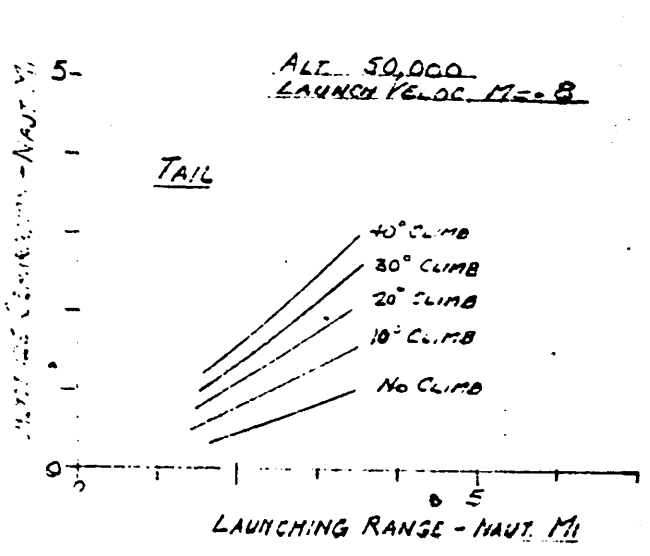


ALTITUDE CAPABILITY OF C-105 WITH [illegible] MISSILES

FIG 1:10





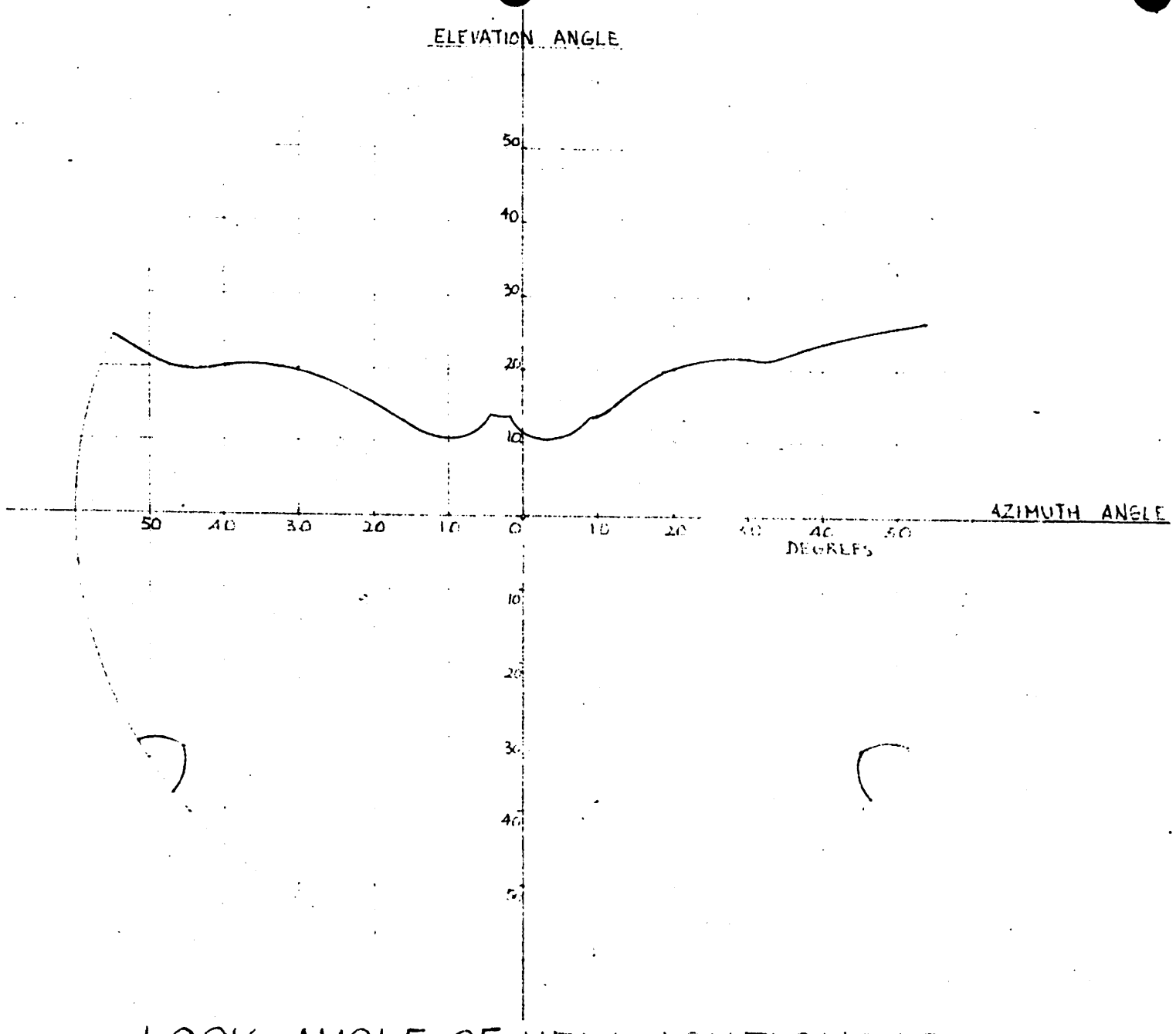


(REPRODUCED FROM D.A.C. BROCHURE DATED NOV 1 -55)

ALTITUDE CAPABILITY OF SPARROW II MISSILE

(NO LOCK ANGLE LIMITATIONS)

