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A.W.I.

SEA VIXEN
TACTICAL MANUAL

R.N. Air Station, Yeovilton.

Y.S.V. 6.

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CONTENTS

		Contained in Classified Supplement Pages	Classification
Section 1 - Air to Air			
Chapter 1.	AI18R Radar		
2.	Airborne Interception Technique		
3.	Red Top	10-35	Secret
4.	Firestreak	36-43	Confidential
5.	2" R/P		
6.	Combat Air Patrol Stationing	45-48	Confidential
Section 2 - Fighter Tactics			
Chapter 7.	Fighter Tactics		
Section 3 - Ground Attack			
Chapter 8.	Basic Theory		
9.	Low Level Bombing		
10.	Dive Bombing		
11.	2" R/P		
12.	Pilot Attack Sight		
13.	Armament Switches		
14.	Armament Safety		
15.	Divisional Attacks		
16.	Strike		
17.	Weapon Effort Planning and Standards		
18.	Less Common Forms of Attack:		
	Firebomb	145	Confidential
	LABS	145	Secret
	Bullpup	157-163	Confidential
19.	Methods of Ground Attack Foreign to the Sea Vixen:		
	Gyro		
	Buccaneer Modes		
	Stick Bombing		
	Strafing		
20.	Night Attacks		
	Lepus		
	Glow-worm		
21.	Aerial Photography		
Section 4 - Trials and Experimental			
Chapter 22.	Tactics Against Low Level Bomber Threat	174-179	Secret
23.	Tactics For Use Against Helicopters	180-181	Secret
24.	Tactics and Lessons From Vietnam	182-187	Confidential

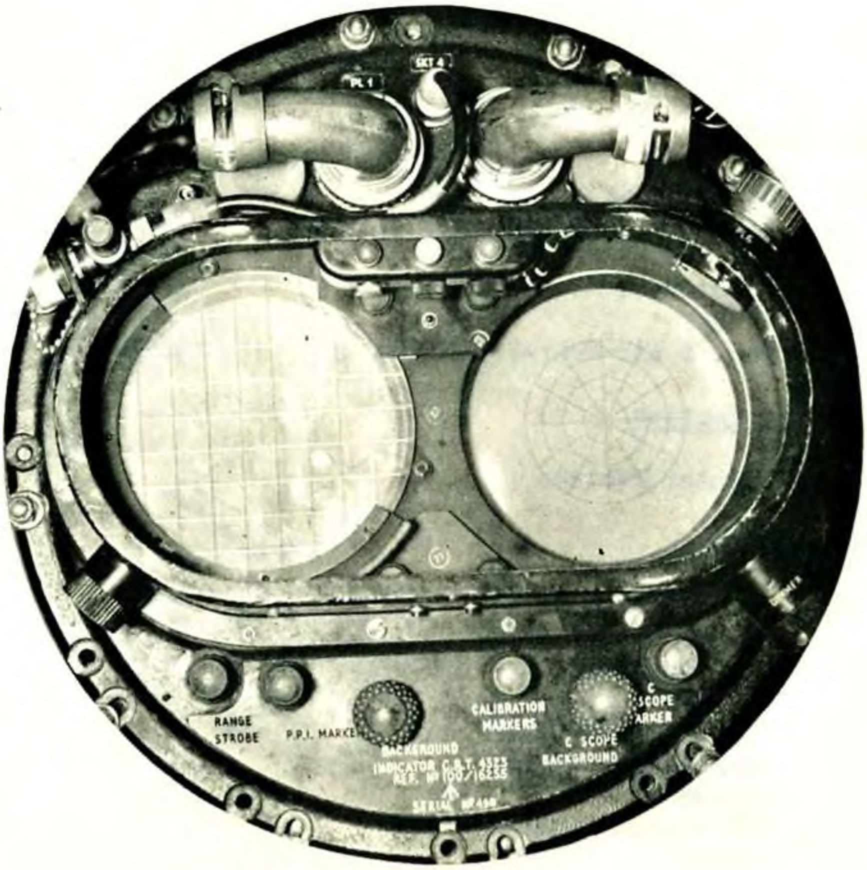


FIG.1–1 INDICATOR UNIT

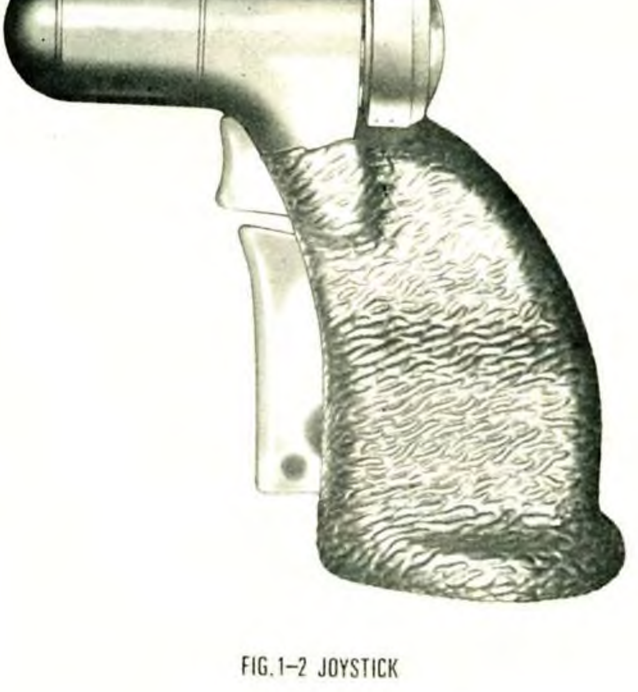


FIG.1–2 JOYSTICK

CHAPTER 1

A.I.18 RADAR MARK 18 R

101. Introduction

A.I.18R is a combined "Search" and "Lockfollow" radar. It is designed to be suitable for use anywhere in the world from sea level up to an altitude of 60,000 feet.

It is used to search for and detect a target and to enable the aircraft to carry out an attack using Red Top or Firestreak air to air missiles or two inch rockets. It also provides an A.S.V. (air to surface vessel) range up to 100 miles.

The radar is scanner stabilised and has a "lock-on" facility to provide signals for air to air guided weapons, predicting gunsight and attack course computes. In addition a special facility is provided to enable the radar to "lock on" to a jamming signal.

102. Presentation to Operator - Indicator Unit (Fig. 1-1)

The operators display is on two 5" cathode tubes: one gives range/azimuth information axes as a P.P.I. presentation, and the other gives azimuth/elevation information in either stabilised or aircraft axes as a C' scope presentation. A graticule with adjustable edge lighting is mounted in front of the two tubes to enable the operator to read off the target position.

The controls on the indicator unit are used to vary the brilliance of the different parts going to make up the radar display and normally should only require adjustment at the beginning of a flight.

103. Operator's Controls (Fig. 1-2)

a. Joystick

Those controls in constant use operationally are grouped together on the joystick.

The scanner is slaved directly to the joystick. i.e. to move the scanner 20° right the joystick is moved to the right. (The centre of the 60° scan is indicated by an electronic marker on the P.P.I.) Similarly the scanner can be selected up and down and a C' scope electronic marker displays the elevation of the scanner.

(1) Range Strobe

A moveable electronic marker on the P.P.I. which must be just below a contact before 'Lock Demand' is selected.

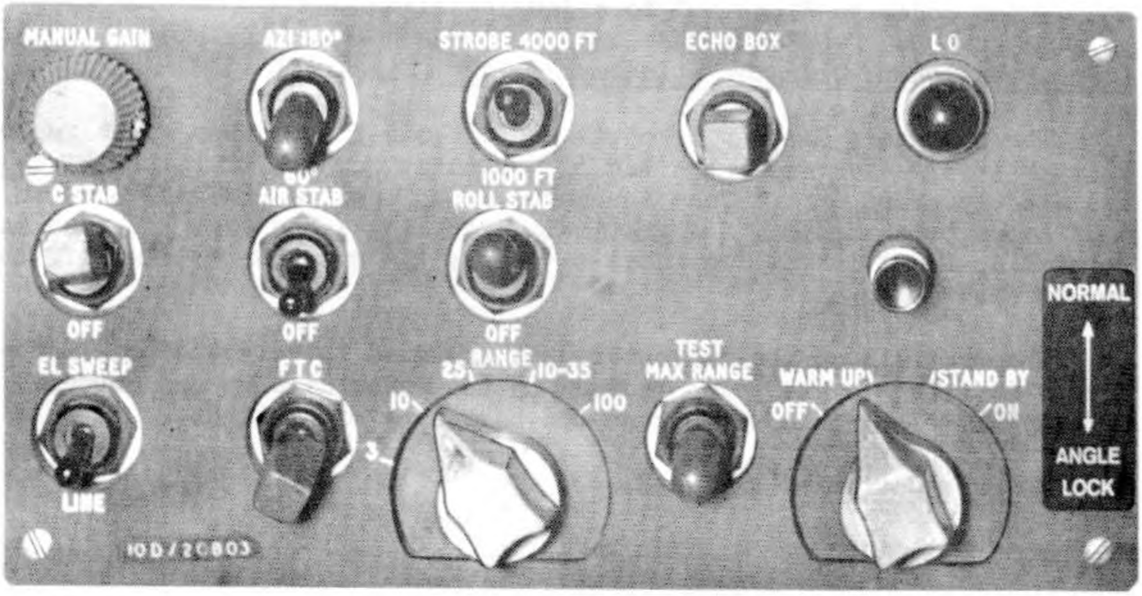


FIG. 1—3 CONTROL UNIT

(2) Lock Demand

When range strobe and P.P.I. marker are through the aircraft contact the 'Lock Demand' trigger is pressed and the radar 'Locks-on' to the target.

(3) Clutch

When full left/right movement has been obtained on the joystick, further movement can be obtained by depressing the clutch. This disconnects the steering mechanism and the joystick is free to resume its original position.

b. Control Unit (Fig. 1-3)

Those controls which are only used at intervals are assembled on the control unit, situated below the indicator unit.

(1) Manual Gain

The gain should always be selected fully right.

(2) Azimuth 180/60

Determines whether the P.P.I. presentation is 180° or 60°.

(3) Strobe 4000/1000

Should always be selected to 4000.

(4) C-Stab/Off

Selects the C-Scope display to be either stabilised or to aircraft axes: the display is to aircraft axes when selected off. Normally selected to C-Stab.

(5) Air Stab/Off

Should always be selected off.

(6) Roll Stab/Off

Enables the operator to remove Roll Stab if a fault should develop. Normally selected to Roll Stab.

(7) Elevation Sweep/Line

The operator may select two line scan giving 8° elevation coverage or line scan giving 2° elevation coverage. Line scan is normally used for A.I.

(8) F.T.C./Off

When selected helps to break up clutter returns.

(9) Range Selector

Ranges available are 3, 10, 25, and 10-35 miles for A.I. use and 100 miles for ASV use.

(10) On/Off

See switch on procedure.

(11) Echo Box/Test Max Range

Used for performance evaluation.

(12) Normal/Angle Lock

Enables the radar to "lock on" to jamming signals.

c. Scan/Park Switch

A scan/park switch is located just forward of the joystick. It should be selected to scan during pre flight checks and selected to park during shut down checks.

104. Switching Procedure

a. Both engines running - generator warning lights out.

b. Switch from OFF to WARM UP - the stand by invertor supplies are connected to radar.

c. Switch from WARM UP to STAND BY - $2\frac{1}{2}$ to 3 minutes later the presentation appears and the scanner commences to scan.

d. The final selection, which can be made any time thereafter is from STAND BY to ON - this starts the transmitter and the radar is then fully operational.

N.B. When the aircraft is on the ground the radar should not be selected to STAND BY or ON for longer than two minutes otherwise overheating will take place. If take-off is delayed it is therefore necessary to revert to WARM UP and, once this is done, the STAND BY condition cannot be regained until a further 3 minute delay has elapsed.

e. To switch the radar off the on/off switch should be rotated anti-clockwise, taking care, at the same time, to depress the 'on' lock button located just above the switch.

CHAPTER 2

AIRBORNE INTERCEPTION TECHNIQUE

201. Introduction.

The object of A.I. is to intercept enemy aircraft at maximum range from the fleet and destroy or cause them to evade before they can initiate an attack.

The interception is initiated by the Direction Officer who controls the Fighter from the deck or from a C.A.P. station into a position so that an interception can be carried out. Once the Observer is 'JUDY' with the target on A.I.18R Radar, he assumes control of the interception.

It is the Observer's responsibility to maintain a clear and concise commentary thus enabling the Pilot to develop a mental picture of events when he is not visual with the target. The Observer also gives executive orders for any alterations in height, heading or speed to manoeuvre the fighter into a murder position. These orders should be given positively and obeyed instantly.

To ensure that the Observer knows that the pilot has executed his orders, the pilot repeats back all orders. Likewise the pilot should keep the Observer informed of the aircraft's rate of turn, speed and whether climbing or descending.

202. Codewords.

R/T Codewords used between the Fighter and the Direction Officer are:-

ANY JOY	- Used by Direction Officer to check if the aircraft has A.I. or visual contact.
NO JOY	- Used by the pilot to inform the Direction Officer that no contact has been gained.
CONTACT	- Used by the pilot to inform the Direction Officer that A.I. contact has been obtained. The Direction Officer still has full control of the interception.
VISUAL	- As above but contact is purely visual.
JUDY	- Used by the Fighter to indicate that a positive contact has been obtained on the target, the Observer now has full control and no further assistance is required. The Direction Officer will monitor the interception but will not assist until asked to do so.

TALLY-HO-POUNCE	-	As above but the pilot has visual contact only and is making an attack as a day-fighter.
MURDER	-	A kill has been obtained under A.I. radar attack.
SPLASH	-	As above by day-fighter attack.
MOREHELP + HEADING	-	Indicates that contact has been lost and further assistance is required from the Direction Officer.
WEAPON BENT	-	Indicates that the A.I. radar is unserviceable. (All interceptions will be Direction Officer controlled until visual contact is gained.)
WEAPON FLASHING	-	Indicates that the A.I. radar is serviceable.
GADGET BENT	-	Indicates that the Direction Officer's G.C.I. radar is unserviceable.
IN THE DARK	-	Indicates that the Direction Officer has temporarily lost radar contact with the Fighter.

203. Fighter Interception Conditions

a. High Level Unless otherwise stated, all figures assume a Fighter height of 40,000 ft., speed 0.85 I.M.N. and a standard turn using 45° angle of bank. This will give a radius of turn of 4 n.m.

b. Low Level During training a Fighter height of 1,000 ft., speed 300 knots I.A.S. and 45° angle of bank are used. This gives a turn of radius 1½ n.m.

204. Murder Positions

a. Missile Murder Astern of the target, within the following "Firestreak" limits:-

Azimuth	-	within 20° of target's stern. (i.e. 40° cone)
Elevation	-	within 2,000 ft of target's height.
Range	-	within 1-1½ miles of the target.

b. 2" Murder Astern of the target, within the following limits:-

Azimuth	-	astern of the target (with at least 3 seconds steady tracking).
Elevation	-	same as the target.
Range	-	within 500-1000 yards of the target.

205. A.I. Orders

a. Horizontal Plane

GO PORT/STBD.	- 45° angle of bank
PORT/STBD. HARD	- 60° angle of bank
PORT/STBD. GENTLY	- 30° angle of bank
PORT/STBD. VERY GENTLY	- 15° angle of bank
STEADY	- Roll out and maintain that heading
HARDER	- Add 15° angle of bank
EASE	- Take off 15° angle of bank

b. Vertical Plane

GO UP/DOWN	- 2,000 ft/min
UP/DOWN GENTLY	- 1,000 ft/min
LEVEL OFF	- Level off and maintain that altitude

c. Speed

MORE SPEED	- Full throttle to gain 0.05 M.N/20 knots
THROTTLE BACK	- Speed off (amount or to a speed)
FULL THROTTLE	- Put on 100% power
THROTTLE RIGHT BACK	- Close throttles, airbrake out
HOLD THAT SPEED	- Maintain the present speed (i.e. Cancels 'Full throttle' and 'Throttle Right Back')

Note:

(1) All the orders in a, b and c above are totally independent and do not affect the other dimensions. (e.g. During turns, maintain height and speed).

(2) If it is impossible to obey two orders simultaneously e.g. 'Port as hard as you can go' and 'Go up' the order of priority is:-

(a) Achieve the turn

(b) Achieve the speed and lastly

(c) Achieve the height

206. Amplifying Orders

The following orders, less often used, involve more than one dimension.

HARD AS YOU CAN GO	- Turn with as much bank as you can hold, if necessary losing height to maintain speed.
CLIMB	- Gain height as fast as possible without losing airspeed.
DIVE	- Lose height as fast as possible without gaining airspeed.
PULL UP	- Gain height as fast as possible, allowing airspeed to fall back to a minimum of 180 knots I.A.S.
BUSTER	- Increase speed to maximum .96 M using full throttle and diving initially; then holding this speed regain original altitude if possible.