FIG. 1:11

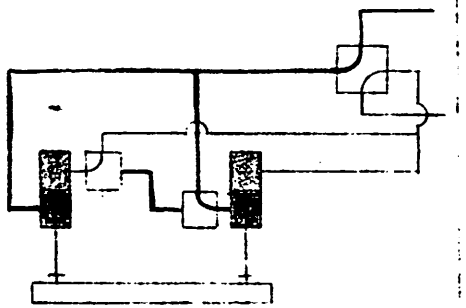


LOOK-ANGLE OF NEW CONFIGURATION

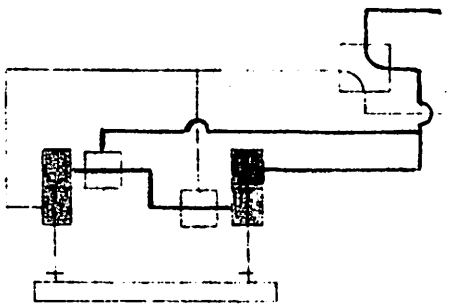
FIG. 1:12

BE INTEGRATED INTO ONE VALVE

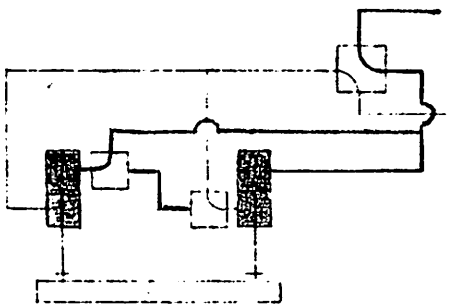
ONE RAISE / LOWER VALVE WILL SERVICE TWO MISSILES.



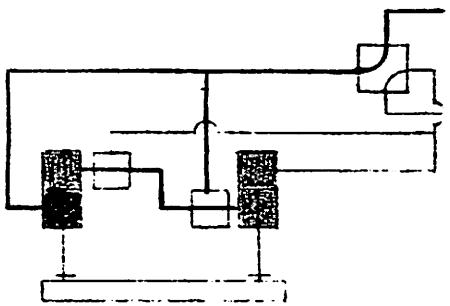
RETRACTED CARRIAGE



LOWERING



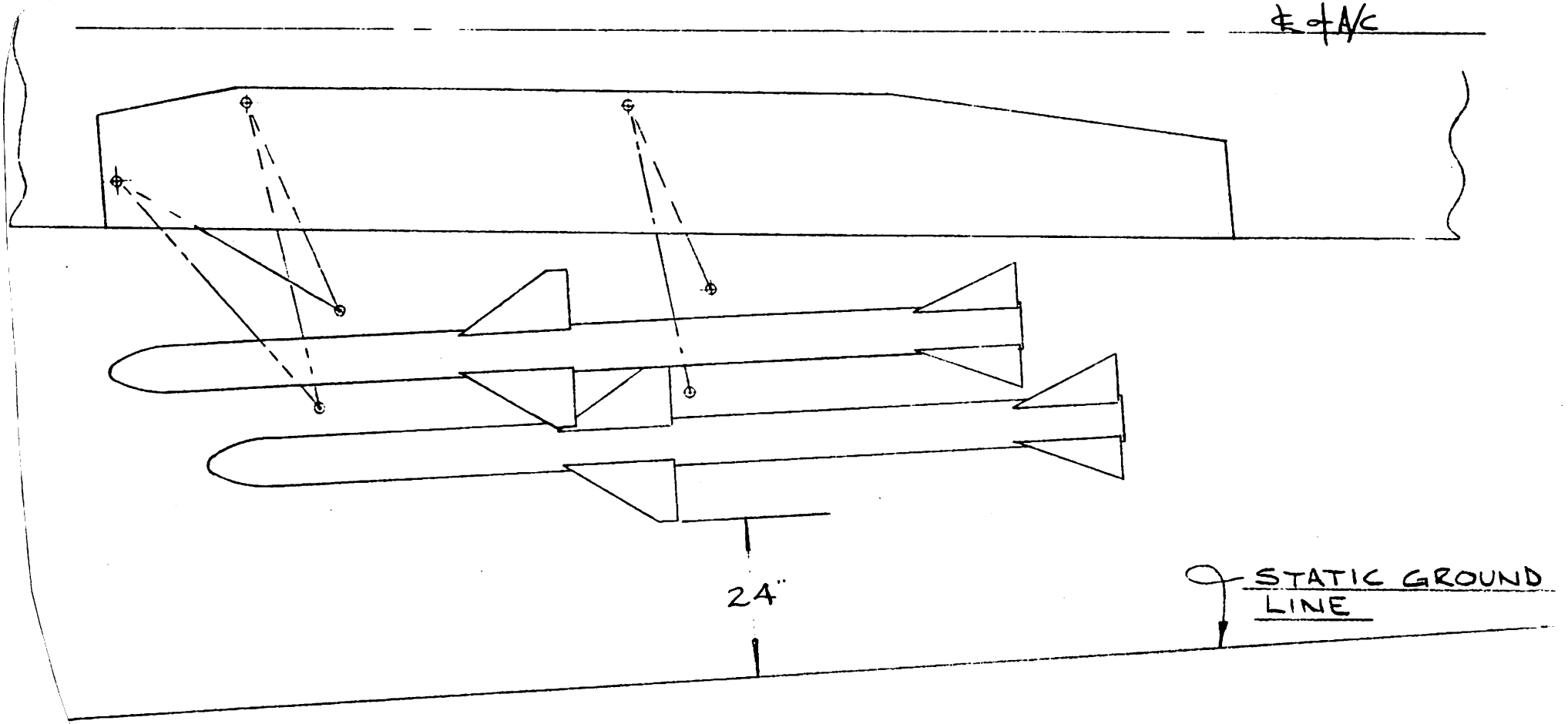
EXTENDED CARRIAGE



RETRACTION

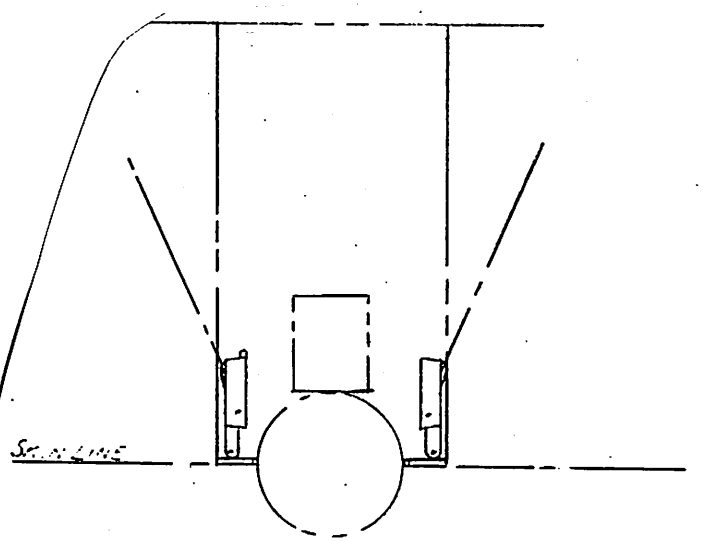
Fig 1:13

HYDRAULIC DIAGRAM (ONE MISSILE).