207. A.I. Commentary

a. Observer's Commentary

Standard indications are given to the Pilot in the following manner:-

LEFT/RIGHT and not PORT/STBD

ABOVE/BELOW and not UP/DOWN

BEARING is given in degrees Left or Right: RANGE is nautical miles and ELEVATION in degrees Above or Below.

e.g. 'Left thirty - Fifteen - Three above'.

The word 'Range' may be used to avoid confusion, where range and bearing are the same.

e.g. 'Left ten, Range ten'.

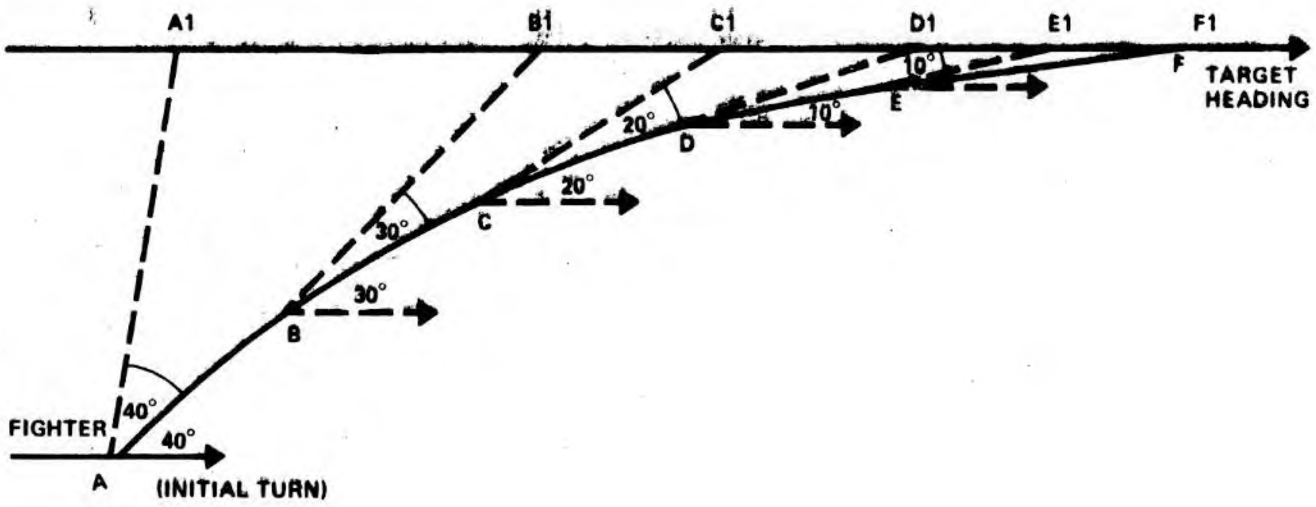


FIGURE 2–1.

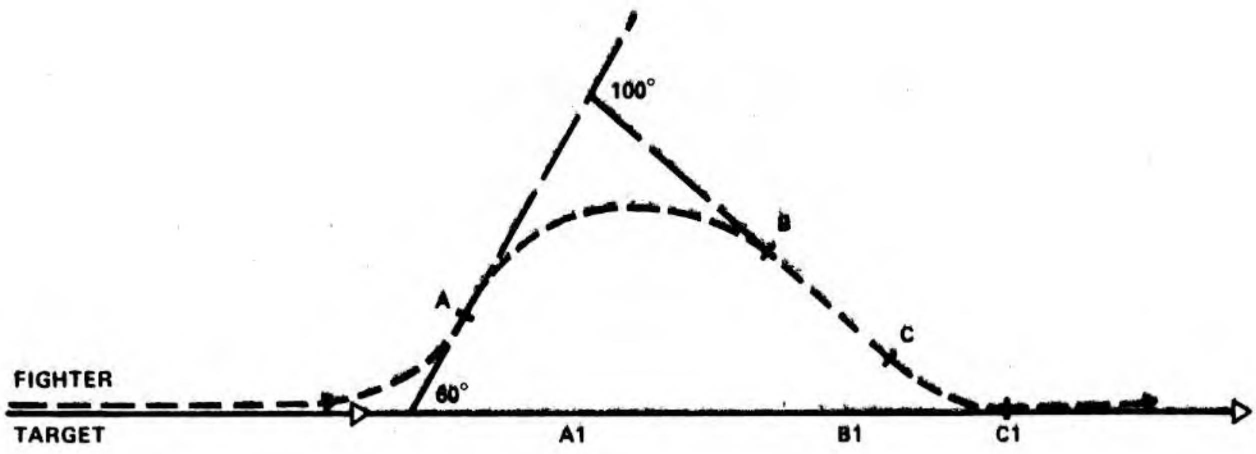


FIGURE 2–2. OVERSHOOT PROCEDURE

Elevation in feet is best assessed by applying the '1 in 60' rule at a convenient range. e.g. 10 miles.

(Elevation in degrees x Range in miles = Height in 100's feet)

b. Pilots Commentary

It is vitally important for the Pilot to keep the Observer informed throughout an interception. This is achieved by:-

(1) Repeating back orders.

(2) Giving degrees to go to Target heading.

(3) Reminding the Observer of orders being executed.

Degrees to go to Target heading should be given every 30° but every 10° during Displacing and Converging turns.

e.g. '150 to go, going Port hard, going down gently'

208. Achieving the 'Murder' Position

As a rough rule, when converging into a 'Murder' position from a parallel heading (e.g. after a blind turn or an overshoot procedure), a hard turn towards the Target through half the Target's "angle off" should be made.

This will close the range and bring the target towards the centre line.

Lead is maintained by subsequent gentle turns back towards Target heading, such that:-

Target's angle off = degrees to go to Target's heading.(Fig. 2-1)

Should the Target close to "murder" range before the Fighter is within the "murder" zone (i.e. by applying too much lead too early) a turn should be made to bring the Target onto the centre-line. Subsequent turns are then made to hold the Target on the centre-line, keeping the range constant. This is to give maximum opportunity for missile acquisition.

209. Overshoot

a. Overshooting

An overshoot should be ordered at any time the fighter approaches close to the target with excessive overtaking speed. It may also be used, in preference to 'S' turns, to allow a slow target to open range. i.e. when rolling out too close to the target.

b. Overshoot Procedure (Fig. 2-2)

At the order 'OVERSHOOT PORT/STBD' the pilot turns hard through

60^{o} in the direction ordered and then reverses into a standard turn through 100^{o} in the opposite direction. This will then put the fighter into a position where a normal converging intercept may be carried out.

During this procedure the observer will lose contact with the target. Contact may be quickly regained when on a closing heading if care is taken to change to 180^{o} scan on the 10 mile range scale and target elevation is allowed for.

c. Very Slow Targets at Low Level

To allow a very slow target to open range the best procedure is to carry out a complete orbit.

210. Catching Up

Should the fighter roll out too far astern of a target which is high and at or near the fighter speed, the recommended procedure for catching up is as follows:

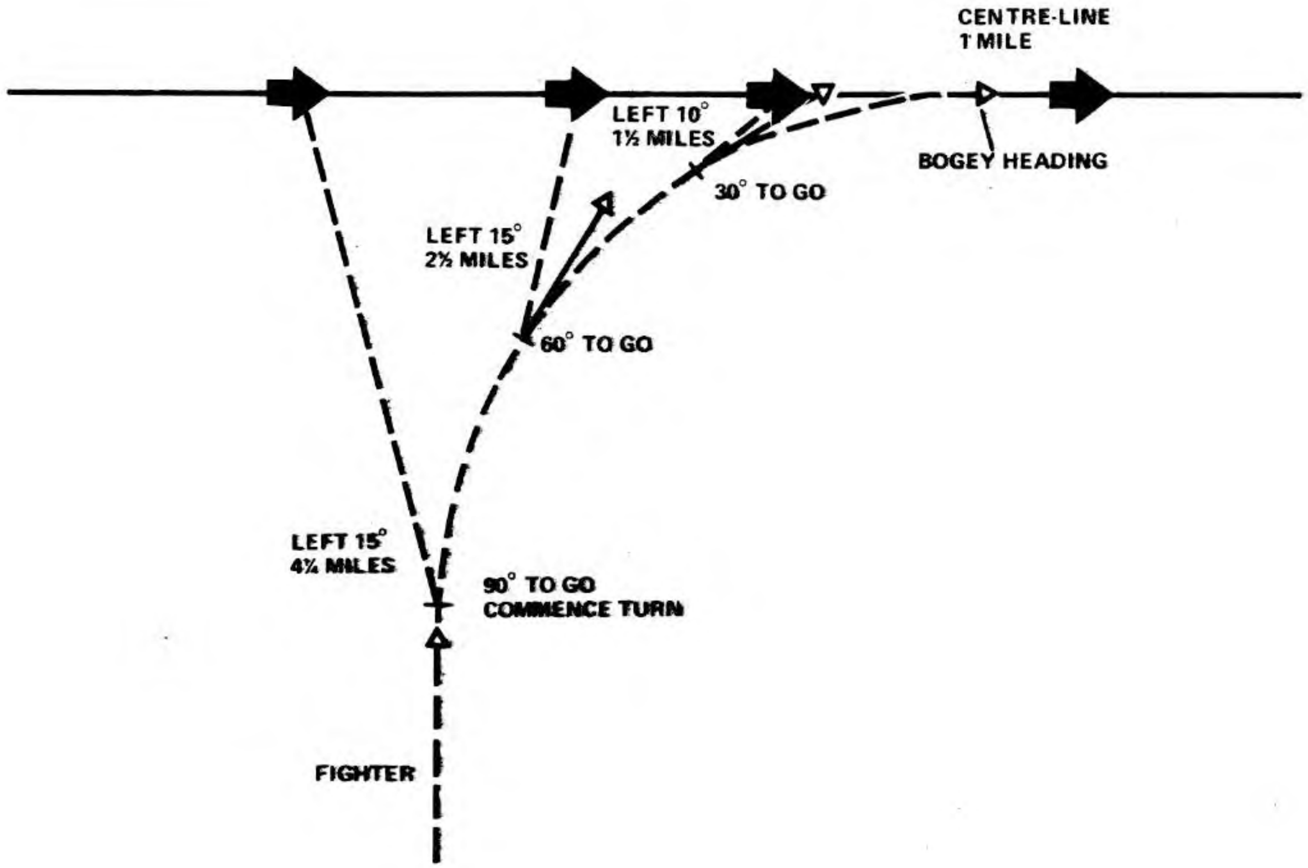
GO BUSTER. At 1 mile pull up to enter the range bracket.

211. Evasion

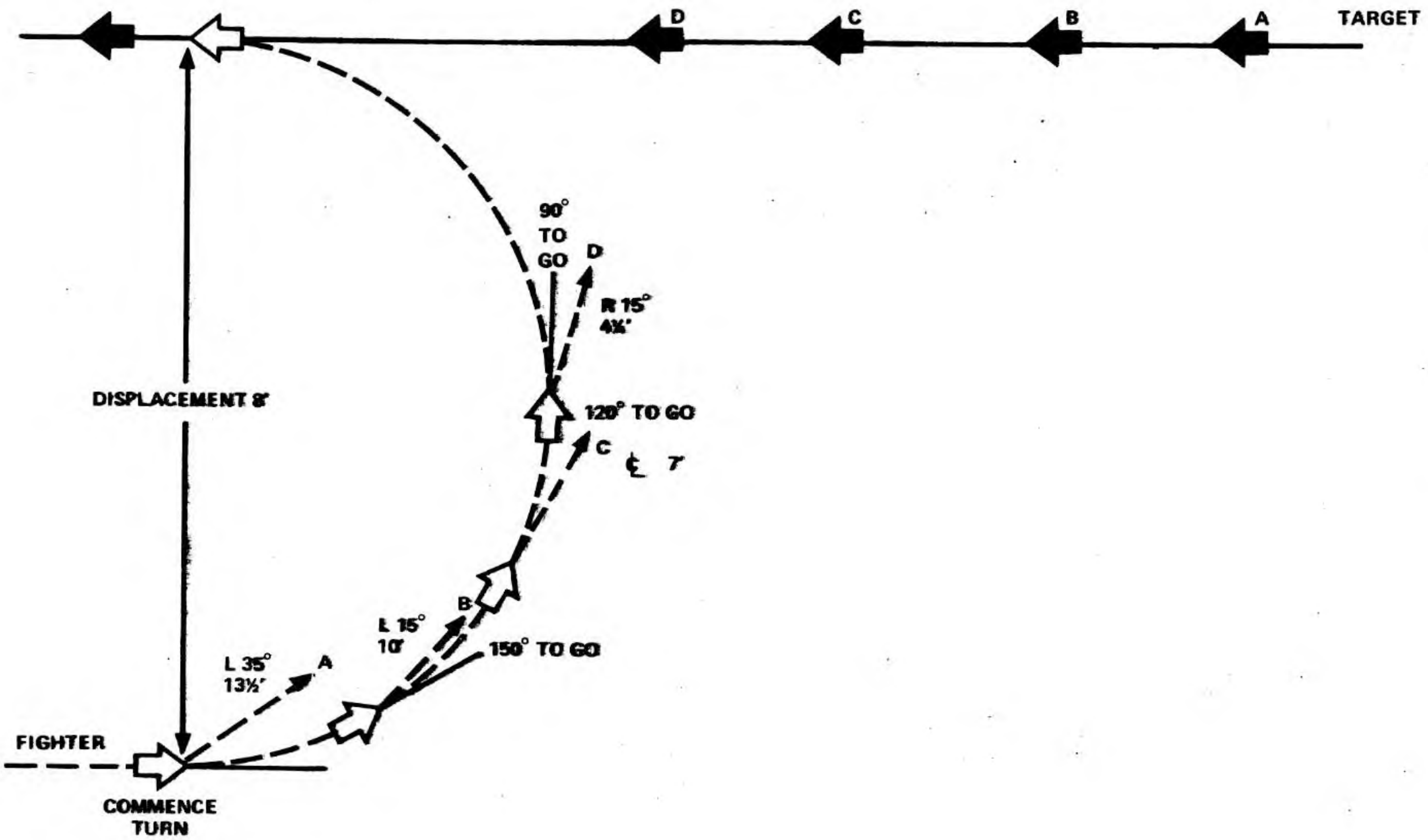
Evasion may be used by a strike aircraft irrespective of whether it has a fighter astern. In general, assuming that a strike aircraft really wants to reach its target, any evasion or weave will have an axis which is readily assessed - i.e. the bearing of the target from the strike aircraft.

Providing the fighter can achieve a quarter position, contact on the strike aircraft is easily maintained and range can be adjusted by positioning the fighter on the outside or inside of turns.

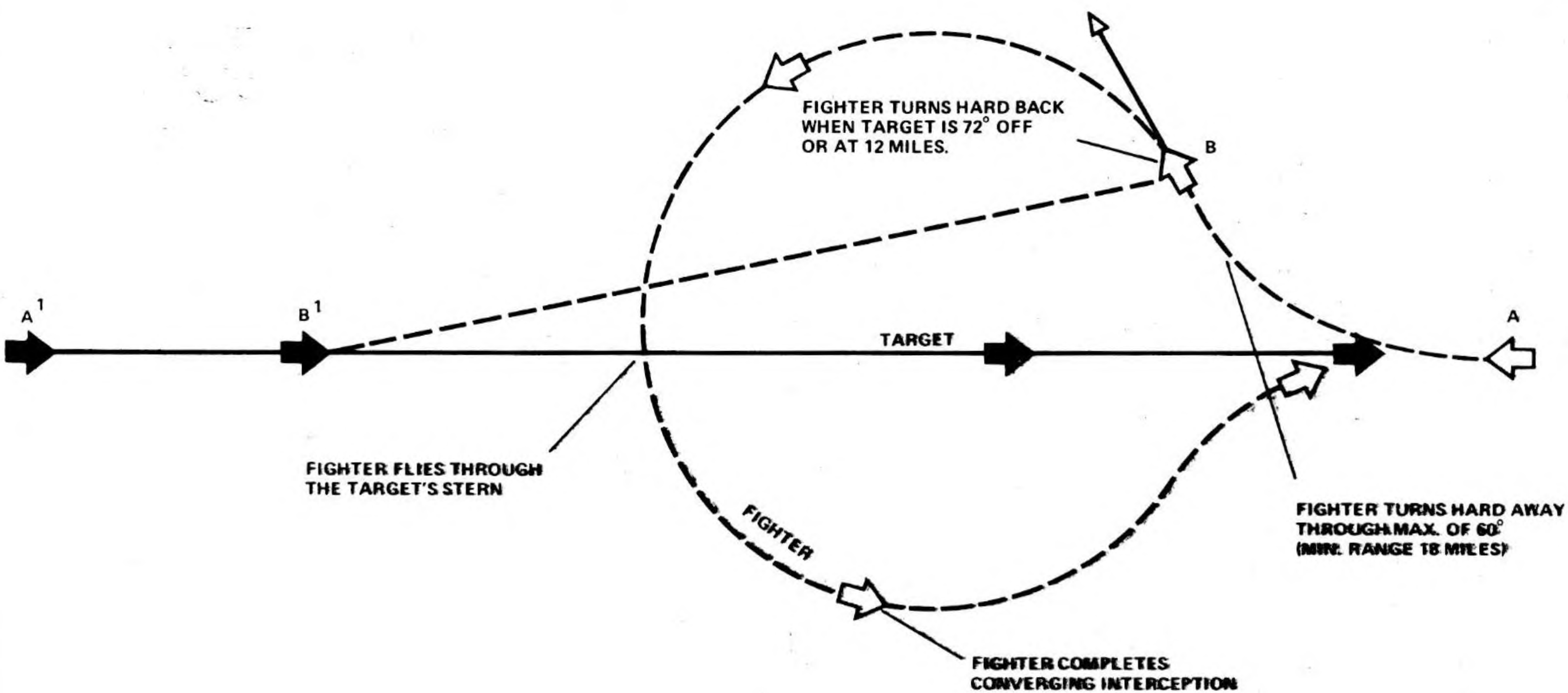
Using Firestreak care must be taken to avoid large angles off, since this will reduce the chances of missile acquisition. A murder is easiest gained during a reversal, when a longer period for acquisition exists.