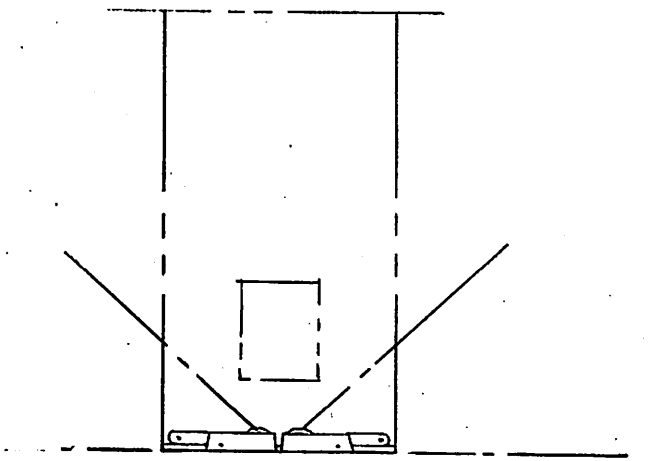


SIDE VIEW of AIRCRAFT WITH MISSILES EXTENDED SHOWING GROUND CLEARANCE

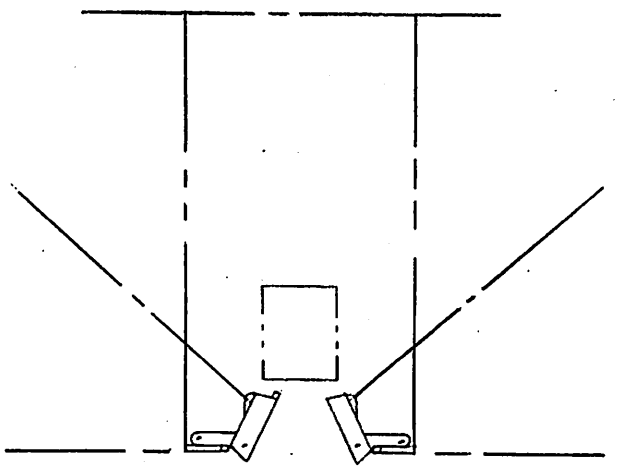
FIG 1 : 14



DOORS OPEN



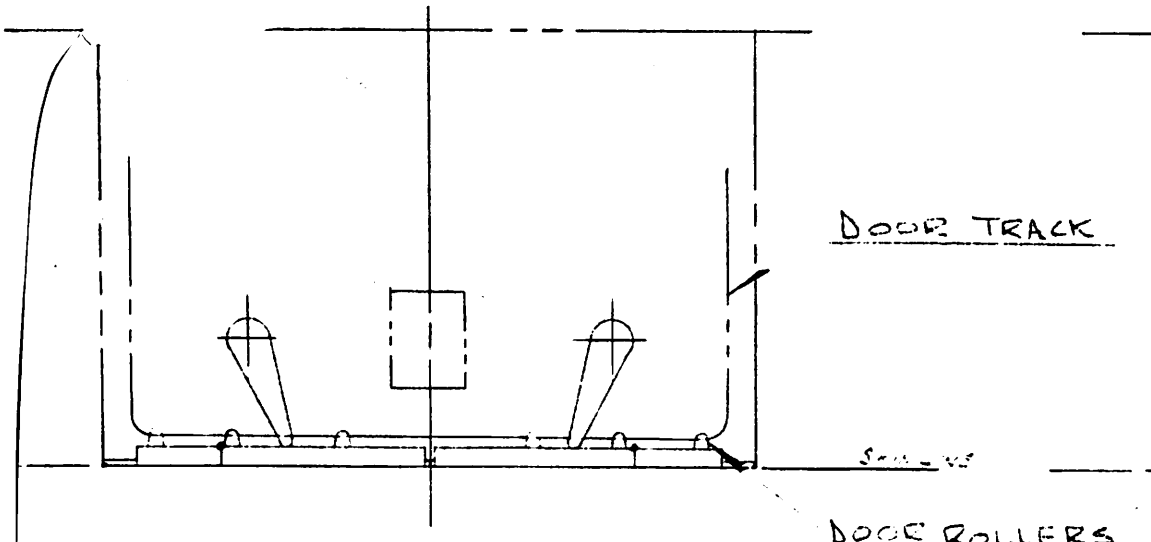
DOORS CLOSED



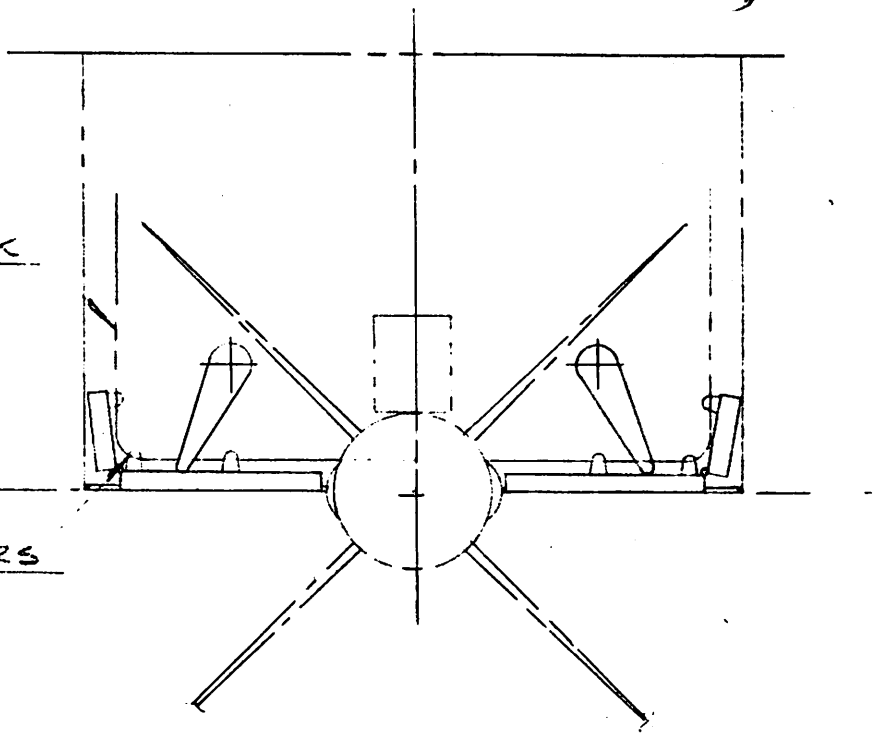
DOORS CLOSING

BODY DOOR OPERATING POSITIONS