APPENDIX A FIGURE 1. STANDARD 90° INTERCEPTION



APPENDIX A FIGURE 2. STANDARD 180° INTERCEPTION



APPENDIX A FIGURE 3. NIL DISPLACEMENT 180° INTECEPTION—LONG RANGE PROCEDURE

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and I burnt it when 899Sqn disbanded and our Sea Vixens
went to bone yards or Llanbedr as Radio Control targets,
back in the days of the Cold War and it all seemed so important
not to let on that such facts as that when it came to the crunch,
2”R/P were the weapon of choice in A/A against a Mig21!
Don’t believe me? Talk to me about the Island of Lesser Tunb
in the Persian Gulf, 1971

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CHAPTER 5

ROCKETS

501. 2" R/P

Aiming the 2" rocket to hit an airborne target is a problem that has not yet been fully resolved.

502. PAS

The PAS is unable to compute the lead required.

503. Fixed Ring Lead

It is possible to set up a fixed ring sight presentation, and fire on World War I and II ring-and-bead principles.

This is an improvement on the PAS solution to the problem, but is also unsatisfactory.

504. Practical Sighting

Achieve as near a line astern position as the tactical situation allows at close range. 250 yards is the minimum range to allow rocket fuse arming.

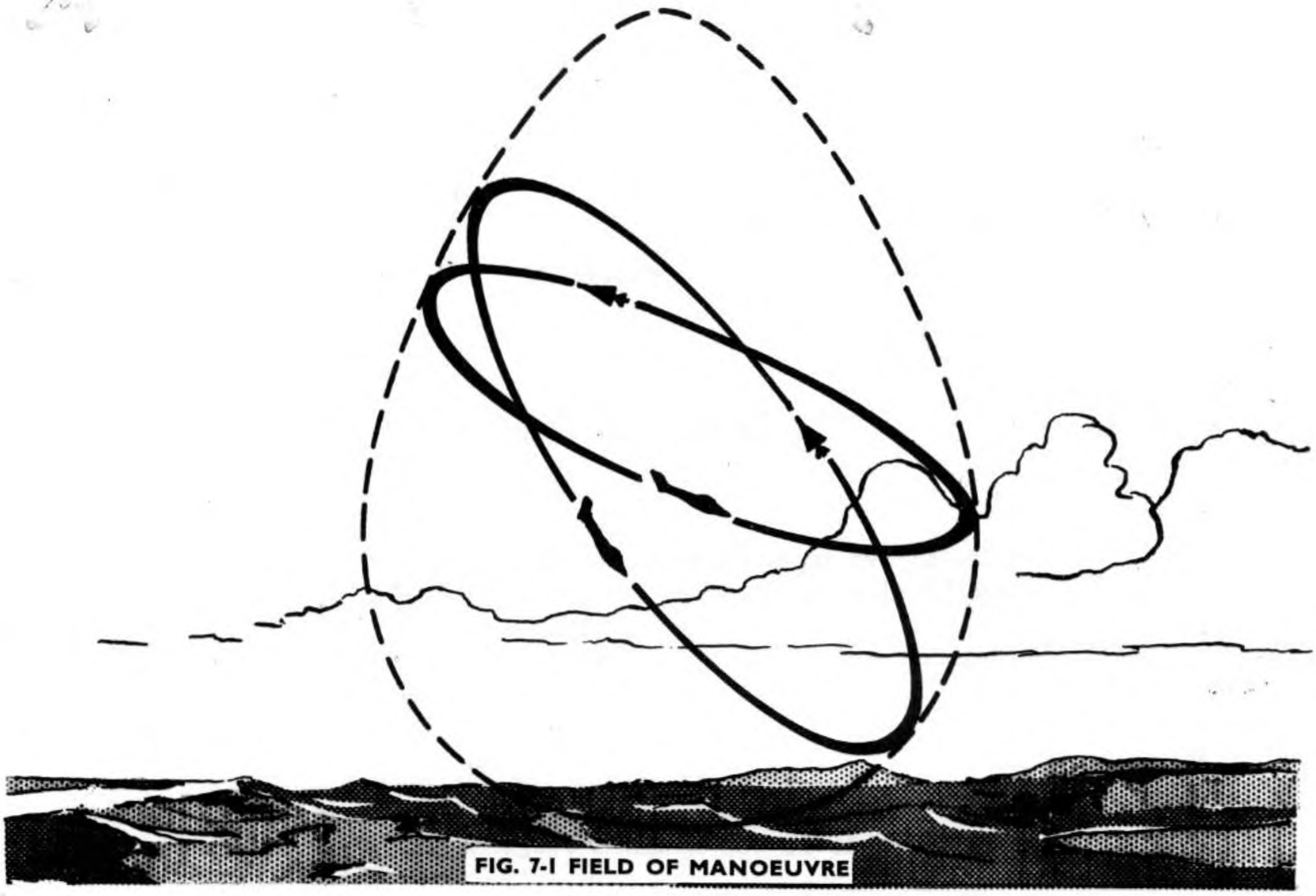

FIG. 7-1 FIELD OF MANOEUVRE

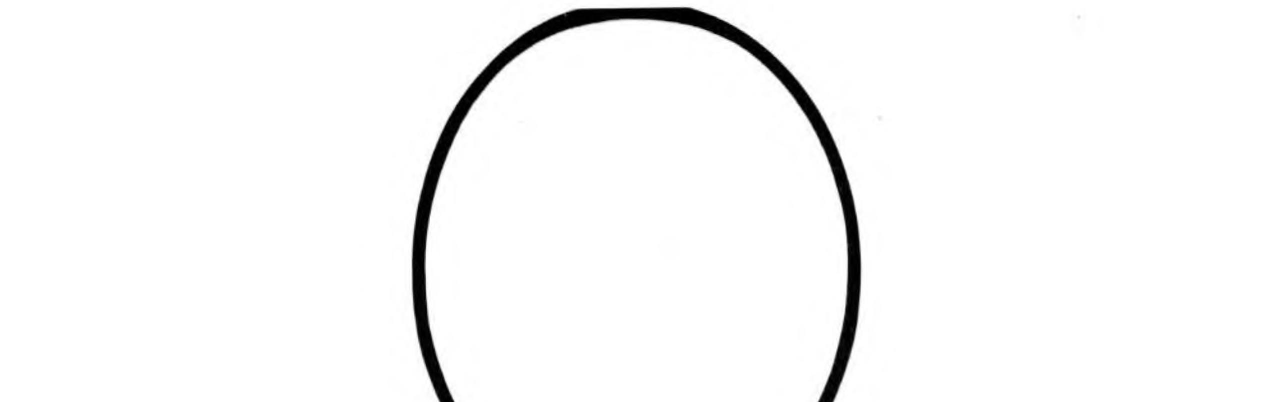

FIG. 7-2 LOOP

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went to bone yards or Llanbedr as Radio Control targets,
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CHAPTER 7

FIGHTER COMBAT

701. Introduction

It is not possible to lay down a hard and fast set of mandatory rules and actions to cover every combat engagement. It is necessary to acquire an understanding of the principles of combat that have been evolved from previous experience and apply them in practice. A lot of the tactics used in World War I are equally effective today, but with advances in equipment and weapons new tactics continually have to be formulated to suit them.

Tactics must be:

Effective
Flexible
Simple

The sequence of events in a successful combat is:

Find and see the enemy - visually or by radar
Appreciate what he is doing
React and Attack accordingly

Basic Principles, Definitions and Rules

702. Field of Manoeuvre

In fighter combat it is a widely held belief that there are an infinite number of situations and solutions in a tactical encounter. While it is true to say that most encounters are unique, and each engagement differs from any other, the same principles of offence and defence apply to them all and they all take place in a field which is three dimensional and finite.

The size and shape of the field is determined by the effect of 1G gravity and the performance limitations of the aircraft and pilot. The field may be imagined as spherical shaped with an elongated northern hemisphere - egg-shaped (Fig. 7-1).

The spherical shape is generated by a manoeuvering fighters turn and speed operating in 3 dimensions, and the elongation results from the effect of 1G gravity on the fighter in this 3 dimensional field of manoeuvre.

A loop flown at a contant applied G and constant speed demonstrates this in two dimensions (Fig. 7-2). To fight his aircraft to the best advantage, an attacker need only visualise turn speed and G projected on to this spheroid shape. Although the pilot has no control over the force of gravity he can exercise complete control over aircraft turn and speed and as a result can so manoeuvre as to use the effect of gravity to his advantage.

With the present generation of long range guided missiles with an all round firing capability a close combat dog-fight situation may never arise - an opponent may not even know he is menaced until the missile impact puts him in and out of the picture. Not all potential enemies are equipped with weapons of this sophistication and many have to rely on closer range weapons capable of being fired in the opponents rear hemisphere only. It is in these circumstances that the principles of fighter combat primarily apply.

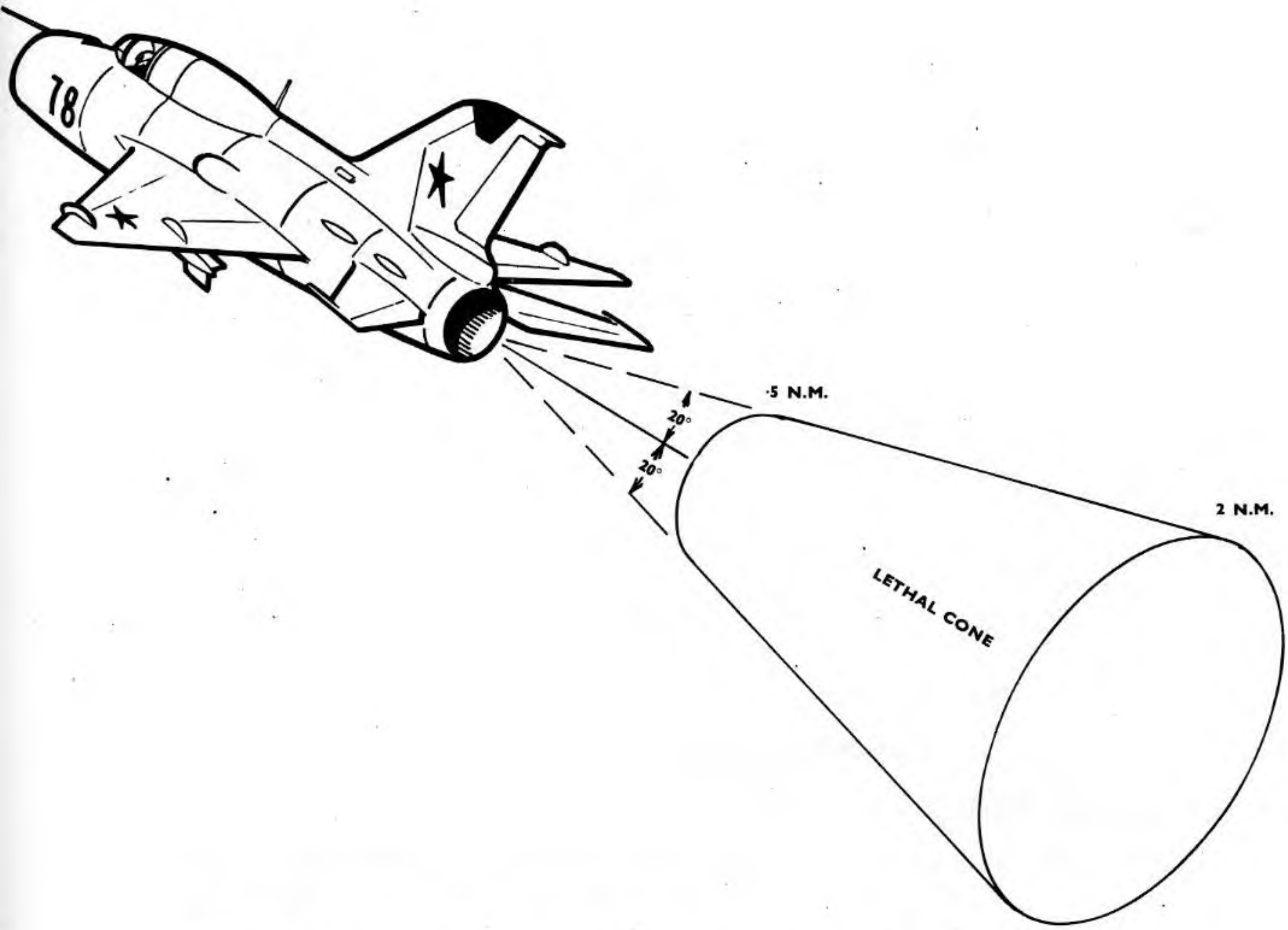


FIG. 7-3 LETHAL CONE IN RELATION TO A HYPOTHETICAL I.R. SENSING G.W.

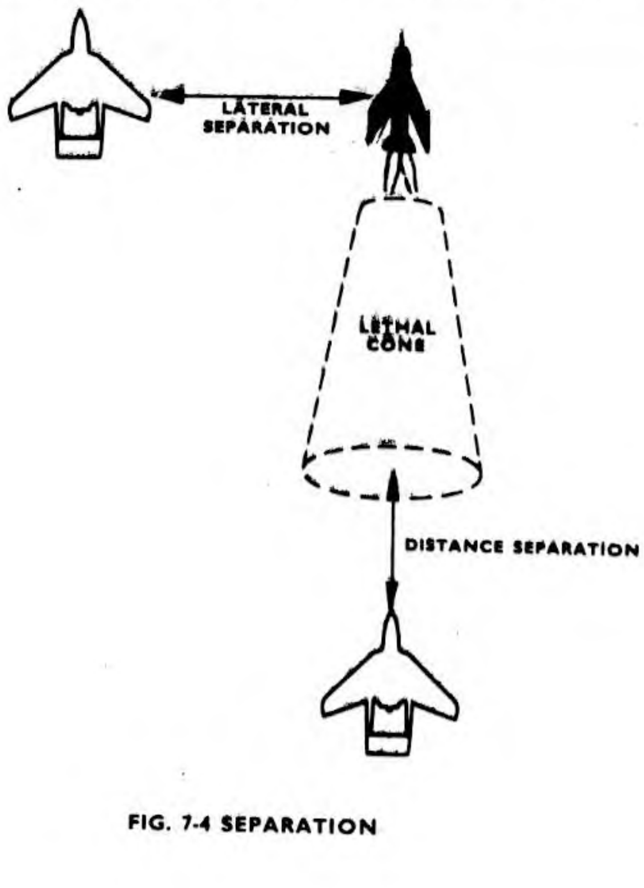


FIG. 7-4 SEPARATION

703. Lethal Cone (Fig. 7-3)

To destroy an enemy the attacker must achieve a position relative to the target within the range and angle off capabilities of the weapon system employed.

For the less sophisticated types of armament this may be imagined as a cone of lethality astern of the target.

704. Separation (Fig. 7-4)

There are two ways of achieving safety from an attacker.

a. Distance Separation

By remaining outside an attacker's firing range brackets, safety is achieved. Therefore the attacker must not be allowed to penetrate the lethal cone along the target's fore and aft axis.

b. Lateral Separation

By remaining outside an attacker's weapon angle off capability safety is also achieved. In the simplest case of a gun-armed attacker with a maximum firing range of 1,000 yards for example, if the attacking aircraft is at 300 yards, but on the beam, safety is achieved by means of this lateral separation.

705. Speeds for Best Rate and Radius of Turn

a. Introduction

The manoeuvring performance of an aircraft depends on the following:-

(1) Maximum thrust.

(2) Maximum usable G - Limited by buffet, structural G limit or pilot blackout.

(3) Controllability - Limited by lateral control, transonic effects or pilot strength.

For a particular aircraft these parameters dictate optimum speeds for turning performance.

b. Level Turns

In a level turn at constant speed, at a particular height and weight a unique speed exists for maximum rate of turn and a slower speed for minimum radius of turn. These speeds depend on the thrust available and the aerodynamic characteristics of the aircraft. For nearly all height/weight combinations the Sea Vixen is limited by the maximum thrust available because the maximum usable G cannot be sustained in level flight without loss of airspeed.

Optimum turning speeds exist for each weight/height combination but it is impractical for a pilot to perform such a feat of memory or to attempt continual adjustment. A compromise of 0.85 M/380 knots gives the best rate of turn for the Sea Vixen.

c. Combat Manoeuvring

Once engaged in fighter combat, level flight is seldom if ever sustained. However the level flight best turning speeds are also used in combat manoeuvring, but in addition a descent can now be used to assist thrust in maintaining 0.85 M/380 knots while pulling to the maximum usable G.

If in the Sea Vixen, at low altitudes, the maximum usable G is the structural limit (rather than buffet limit) the maximum rate of turn is given by the slowest speed at which the structural limit G can be obtained. At high altitudes, Mach Numbers much above 0.85 M result in transonic drag rise, buffet at lower G values and less effective elevator control, all of which severely reduce the manoeuvre capability. Speeds below 0.85 M result in less available G.

By climbing and then rolling on more than 90° bank, the wing no longer supports the weight of the aircraft and all the usable G can be used to turn. The reduced speed at the top of a yo-yo for example also results in a smaller radius of turn and may allow the use of flap to increase the maximum usable G.

d. Conclusions

Best rates of turn in the Sea Vixen are obtained by using 0.85M/380 kts.

In combat manoeuvring use the maximum obtainable G at 0.85M/380 kts.

For minimum radius of turn use the maximum obtainable G at a slower speed.

706. Plane of Attack

Always turn into the plane of the attack. This gives the attacker the maximum angle-off problem. If the attacker comes in high pull up into the attack, if low dive down into it.

707. Fuselage Lines

Matching fuselage lines with an opponent prevents him taking the initiative. For example, in a low speed yo-yo when he starts diving to gain speed, dive at the same angle keeping fuselage lines matched and follow his pullup by the same method; at the end of the manoeuvre the relative positions will be least changed. If you initiate a manoeuvre to gain the advantage and your opponent matches fuselage lines the same way, a stalemate ensues, and it will then be necessary to manoeuvre so as to break the stalemate such as opening for a re-attack.

This is a somewhat negative form of manoeuvre, but there are occasions where it can be useful.

Figure 705-1

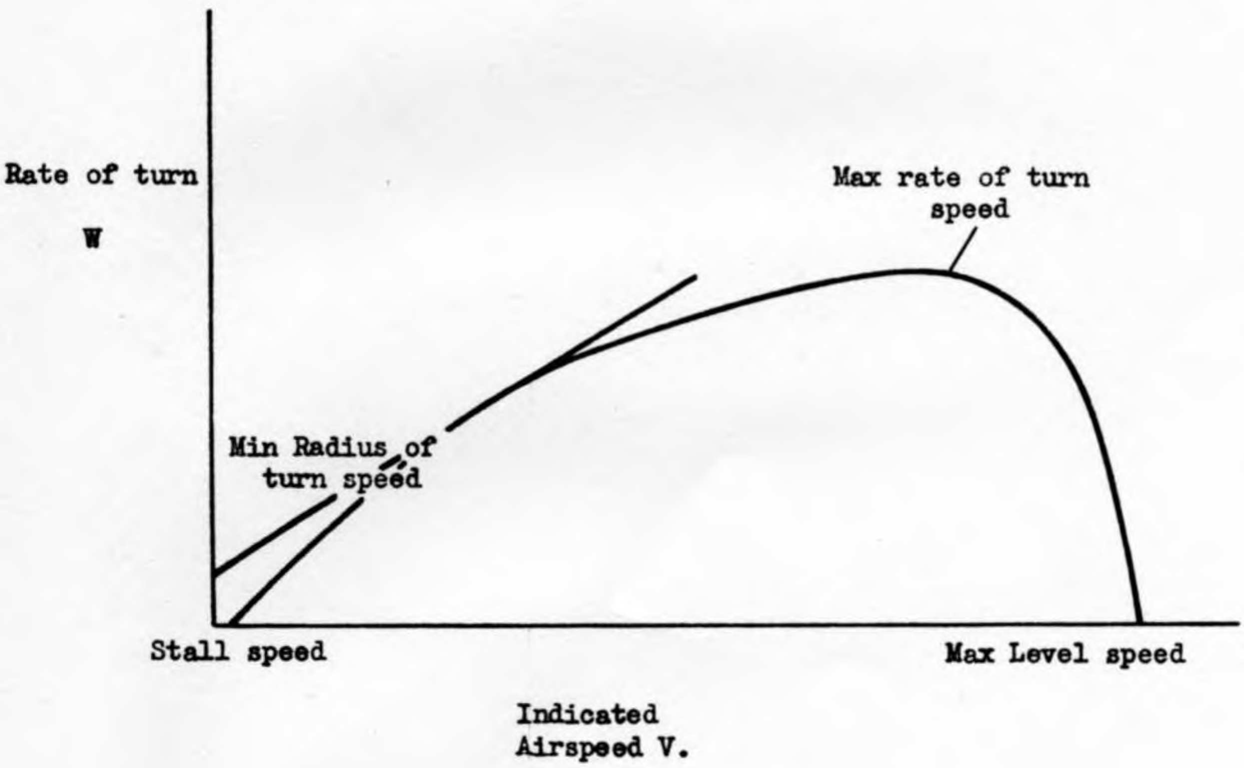
If the level turning performance is plotted as shown, it is an observed fact that a curve of general shape as shown results.

Radius of turn $R = \frac{V}{W}$

For minimum Radius $\frac{V}{W}$ must be a minimum

This occurs where the tangent touches the curve at a speed below maximum rate of turn speed.

LEVEL TURNS AT FULL POWER - RATE V. SPEED



708. Turn Reversal

Reversing a turn from one direction to another means that at one stage of the reversal the aircraft is flying straight and level with no rate of turn. In a close combat situation this is a position of disadvantage particularly when on the defensive and an alternative is the high G barrel-roll. Employing this manoeuvre enables the direction of turn to be changed while still maintaining a continuous rate of turn, with obvious advantages. A further use of this manoeuvre is covered later.

709. Change of Direction

The quickest method of changing direction from North to South is by a half aileron roll in the vertical plane (90° climb or dive).

710. Conservation of Energy

Height can always be converted to speed and vice versa. Never kill or throw away either, always convert (except in exceptional circumstances e.g. Scissors).

711. Rudder

When slow, use rudder with aileron to initiate turns and to maintain balanced flight.

712. Spin

a. An aircraft will not stall under zero G conditions.

b. To spin, an aircraft must be stalled.

c. Intentional spinning is prohibited.

d. Unintentional spinning is a sure sign of a ham handler.

e. Know the spin-recovery techniques - they are in Pilot's Notes, but you won't have time to refer to them once you are spinning.

713. Sun

Use the sun to advantage.

714. Contrails

Always fly above or below contrail levels, never in them.

715. Weapon Lethality Zones

The following is a guide to the probable weapon performance characteristics of present day fighter aircraft.

a. Guns

A lethal cone of 30° semi angle off the target's tail out to a range of 1,000 yards.

A counter should be initiated before the gun-armed fighter approaches the cone, and a break to prevent him entering or when he is inside it.

b. Guided Weapons

Depending on the type of weapon and its degree of sophistication these have an all round capability out to about 16 miles reducing to a stern cone of approximately 30° semi angle out to 2 miles only for the simplest missile.

They may use either passive, command, beam-riding, semi-active, or active homing, guidance systems. As far as is known the passive use only the infra-red seeking principle.

Intelligence should indicate the type of weapon with which the enemy is likely to be armed, and tactics should be formulated largely on this basis.

716. Basic Countermeasures to Ahead Sector Guided Weapons

On detecting or sighting an enemy aircraft which intelligence suggests may be armed with ahead sector weapons the possible countermeasures are:-

a. If it is certain that the enemy is well outside his maximum missile firing range turn away and dive to the sea or ground.

b. If it is not certain that the enemy is outside his maximum missile firing range turn towards the threat and dive to the sea or ground to prevent the enemy's radar holding lock.

c. Close the throttles to prevent I.R. homing and fuzes functioning.

d. Dive through cloud to reduce I.R. and possible radar performance.

e. If the enemy is moving into a position that will shortly enable him to fire a weapon get into close combat to prevent him breaking away for an attack.

717. Basic Countermeasures to Astern Sector Guided Weapons

The limitations which affect the enemy's ability to fire a lethal round in the astern sector are:-

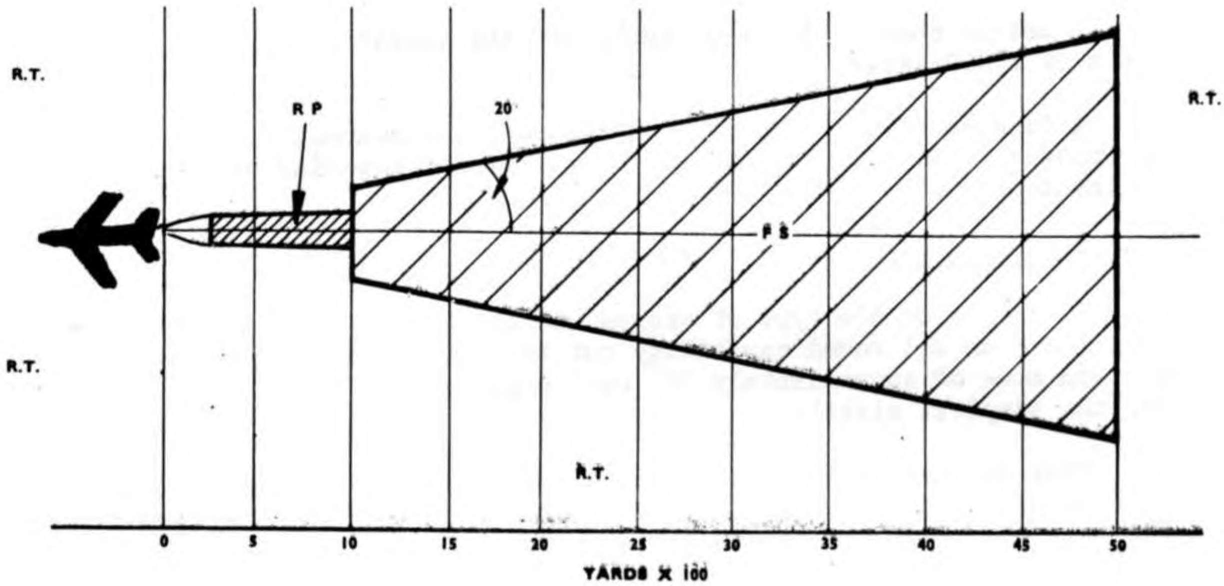


FIG. 7-5 SEA VIXEN WEAPON FIRING ZONES

a. Range.

b. Angle Off. The area behind an aircraft in which an I.R. weapon can detect a high temperature source forms a cone. The hotter the temperature source, or the more advanced the weapon, the larger the limits of the cone will be.

c. Crossing Speed. A high crossing speed may cause the attacker or the missile or both to exceed their manoeuvre limitations.

718. Rules of Thumb for Use Against IRGW Armed Fighters

If an IRGW armed enemy is sighted anywhere inside a range of 6 miles a counter towards should be made.

If sighted anywhere in the rear hemisphere inside 2 miles a break should be made.

Both to be called for missile, (e.g. "Missile counter starboard go") and made throttles closed to reduce IR radiation.

719. Sea Vixen Weapon Firing Zones (Fig. 7-5)

a. 2" R/P

From 250 yds to 1,000 yds in near line astern, but see Chapter 5.

b. Red Top

From approximately 1,000 yards. See firing zone diagrams, Chapter 3, for details.

c. Firestreak

From approximately 1,000 yards to 5,000 yards in a cone of 20° semi-angle off the target's tail.

DEFENSIVE

720. Introduction

The approach to fighter tactics may appear to be defensive in nature by starting with the defensive turn. However this is not so because any offensive action depends directly on the manoeuvre which the defendant executes, and this is the basic manoeuvre by which the defender aims to nullify an attacker's advantage.

721. Defensive Turn

There are two basic defensive turns.

a. Counter

A counter should be initiated as soon as the enemy is seen in a threatening position and should be maintained sufficient to keep him at a high angle off outside the lethal cone that he cannot solve the tracking problem. Speed and height are maintained by the use of increased power, and the rate of turn is such that divisional integrity should be maintained.

b. Break

Is used when the enemy is about to enter (or has entered) the lethal cone either through late detection, or when by reason of superior performance he is able to maintain his threatening position after a counter.

The execution of the break should be immediate, with application of full power and rudder to enter a maximum rate turn into the plane of the attack. Divisional integrity may be lost but sectional integrity should be maintained.

At long range the rate of turn required for the enemy to track is considerably less than the Vixen's, since he is in a pursuit curve attack and his rate of turn is a function of target speed and angle off, and closing rate increases with decreasing range.

Approaching gun range the enemy will attempt to reduce the angle off and slide into the six o'clock position. To prevent this the Vixen must increase G and rotate the lethal cone away from the enemy, acquiring a smaller turn radius than the enemy's. This will force the enemy outside the turn and prevent solution of his tracking problem. The fighter with the lower speed and/or greater G has the smaller turn radius. By reason of the attacker's greater closing speed which enabled him to attack in the first place, and by having to play his turn in respect to the Vixen to enter the lethal cone, his G will be less, which in turn means a reduced rate of speed decay and he will overshoot. This presupposes that the Vixen is turning at or near maximum rate. The enemy's overshoot provides the lateral separation that is a requirement for the Vixen's subsequent actions.

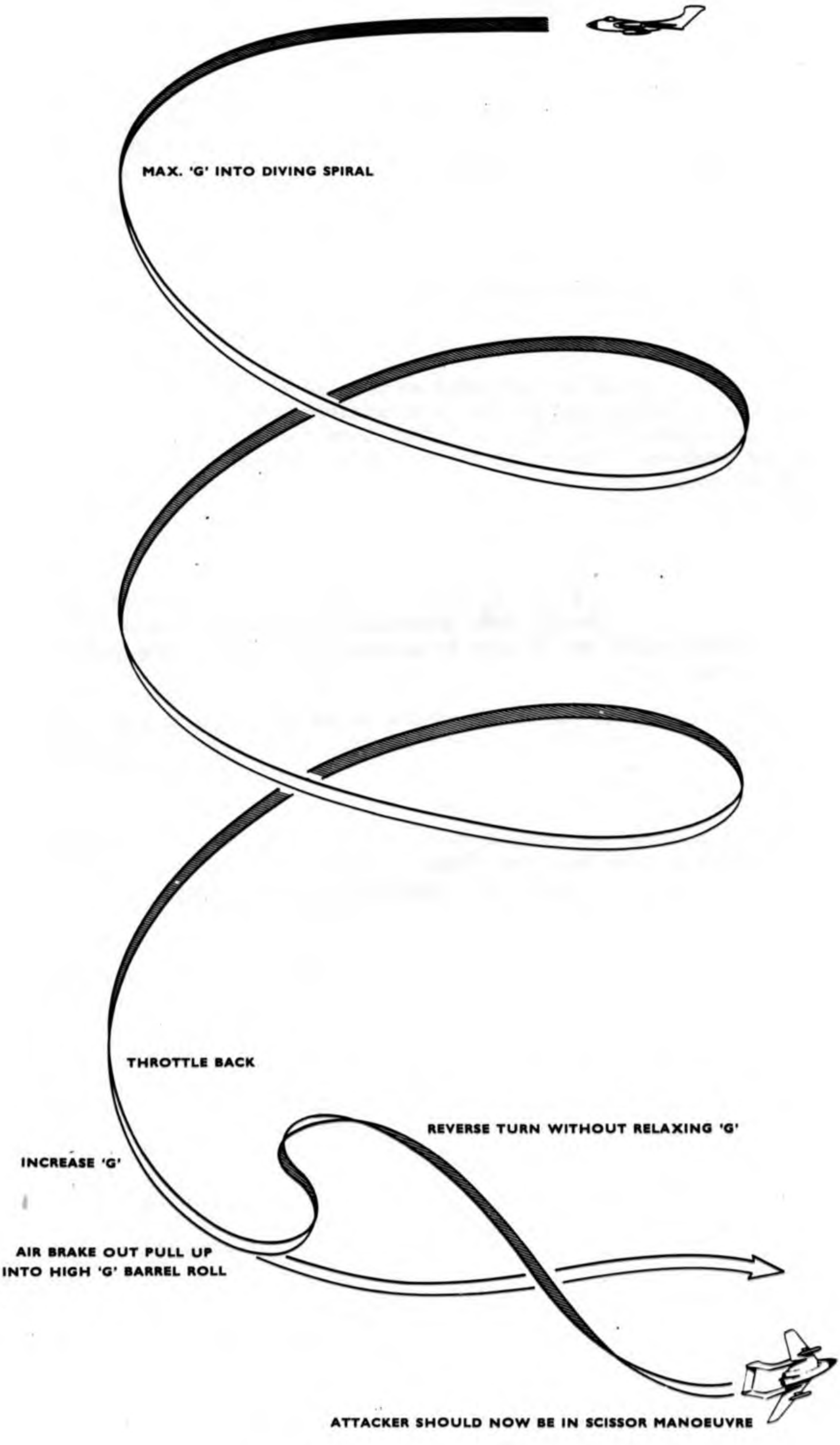


FIG. 7-6 THE LAST DITCH MANOEUVRE

722. Diving Spiral

If unsuccessful in forcing the enemy to overshoot and he hangs onto your tail the best protection with an aircraft at your six o'clock is a maximum rate turn using G. You need speed to get G - thus, the diving spiral. Keep the G's on and keep the nose down so you can keep enough airspeed on to make it difficult for the attacker. Try to watch the aircraft behind you. If you can see the belly of his aircraft, he is beginning to pull lead and may be about to fire. Tighten up your turn immediately.