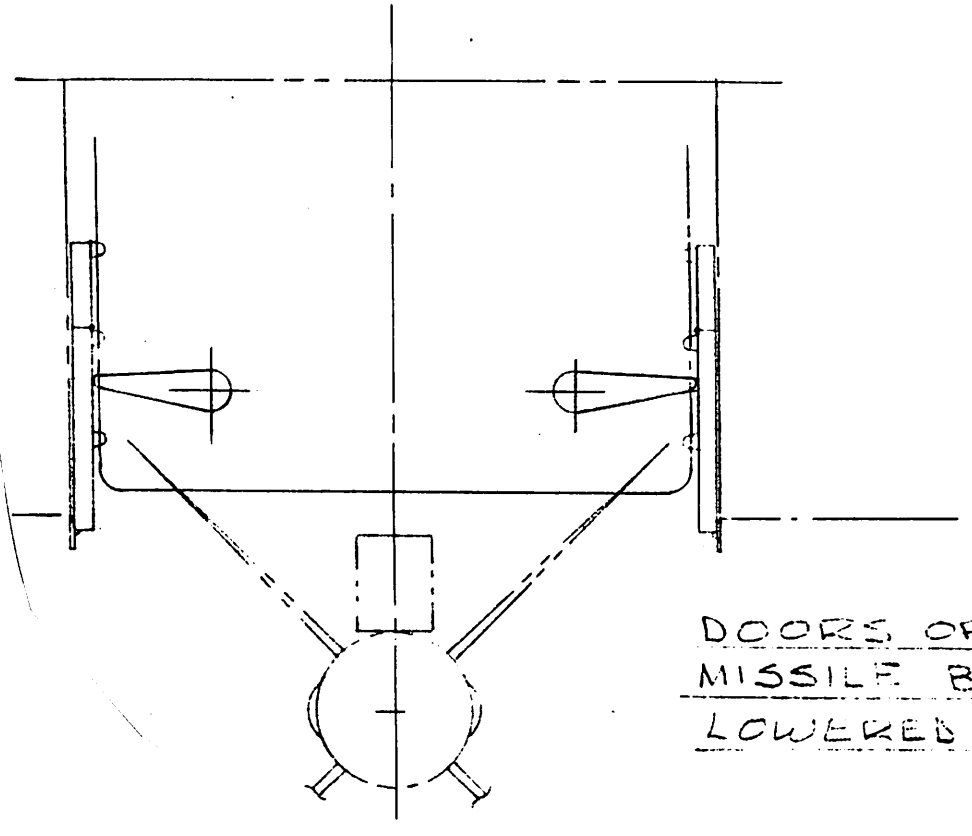
FIG 1:15



DOORS CLOSED
MISSILE FIRED



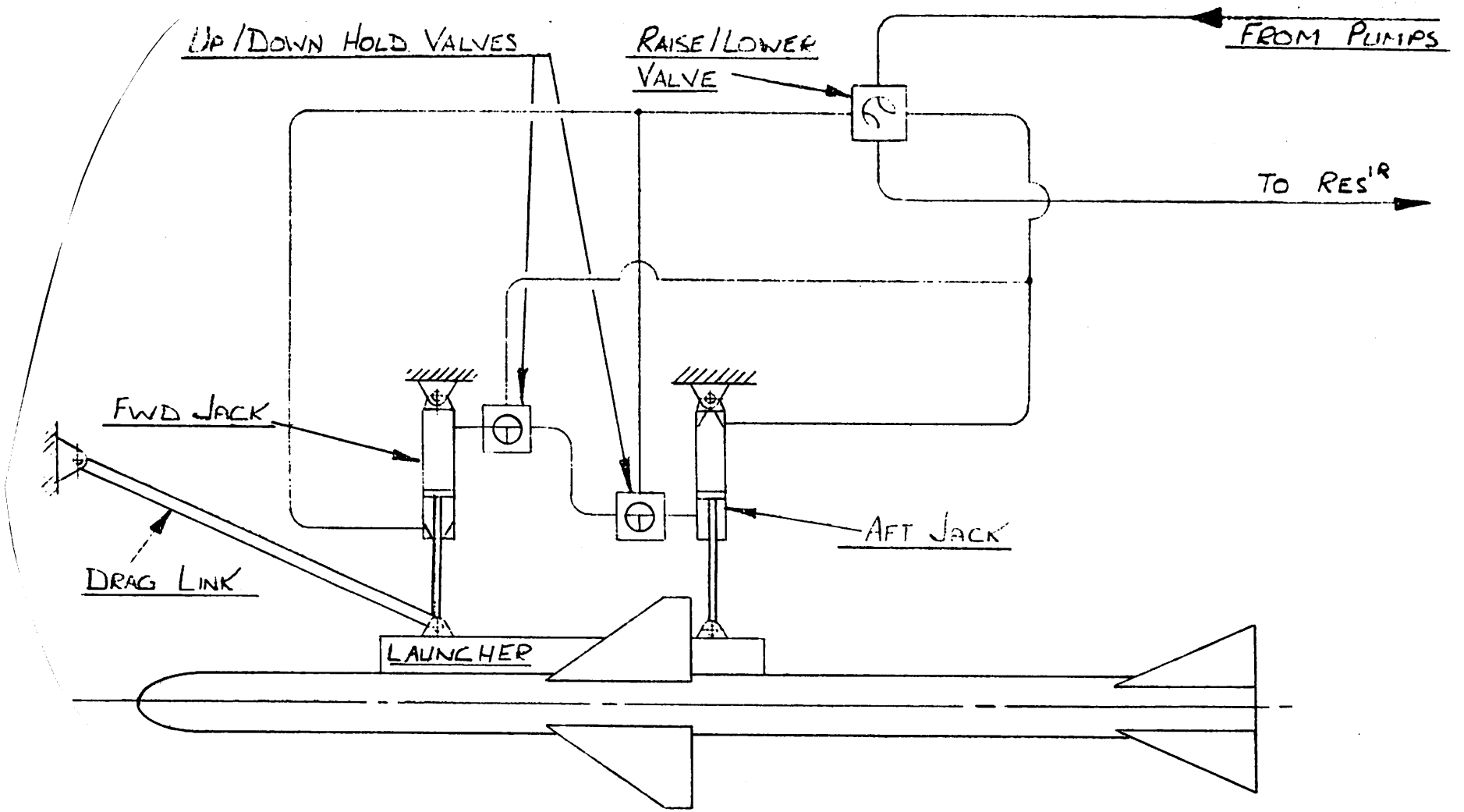
DOORS CLOSED
MISSILE STOWED



DOORS OPEN
MISSILE BEING
LOWERED

WING DOOR OPERATING POSITIONS

FIG 1:16

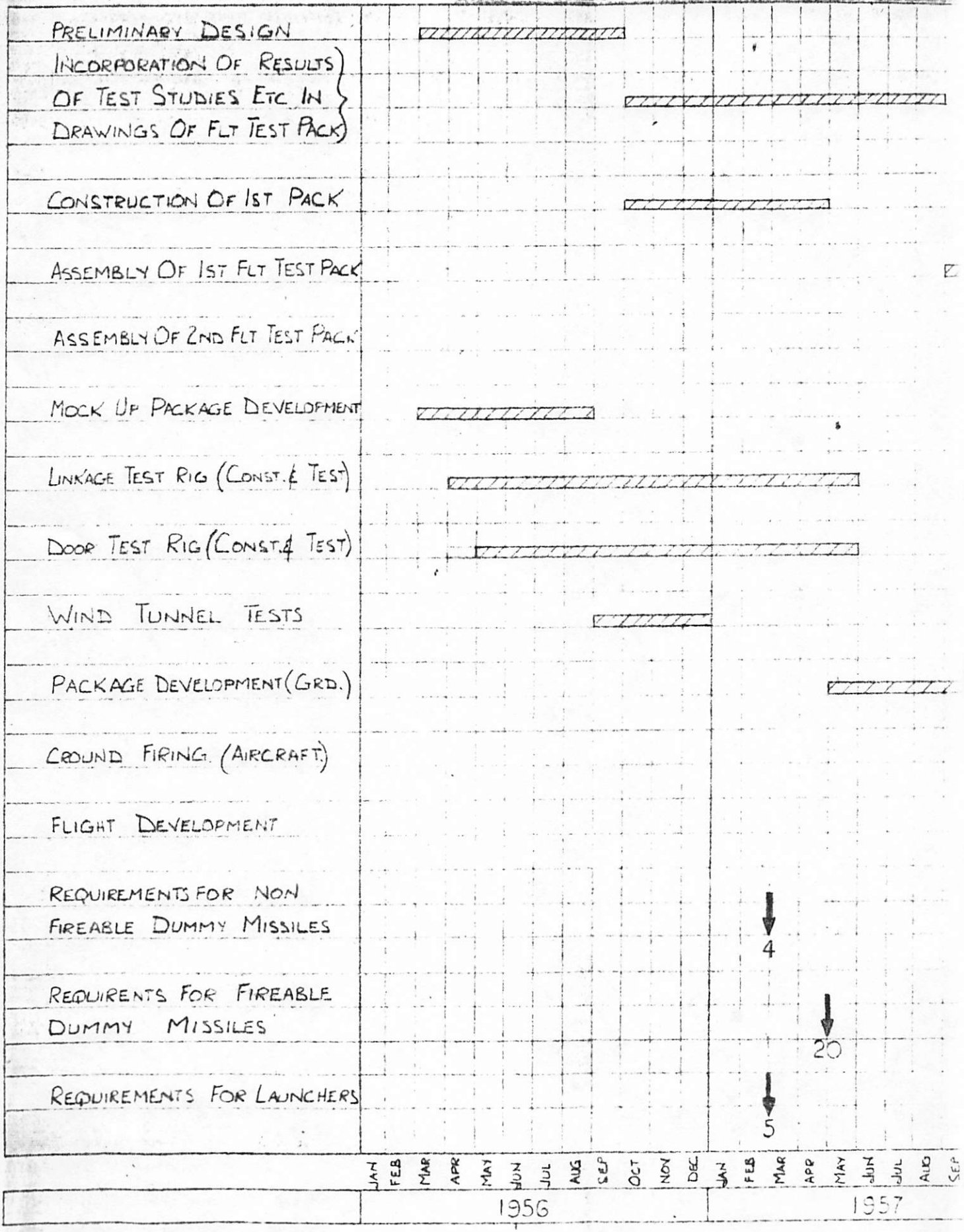


THE TWO UP/DOWN HOLD VALVES WILL BE INTEGRATED INTO ONE VALVE