723. The Last Ditch (Fig. 7-6)

This manoeuvre is used if an aircraft is at your six o'clock within range and close to your airspeed. The first essential is not to panic:-

a. Get your aircraft into a maximum G turn as quickly as possible, lowering the nose into a diving speed.

b. After 10,000 feet of this a half-hearted attacker may break off the attack or you may be able to dive into cloud. Near the ground you may be able to effect your escape by keeping up a hard weave at high speed as close to the ground as possible.

c. If in the spiral you find you still have an aggressive pilot on your tail, you may be able to get him to overshoot by throttling back at the same time trying to increase G.

d. As you reach idle, out airbrake and pull out and up into a high G barrel-roll, thus reversing your direction of turn without releasing any of the G's.

e. After about thirty degrees of this turn, reverse again, putting your attacker into a full scissor manoeuvre.

f. Even a good pilot should not appreciate the initial decrease in throttle as the increase in G will keep him the same distance behind.

g. Your selection of airbrake and high G barrel-roll should cause him to overshoot, thus giving you one essential in air to air combat - Lateral Separation.

Other alternatives may be used such as flying into cloud, bunting through the sun, rudder, unbalanced flight and frequent varying applications of G.

In the case of a tighter turning aircraft beginning to track in a low airspeed situation, an effective manoeuvre to gain separation and airspeed is to note the enemy's nose position, and as he starts to get the required lead (judged from the view of his belly) push forward to zero G maintaining the angle of bank that was held during the break. The enemy will be caught by surprise and his nose will shoot through giving excessive lead for tracking. Hold zero G and bank angle until the enemy reacts to correct the situation; during this time your aircraft is accelerating and separation is increasing.

As the enemy's nose starts coming back on aim, or he reverses to resolve the situation, the alternatives are:-

a. Increase G to maximum again in the original direction of turn to force an overshoot.

b. While still at zero G reverse bank angle and increase to maximum G in a turn in the opposite direction.

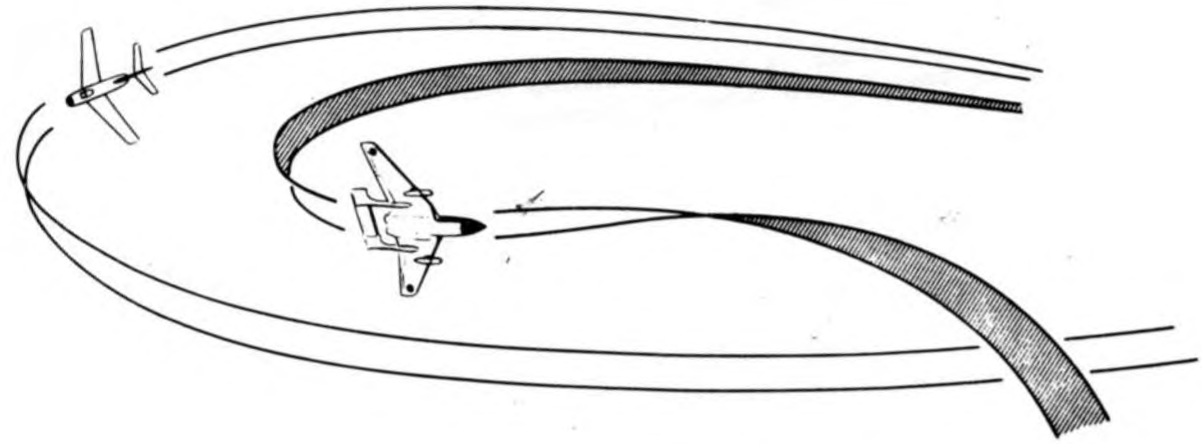


FIG. 7-7 CHANGING DEFENCE TO OFFENCE

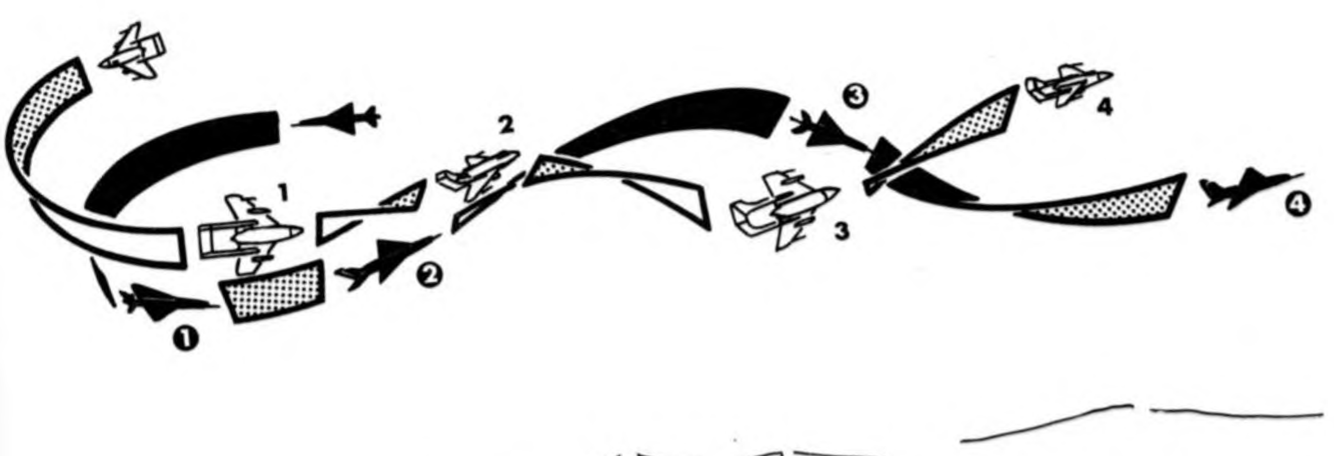


FIG. 7-8 SCISSORS

DEFENSIVE TO OFFENSIVE

724. Reversal (Fig. 7-7)

Turn reversal is the quickest way to go from the defensive to the offensive, and it is also the quickest way to get shot down if used at the wrong time - a statement worth reiterating.

725. Scissors (Fig. 7-8)

Having forced the enemy to overshoot in the break the Vixen reverses to gain the offensive (position 2). Judgement of the rate at which he is crossing the tail is all important to the timing of the reversal. If the enemy's approach to the overshoot is at high closing speed and high angle-off a late reversal is required. This may be judged by comparing fuselage lines - if attitudes match the enemy may not overshoot at all; the greater the mismatch the more likely the overshoot.

If in doubt wait until he has gone through your 6 o'clock before reversing.

The ability to reduce speed more rapidly and to the lowest level gives the advantage and forces the enemy ahead most quickly. This is best achieved by an immediate nose-high reversal throttled right back with airbrake extended.

The higher the nose attitude the smaller the forward velocity vector.

The Vixen must watch the enemy closely during the reversal. If he is level and turning to attempt to manoeuvre in phase with the Vixen, the Vixen must reverse the turn again as the enemy approaches high flight path.

Continuing this series of turns and reversals forces the enemy into the scissors. The more rapid and tighter the reversal the less the forward distance travelled along the mean line of advance, putting the Vixen towards the enemy's six o'clock.

When the enemy has been forced out in front, timing each succeeding hard turn reversal to get in phase with him is critical.

If the scissors turns into a stagnated series of reversals with neither gaining the advantage, aim to get below the enemy by using flap to increase drag and induce a sink rate. Once below, reduce the drag by lifting flap and continuing to attempt to get in phase while still below him. The Vixen will now be in his blind spot worrying him and he will manoeuvre in an attempt to regain sight by dropping a wing, continuing a turn, or generally relaxing concentration on maintaining maximum performance.

This will be to the Vixen's advantage - dropping a wing for sighting produces either a stall if G is not relaxed or if it is, a decrease in turn performance allied to acceleration, all putting the enemy further ahead.

It may be to the Vixen's advantage to disengage. This can be achieved two ways:-

a. From a position in his blind spot below him dive away 180° from the Flight Path gaining distance separation all the time.

b. If unable to get in phase, relax G apply fuel power and roll down and 180° away from the fight just as the enemy's flight path is crossed and just before the enemy starts his reversal. In this situation you should also be blind to the enemy.

Points

When speed is reduced to the minimum:-

(1) Use full power for maximum rate reversals and delaying the stall.

(2) Use rudder to initiate turns and to maintain balanced flight.

(3) Judicious use of the ailerons is required to prevent departure from controlled flight.

(4) Flap may be used to advantage.

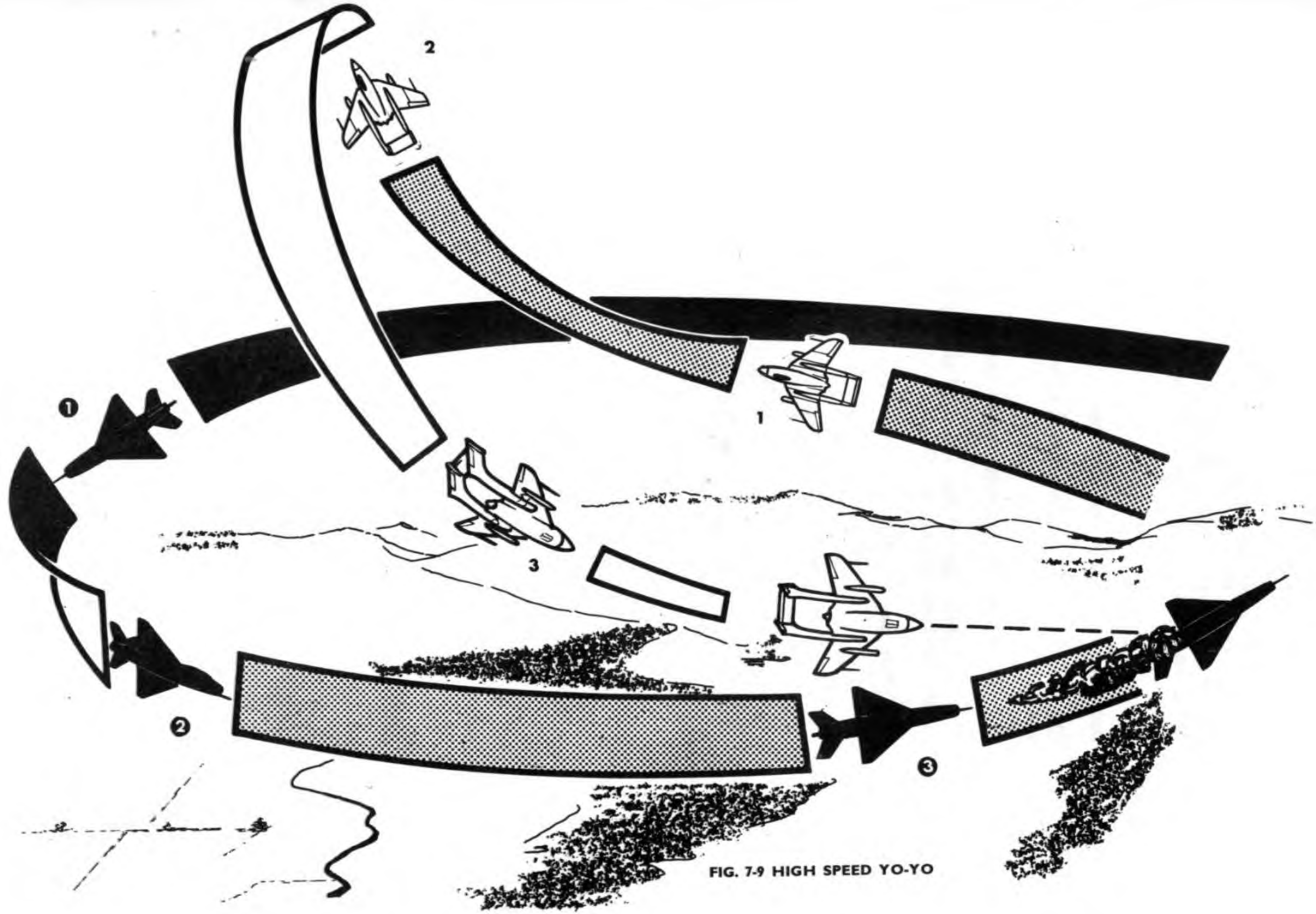


FIG. 7-9 HIGH SPEED YO-YO

OFFENSIVE

726. Introduction

The most successful method of destroying an enemy is by penetrating undetected to firing range inside his lethal cone. This is best achieved by taking advantage of the sun, cloud, his blind arcs, and approaching at high speed to give him minimum sighting time. The advantages of using radar lock must be weighed against the warning this will afford an enemy fitted with suitable passive detector equipment.

Any enemy worth his salt will not allow an attack to be carried out in this manner and will perform a defensive manoeuvre to prevent the attacker entering his lethal cone probably in the same way as has been described.

If he does not, enjoy yourself but make sure the first firing run counts - you may not have the opportunity for a second.

If he performs a defensive manoeuvre, continue the attack until it becomes obvious that you will be unable to achieve a position inside his lethal cone. Then use speed and any height advantage to break away and set up for another attack. A series of slash attacks making use of the principle of energy conservation allows you to maintain a position of advantage and denies the enemy the opportunity of taking the offensive. All the time you are towards his rear you are menacing him forcing him on to the defensive.

He will attempt to gain the offensive at the earliest opportunity - the aim of any fighter pilot - the scissors being a good way to achieve this.

As an attacker never get lured into a scissors manoeuvre; always conserve your speed and height advantages.

727. High Speed Yo-Yo (Fig. 7-9)

This is an offensive tactic, manoeuvring through the vertical and horizontal planes to prevent an overshoot in the plane of the enemy's turn.

Having continued an attack on the enemy performing a defensive turn, when it becomes obvious that an overshoot is likely to occur the Vixen rolls off bank to near wings-level and pulls up into the vertical plane (position 1) This allows distance separation to be maintained. As the nose comes well up a roll towards should be initiated (position 2) to keep the enemy in sight, and at the slower speed at the apex with 1 G gravity assisting the nose should be pulled back down through the horizon aided by the use of bottom rudder, to realign with the enemy's six o'clock. An excessive nose-down attitude should be avoided as this may allow the enemy to pull up into a vertical scissors. This will only occur if the apex of the yo-yo has been too high. Another disadvantage of the too high apex is that when the Vixen is there, distance separation may become so excessive as to allow the enemy to roll away in perfect safety outside firing range to open the distance still further.

The timing of the pull-up is important. Too early and the attacker will dive for separation leaving the Vixen nose-high, high and slow.

Too late and the Vixen will be directly above or even ahead of the enemy, and will become the defender if the enemy reverses and pulls up into the attack.

Properly executed the Vixen maintains the threat while remaining inside the enemy's turn-radius to successfully complete the attack.

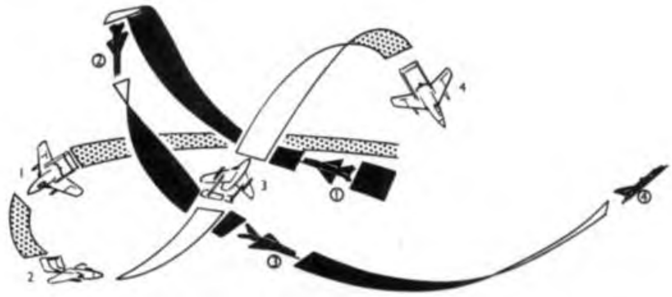


FIG. 7-10 COUNTERING THE HIGH SPEED YO-YO

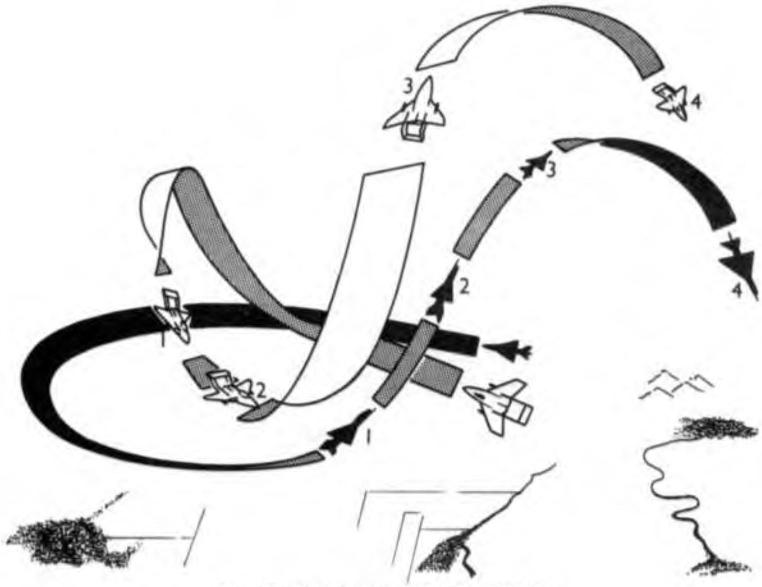


FIG. 7-11 COUNTERING DEFENSIVE PULL-UP

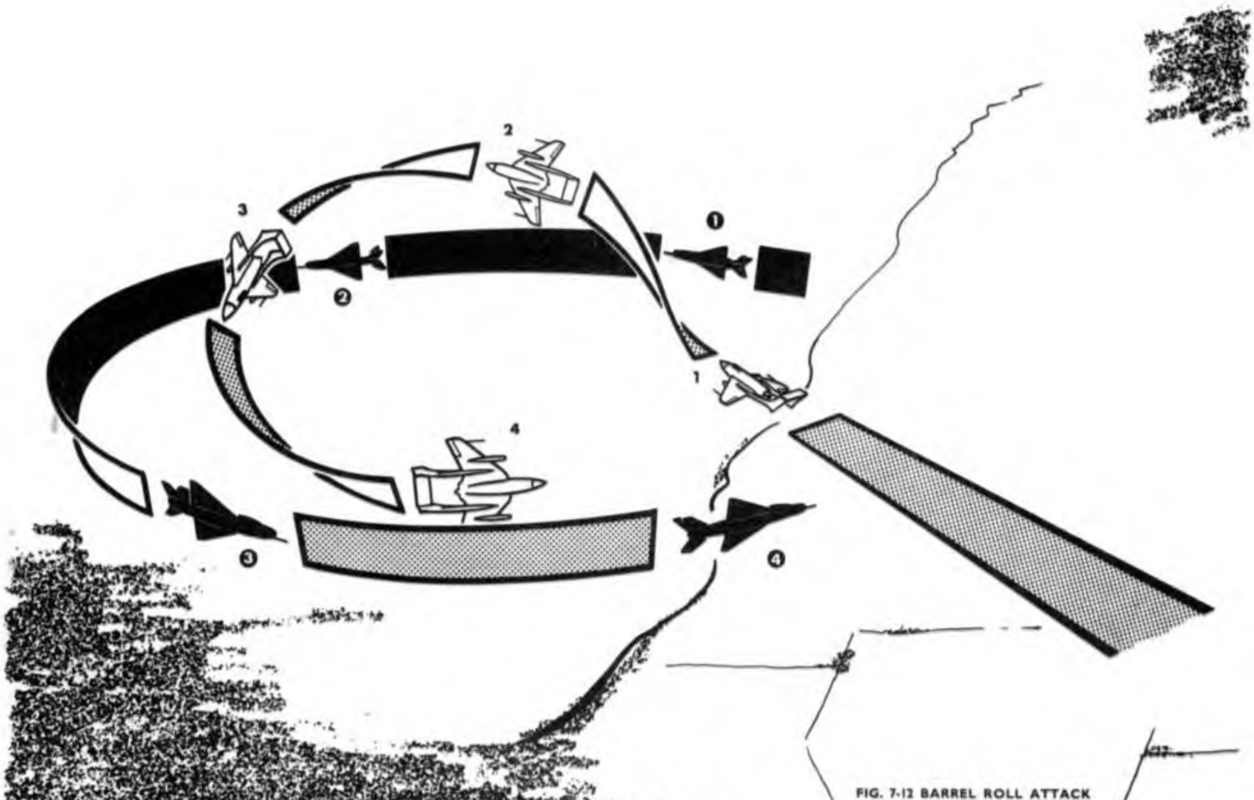


FIG. 7-12 BARREL ROLL ATTACK

728. Countering the High Speed Yo-Yo (Fig. 7-10)

The methods of countering a poorly executed yo-yo have already been covered.

To counter a well executed one, remember that while the enemy is yo-yoing he is not in the Vixen's lethal cone, he is menacing and manoeuvring to enter it subsequently.

While he is performing the yo-yo the Vixen should relax G and hold the same angle of bank (position 1). This will allow speed to increase and the nose will drop slightly below the horizon. When the enemy commits himself to press home his advantage by dropping his nose, the Vixen should pull up into the attack (position 2). This nose high attitude in relation to the enemy's nose-low should force him to overshoot below and forward of the Vixen's line of flight. The Vixen should then roll-off into the enemy's six o'clock (position 4).

729. Countering the Defensive Pullup (Fig. 7-11)

In this case the Vixen has performed a yo-yo and the enemy has countered with a defensive pullup. To successfully manoeuvre against the pullup the Vixen must maintain distance separation by turning in a plane away from the enemy's turn. As soon as the enemy's rolling pullup is seen the Vixen should roll a quarter away from the enemy's line of flight (position 1) and start a pullup. The pullup should be played so as not to overshoot the enemy's original height (position 2). (This would be the same as an overshoot in the horizontal plane before performing a high speed yo-yo). If the enemy continues his pullup the Vixen's higher initial speed enables him to zoom above and roll behind the enemy (position 4).

730. Barrel Roll Attack (Fig. 7-12)

This is an offensive manoeuvre that may be used instead of a yo-yo.

The situation is the same as for the high yo-yo, with an overshoot appearing inevitable to the Vixen because of his closing rate and high angle off. The manoeuvre is best performed if the Vixen starts from a position low on the inside of the enemy's turn. At a somewhat greater range than for a yo-yo the Vixen should pullup and barrel-roll away from the direction of turn(position 1) (i.e. if the enemy is turning left the Vixen rolls right and v.v.). The intention is to reduce closing speed along the forward vector of the line of flight, while reducing angle off, and reduce aircraft speed temporarily before regaining it to enter the enemy's lethal cone.

The manoeuvre is not a high G barrel-roll - the Vixen is aiming to Kill vector velocity not aircraft velocity.

At the nose high inverted position in the roll (position 2) bottom rudder should be fed in, with back stick pressure to obtain a nose low 270° change in direction. During this phase of the manoeuvre 1G gravity is assisting the rapid change in direction towards the enemy's six o'clock. If the manoeuvre has been correctly performed inside the enemy's turn radius, the Vixen will be at reduced angle off and above the enemy in a good position with sufficient speed to slide down into the enemy's lethal cone (position 3).

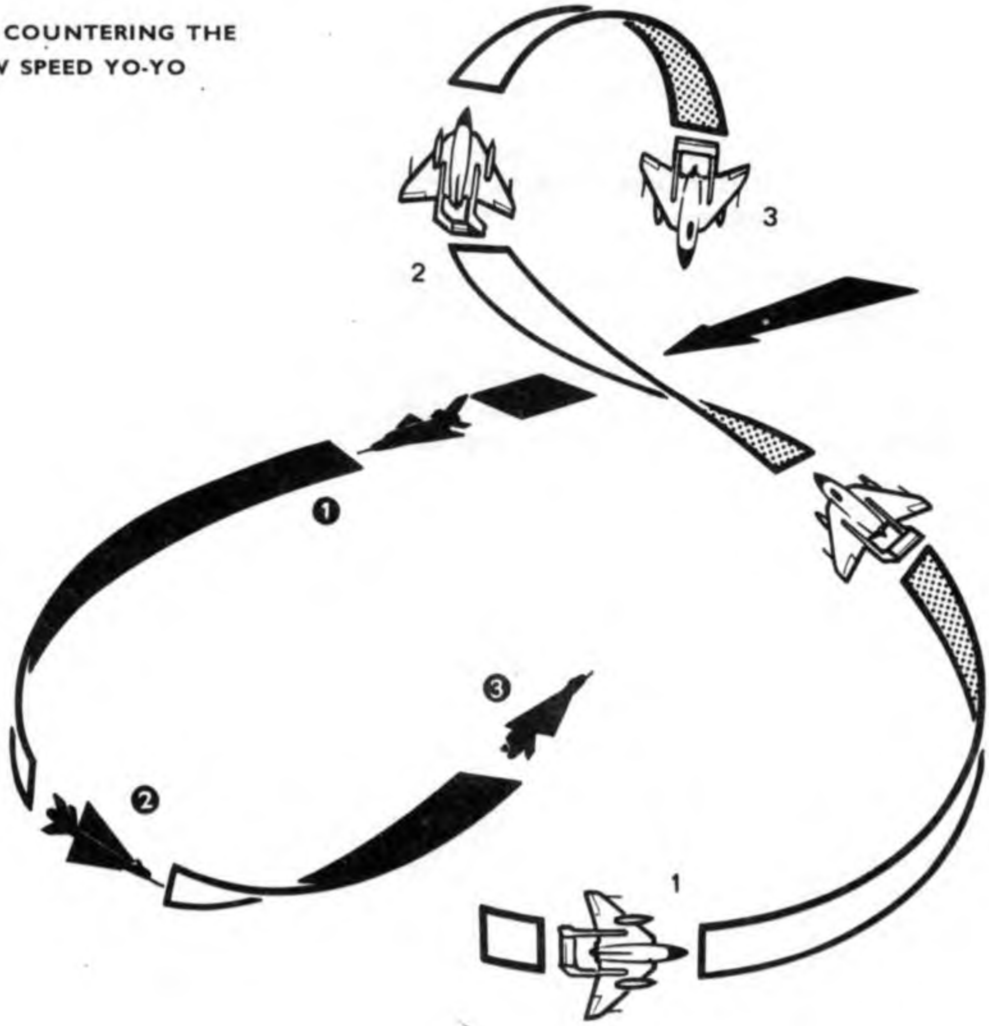
The advantage of this manoeuvre compared to the yo-yo is that the timing is not so critical with regard to the ability of the enemy to dive away in safety when the Vixen is at the yo-yo apex.

This is particularly true where the Vixen commences the attack from the low position inside the enemy's turn, but holds good in any case for the following reasons.

a. The vertical displacement during the barrel-roll is reduced decreasing distance separation during the manoeuvre.

b. Forward velocity component only towards the enemy is reduced while aircraft velocity remains high. This also provides greater energy with which to counter any enemy defensive manoeuvre.

FIG. 7-14 COUNTERING THE LOW SPEED YO-YO



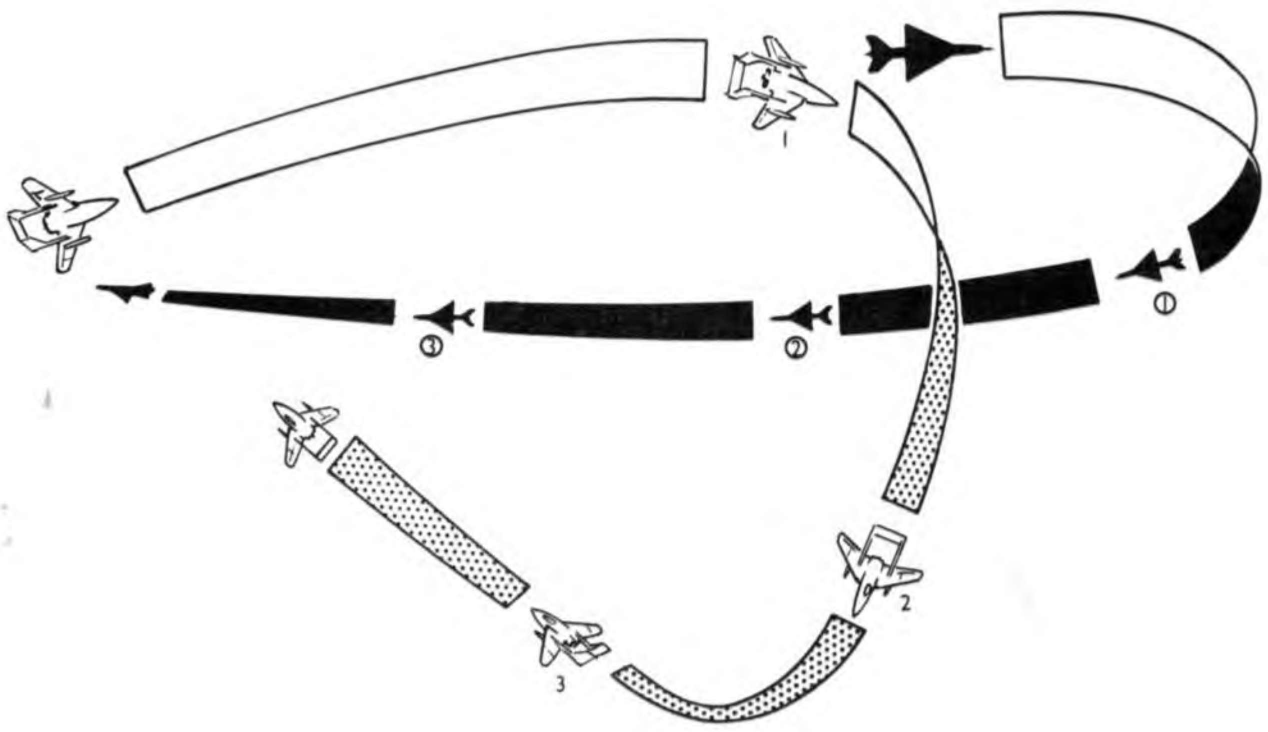


FIG. 7-13 LOW SPEED YO-YO

731. The Low Speed Yo-Yo (Fig. 7-13)

The low speed yo-yo is an effective offensive manoeuvre to decrease range or increase closing rate or both.

It is best illustrated in the circle of joy situation where two aircraft of similar turning performance are max rate turning in a stalemate situation.

This situation will only occur when the principle of 3 dimensional fighting is disregarded.

To gain the advantage the Vixen employs the low speed yo-yo manoeuvre. The result is that by using the third dimension he cuts off inside the enemy's turn radius, turns in the vertical plane ($\frac{1}{2}$ roll N/S principle) and uses best rate of turn, and radius of turn speeds, to gain the advantage.

This is achieved by dropping the nose and rolling in the direction of the turn at relaxed G to allow maximum acceleration (position 1). At this stage the enemy will be high and may appear to have moved round towards the Vixen's rear. At 380 knots or .85 M, the Vixen performs a max rate pullup just off the buffet (position 3), towards the enemy's six o'clock, and will have gained on him. If still not in the enemy's lethal cone after one, continue further yo-yos until successful. The Vixen should remain inside the enemy's lethal cone at the top of the zoom, the nose is pulled down again into a minimum radius turn at slow speed and assisted by 1G gravity before an overshoot occurs.

732. Countering the Low Speed Yo-Yo (Fig. 7-14)

The low speed yo-yo can be countered by matching fuselage lines and performing a similar manoeuvre to maintain the stalemate.

Alternatively if airspeed is sufficiently high the Vixen continues to turn during the diving part of the enemy's yo-yo. At this stage there is no immediate danger and distance separation is increasing (position 1). As the enemy starts to pullup, the Vixen rolls away from his turn and zooms with opposite bank on, turning his lethal cone temporarily towards the enemy (position 2). Care must be exercised here if the enemy is armed with IR G.W. As the enemy's nose comes above the horizon, the Vixen is now nose high and banked towards the enemy head on (position 3). At this stage the enemy is climbing towards with decreasing airspeed while the Vixen is diving with increasing airspeed. If the enemy completes a 180° turn in the vertical plane distance separation increases, and the enemy remains outside the Vixen's lethal cone. If the enemy attempts a cut off he will overshoot in the vertical plane and a vertical scissors manoeuvre may be employed against him, or the Vixen may continue to dive for separation before returning to the attack.