ONE RAISE/LOWER VALVE WILL SERVICE TWO MISSILES

C 105 SPARROW ARMAMENT INSTALL

PROPOSED DEVELOPMENT PROGRA



NT INSTALLATION
T PROGRAMME

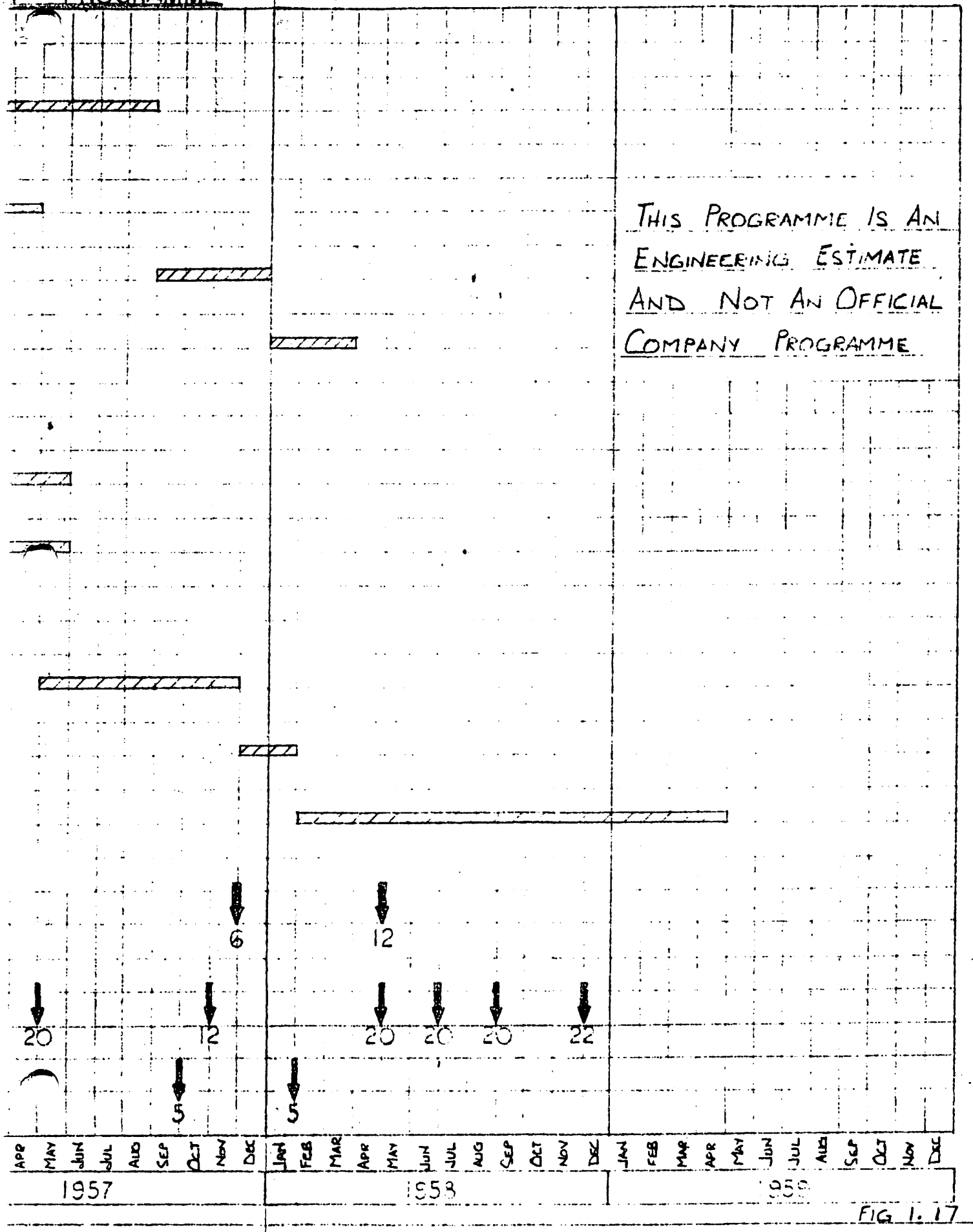


FIG 1.17