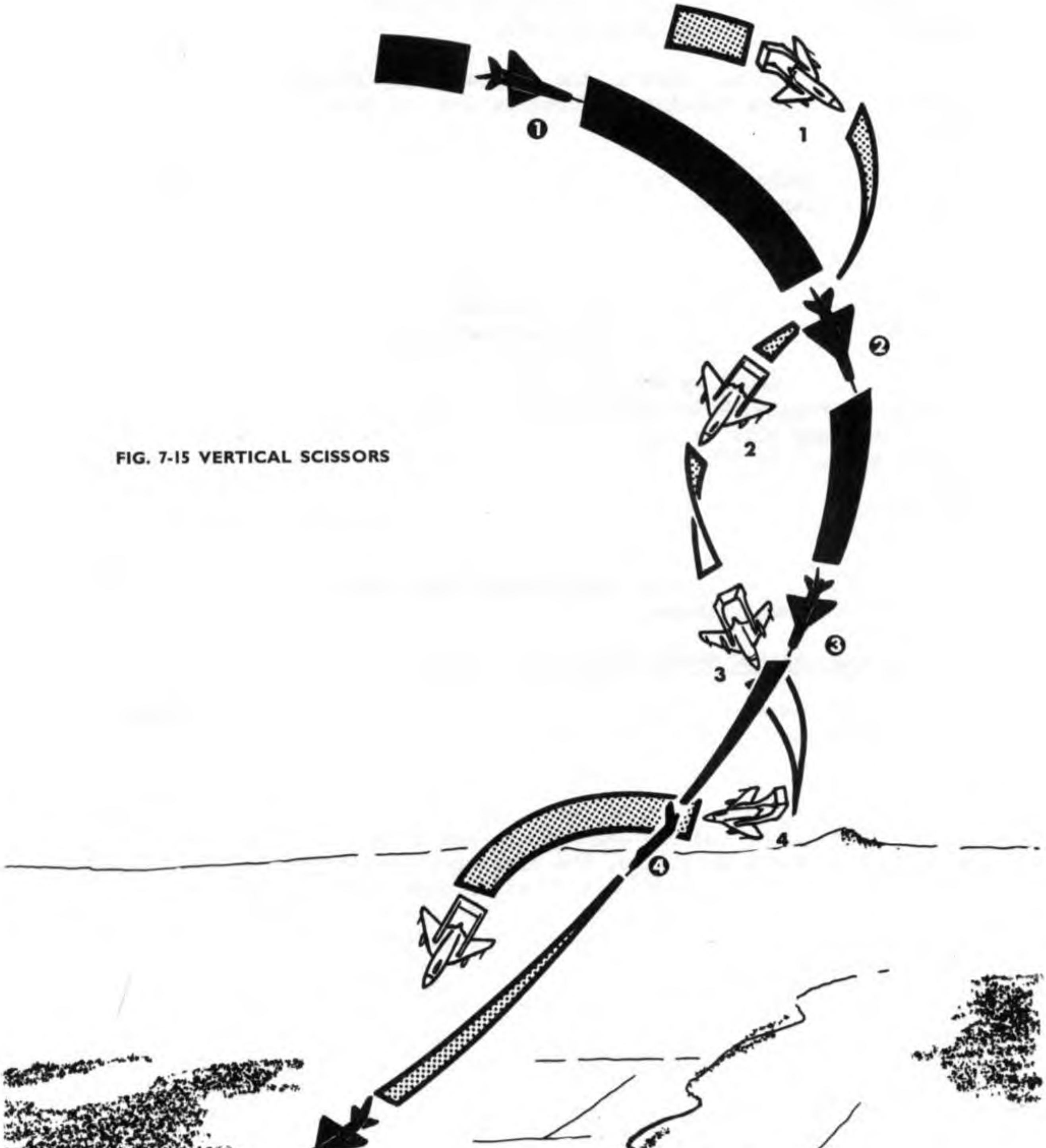


FIG. 7-15 VERTICAL SCISSORS

733. Vertical Scissors (Fig. 7-15)

This is similar to the scissors in principle but in the vertical plane. It may be employed when an enemy overshoots a descending break after an attack from below, or when an enemy is approaching a zooming Vixen's lethal cone in a zoom manoeuvre.

As the enemy overshoots the six o'clock position the Vixen reverses into him with reduced power and airbrake out (position 2). This is the only true reversal - the rest of the manoeuvre is a continuous roll. The Vixen continues rolling towards the enemy's flight path with back stick and top rudder reducing the rate of descent and giving a wider descending arc compared to the enemy who will have a higher initial airspeed anyway. The Vixen should adjust the roll to get in phase and enter the enemy's lethal cone.

FIG. 7-16 THE BARREL ROLL

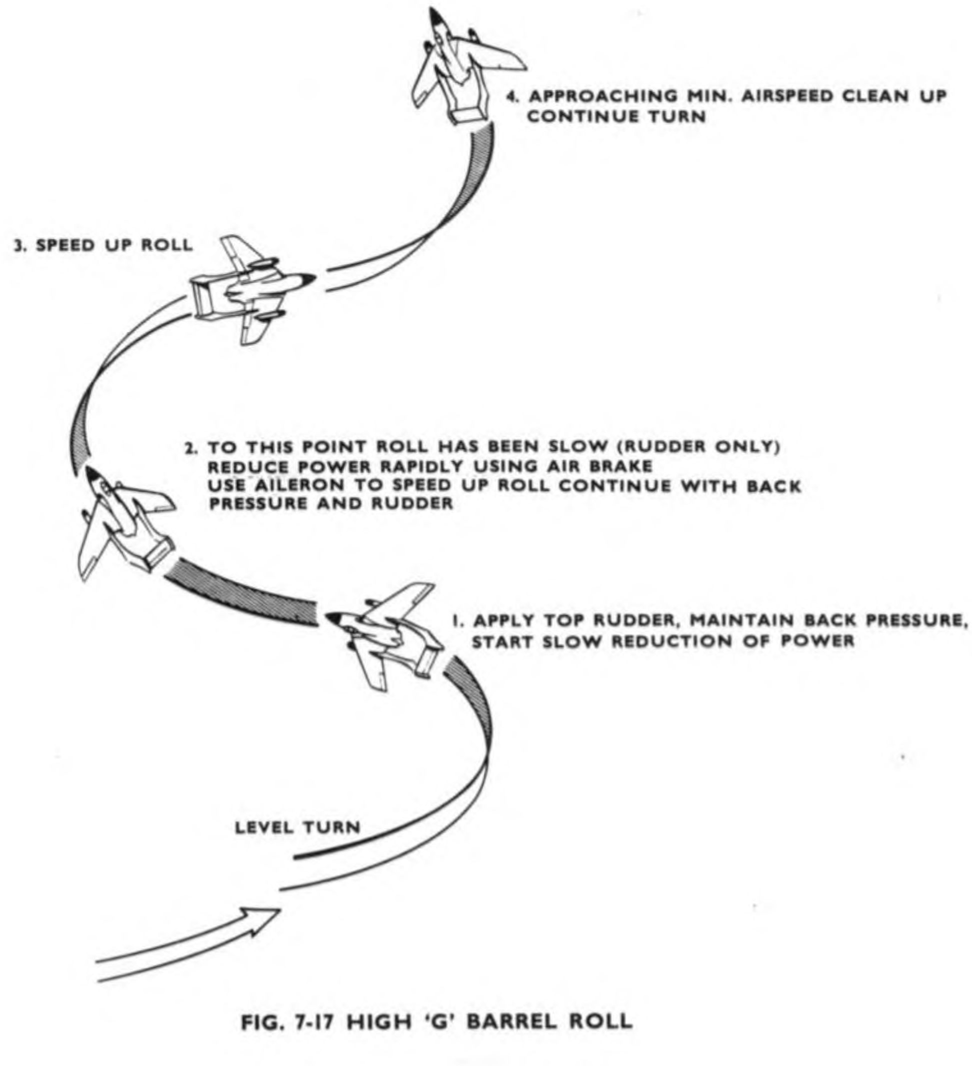


FIG. 7-17 HIGH 'G' BARREL ROLL

734. The Barrel-roll (Fig. 7-16)

This is an extremely basic and simple manoeuvre that enables an aircraft to lose distance to get astern of another similar speed aircraft. This it achieves by covering a greater distance at the same speed, reducing its forward velocity component, and by losing aircraft speed as well because of the vertical vector of the manoeuvre.

A high G variation, over the top or underneath for speeds greater or less than 250 knots respectively, may be used to throw an attacker ahead who is in a close six o'clock position, but this is a form of last ditch manoeuvre to be used only when all other methods of throwing him have failed, and is by no means a cure all for an ugly situation.

735. The High G Barrel-roll (Fig. 7-17) (IAS above 250 knots)

The high G barrel-roll can be used to get an attacker to overshoot when he is in a favourable firing position - in your six o'clock at a low overtaking speed and within firing range.

With the attacker in position (position 1) feed on top rudder still pulling maximum G. The attacker will have to take off bank in an endeavour to get deflection - in taking off bank he will accelerate. As the attacker will be concentrating on his sighting and tracking problem, he may not immediately realise that he is closing. Holding top rudder and still pulling max G. use opposite aileron to hold the bank (N.B. spin condition). Judicious aileron variation will allow the nose to rise to about 40° during the next 10 seconds due to the effect of top rudder. Keep it coming up for this period to allow the enemy's speed to increase. Then, with same aileron as rudder, barrel-roll (position 2). By reducing power and using airbrake the attacker's initial overshoot will be accentuated. When he is well committed hold top rudder when coming down the outside of the roll. This will prevent dishing and flatten out the roll. As you roll out at the completion of the roll(position 3) clean up the aircraft and open up the power, still keeping the nose high and maintaining a low airspeed to ensure that he does overshoot (position 4). Look for the attacker high and from the direction of the roll. He will slide below and forward from that position providing you hold top rudder. If he has maintained an attacking position, your low airspeed, high nose attitude will give him a difficult tracking problem.

If the attacker slides well below and forward, complete another roll in the same direction and drop into a six o'clock position, keeping your opponent in sight at all times.

If your opponent does not slide forward, use a scissor manoeuvre to achieve offensive potential.

Try and keep your opponent in sight at all times, as he can pull out of the roll and wait for you to complete before coming in again. If he should pull high, manoeuvre as outlined below:

a. Check the attitude of your opponent's aircraft relative to the horizon.

b. If he has an extremely nose-high attitude, relax Gs and spiral or dive for airspeed.

c. If he has a level or slightly nose-high attitude, continue to roll. Since your opponent's line of flight is now a straight line and your aircraft is describing an arc, you will tend to slide to the rear and below your opponent.

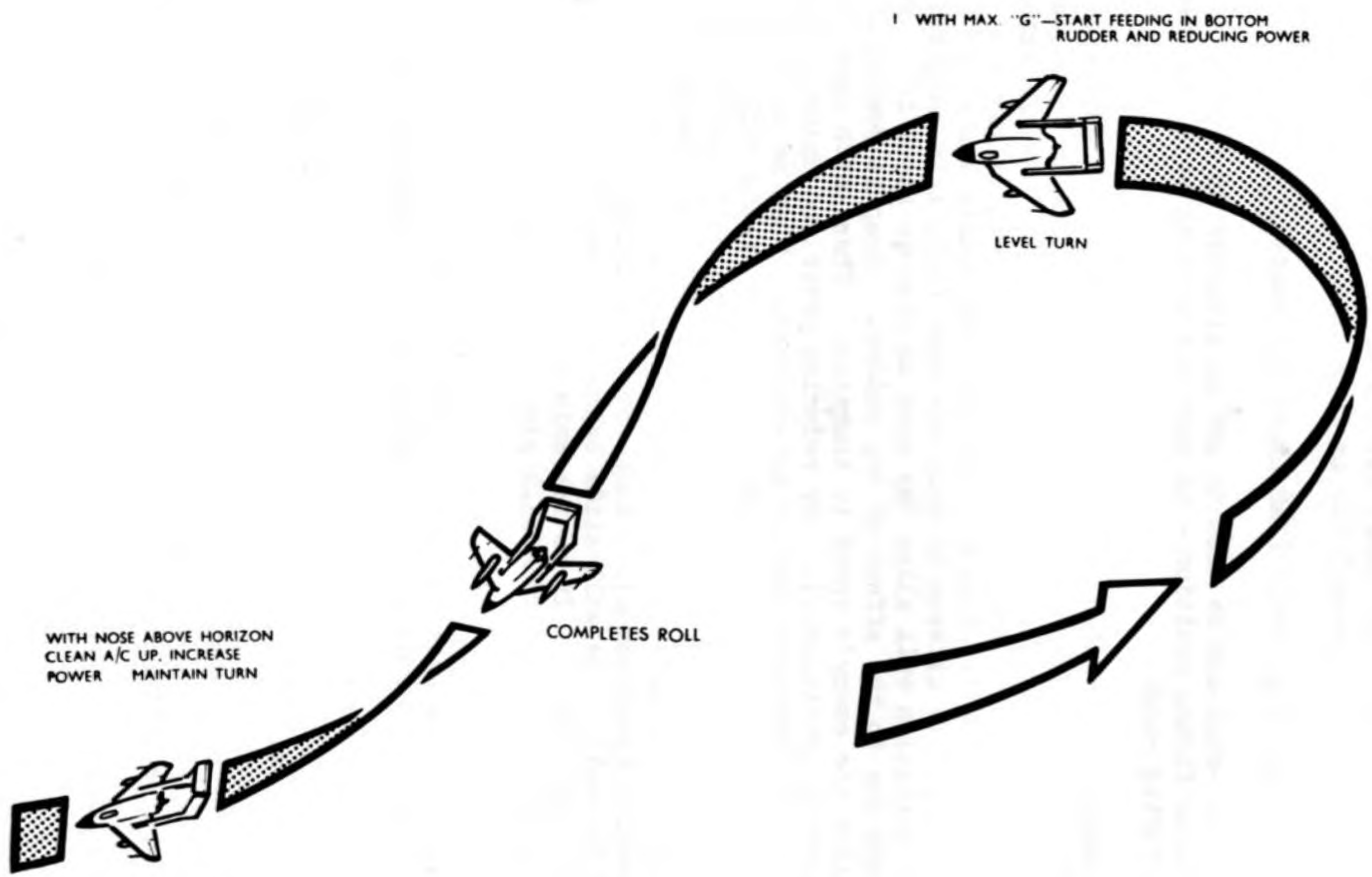


Fig 7-18 HIGH 'G' BARREL ROLL UNDERNEATH

736. The High G Roll Underneath (Fig. 7-18)

The essential difference between this manoeuvre and the High G Barrel-roll, is that it is essentially a low speed manoeuvre and can be carried out at speeds below 250 knots.

Initiate a hard turn, if the attacker is still at your six o'clock roll underneath feeding in bottom rudder and some aileron, still keeping the 'G' on. This will prevent any great increase in airspeed and make it very difficult for the attacker to solve his tracking problem.

Hold rudder in the direction of the turn all the way round the roll, reduce power and select air brake. Your opponent will probably attempt to follow but will not be concentrating on the rudder and stick pressures as you have. Consequently his aircraft will be "cleaner" aerodynamically, and an overshoot will most likely occur. By holding the rudder you will prevent a steep nose-low spiral and a subsequent tracking problem. As the attacker is concentrating on the gunsight an overshoot underneath may be effected before he can counter with the same stick and rudder technique. Once separation has been achieved, manoeuvre to achieve a firing position.

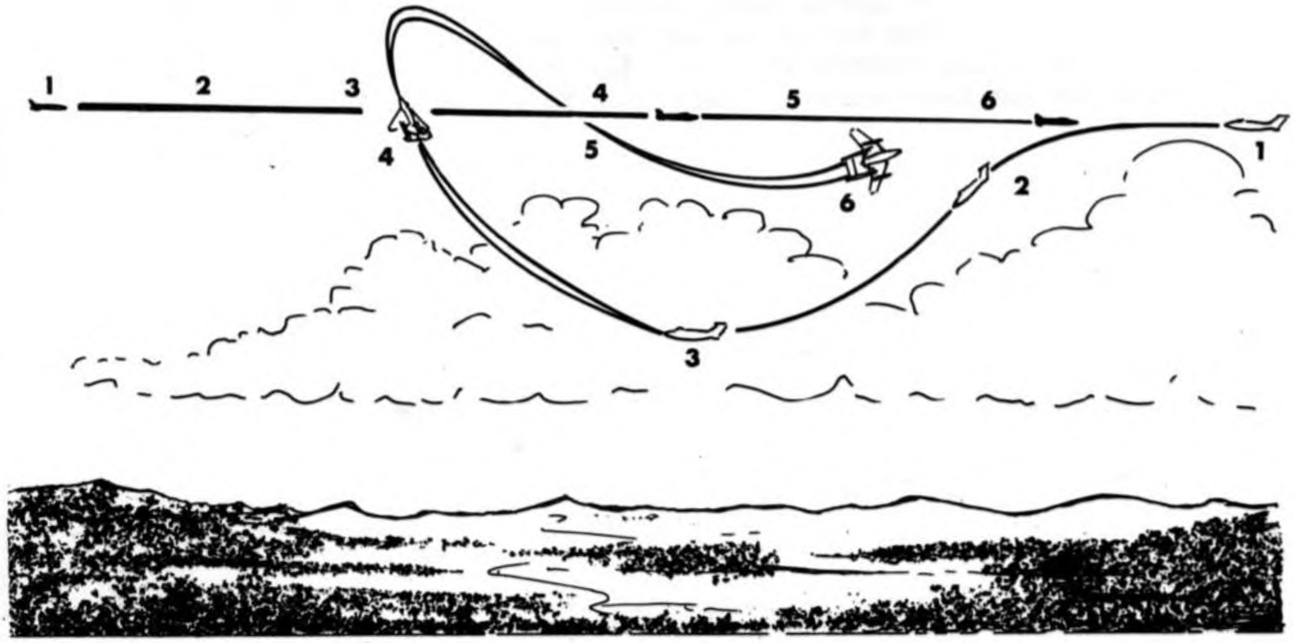


FIG. 7-19 HEAD ON ATTACK

737. Head On Attack (Fig. 7-19)

Many fighter combat situations start from a head on position. The fighter that sees the enemy first is at an advantage. He should dive at full power to increase energy potential. This increases his advantage by making it more difficult for the enemy to see him than it is for him to see the enemy framed against blue sky. The Vixen should aim to descend about 5,000 feet on average below the enemy and turn for an offset in the horizontal plane to allow for the subsequent turn radius into the attack. If the enemy fails to react to this offset turn it is an indication that he is not in visual contact. If he were he would turn towards to put himself 180° out from the Vixen, giving both aircraft the same angle off to turn through to enter the lethal cone. From the low offset position with speed in hand the Vixen is ideally placed to turn through both the vertical and horizontal planes to enter the enemy's lethal cone, commencing the turn-in at a suitably judged point before the enemy comes abeam.

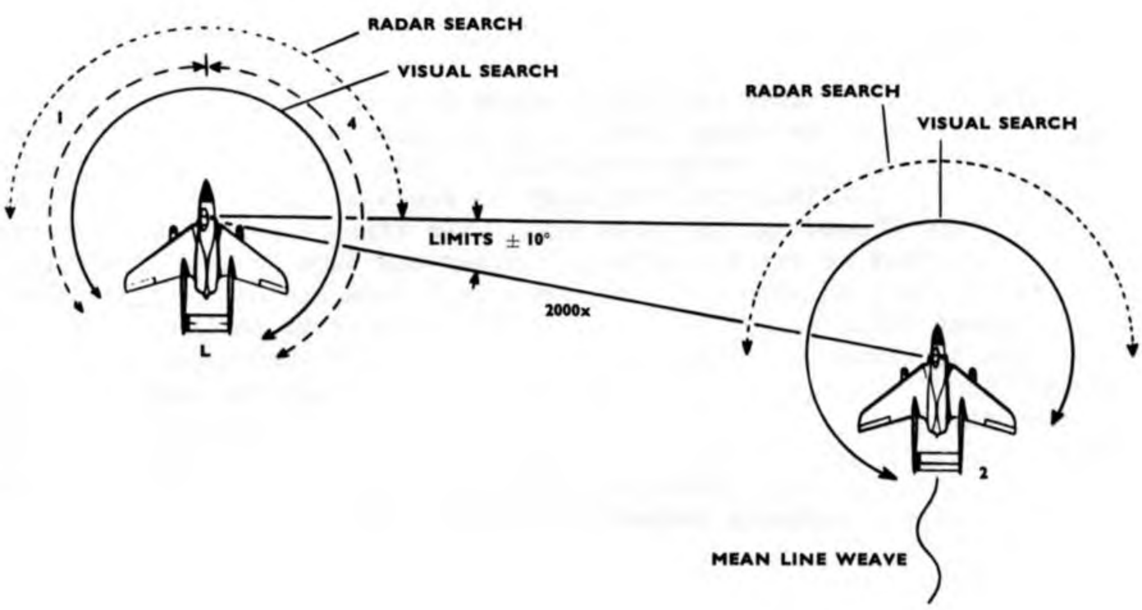


FIG. 7-20 PATROL POSITION

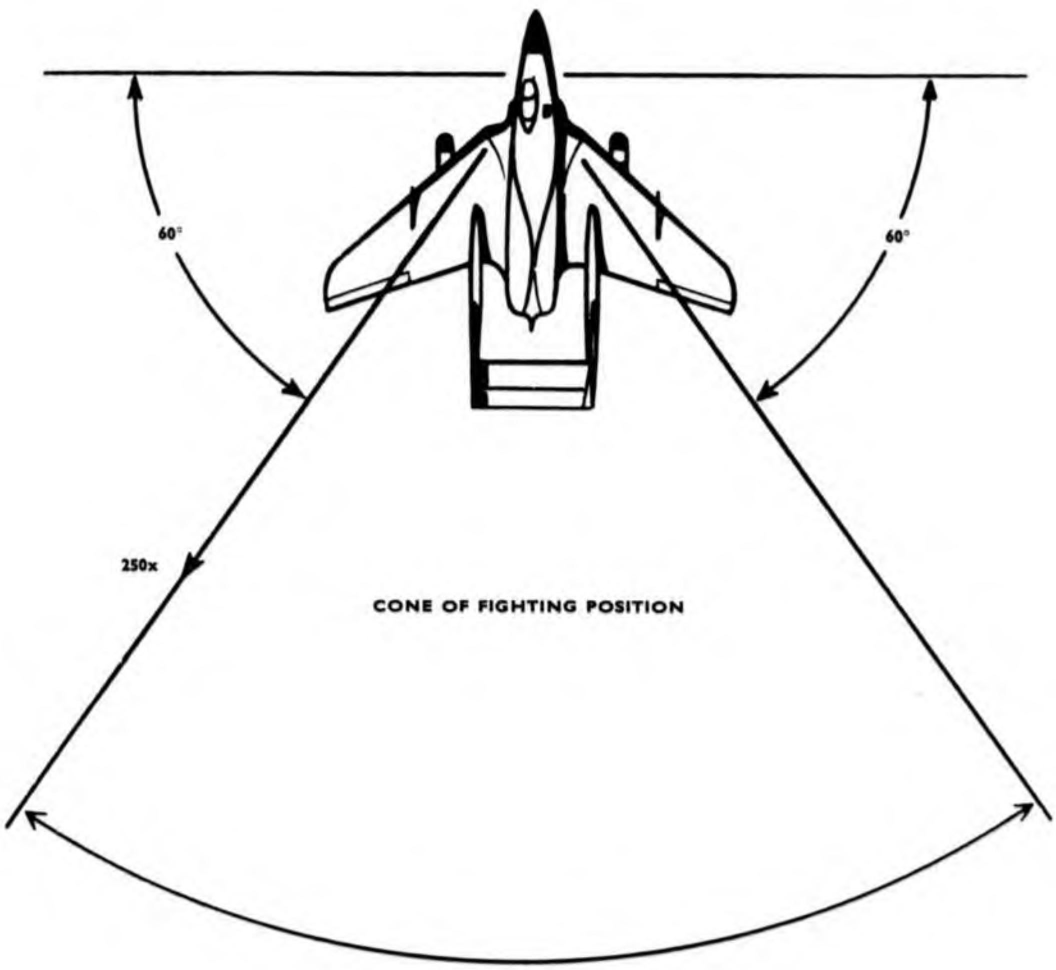


FIG. 7-21 FIGHTING POSITION

Multiple Aircraft Tactics

738. Basic Fighting Unit

a. The basic fighting unit is a pair or section. This provides increased lookout, mutual support, cross cover and maximum manoeuvrability.

b. The aim of the pair is to ensure that the leader is free to concentrate on destroying the enemy while his wingman ensures that no other aircraft menaces the leader.

c. The wingman must do two things:

(1) Fly his aircraft in such a manner that regardless of the leader's manoeuvres he does not become separated.

(2) Lookout, particularly astern and behind his leader, using radar in addition to his eyes in the ahead sector.

STICK SEARCH REPORT

739. Section Formations

a. Patrol Position (Fig. 7-20)

This gives maximum lookout cover with decreased manoeuvrability.

b. Fighting Position (Fig. 7-21)

This gives reduced lookout, with close support and best manoeuvrability.

A GOOD WINGMAN NEVER LOSES HIS LEADER

740. How to Fly the Fighting Position

Fig. 7-21 shows the area in which to fly - i.e. in a 60° cone about 250 yards back. That is, the wingman must be close enough to the leader so that if an enemy fighter does get into firing range, he must out-perform and out-manoeuvre the Leader in order to shoot down the wingman. This is a very difficult position to fly and initially the wingman will be concentrating on position keeping to the detriment of look out. The latter will only come with practice. Observe the following points:-

a. Stay on the inside of the turn until G forces you to the line astern position. As soon as the G comes off, back to the inside, and start searching.

b. Stack down slightly and avoid flying in the same geometric plane with the leader's wings on the inside of the turn.

c. Manoeuvre through both horizontal and vertical planes to maintain position.

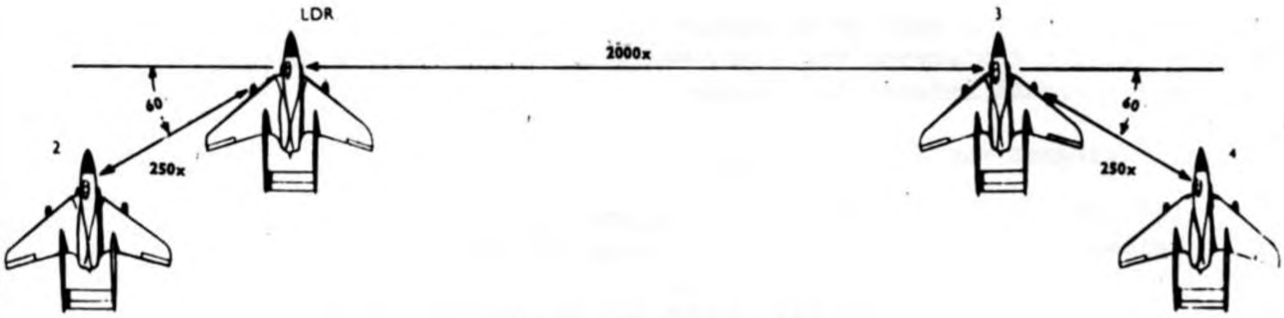


FIG. 7-22 THE DIVISION

d. Keep searching, keep your tail area cleared.

e. Keep your leader informed of the situation behind. Be careful not to blot out emergency calls.

f. If you should become separated inform the leader immediately and head for pre-arranged rendezvous position keeping high mach number and continually clearing your tail.

g. Your responsibilities:

STICK, SEARCH, REPORT.

h. While you are a wingman, think as a wingman, play with the team - no individualists.

741. The Division

a. The normal division consists of four aircraft comprising two sections in the formation shown. (Fig. 7-22)

b. This fulfils the basic requirements of a formation which are:-

(1) Lookout

(2) Mutual support

(3) Manoeuvrability

c. The distance apart between sections depends on:-

(1) The threat (gun or G.W.)

(2) Height

(3) Visibility

d. It is a very flexible formation in attack.

e. If the division is attacked the attacker has the continual problem of the threat of the sandwich to overcome.

742. Use of the Radio

a. If you have nothing to say remain silent.

b. Think what you're going to say before pressing the PTT button.

c. Do not 'blot out' other important calls.

d. If radio silence is in force it should be broken for matters of importance such as bogey sighting.

e. Once radio silence is broken use the radio to the best advantage.

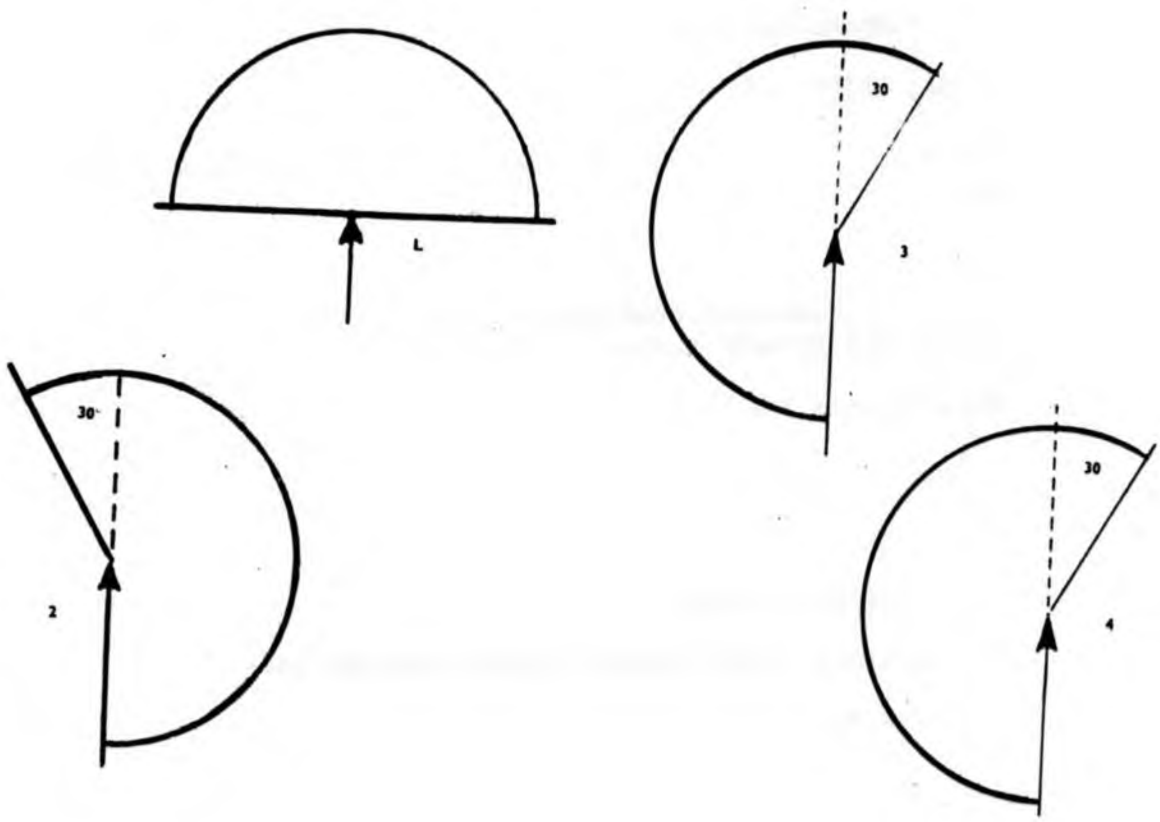


FIG. 7-23 VISUAL SEARCH AREAS

f. In close combat a tactical commentary must be kept going. Don't hog the air - make transmission breaks so that others can get a word in.

g. Recently in Vietnam 8 aircraft saw a missile attack, but could not get a call in to prevent an aircraft being hit by it because of radio "chatter".

743. Visual Search (Fig. 7-23)

Your area of search is part of a sphere - cover it completely from nadir to zenith starting astern and moving in successive sweeps to ahead. Don't just scan the area near the horizon. Start at the nadir (looking down) to focus the eyes at infinity and refocus every time you sweep through the horizon. Remember that your eyes' relaxed focus is about ONE YARD.

Screw your head round until you can see the fins to give full coverage aft. Really rubberneck!

Visual search should be continuous from takeoff to landing.

744. Visual Reporting

Reporting must be automatic, crisp, clear, concise and correct.

Where	-	Right 2 o'clock high
Whence	-	Far
Whither	-	Crossing right left
What	-	2 Fishbeds
Who	-	Red 3

All reports relative to Leader.

745. Leader's Acknowledgement

See him	-	Leader has contact - no further reports required.
Watch him	-	Report the bogey at maximum intervals of 15 secs. amplifying as necessary.
Disregard	-	No further reports or action required.

NOTE: "Roger" is not to be used as a reply to a bogey report.

746. Radar Search

The radar policy will have been decided and briefed, the advantages of early detection against self advertisement having been weighed up.

All aircraft search over the full azimuth range of the set, and priorities for high and low search are allocated (e.g. L and 3 high, 2 and 4 low).

747. Radar Reporting

Bearing in degrees	Contact right 60
Range in miles	12
Height	Low
Movement	Closing
Originator	Red 3

All reports relative to originator.

748. Leader's Acknowledgement

As for visual except "Contact" instead of "See him".

749. Passive Search

Wide Band Homers, both X and S band, should be used continuously except in a confused radar situation.

750. Passive Search Reporting Code

Item	Example of Report
Any passive indication	Pinnacle
Waveband X or S	Xray
If it appears to be locked (omit this item if radar is unlocked)	Locked
Bearing Left/Ahead/Right	Left
Intensity Strong/Moderate/Weak	Strong
Reporting Aircraft Callsign	Eighteen - two

The Leader's reply as for Radar.

The reports can be amplified by using the following standard codewords:-

Type of Radar	Codeword
Missile and Fire Control	Flash Photo
Bomber	Big Photo
Ground	Ground Photo
AI	Little Photo
Ship	Ship Photo

PRF	Codeword
Below 500 cycles	Pitch Low
Between 500 and 1000 cycles	Pitch Medium
Above 1000 cycles	Pitch High

or, if an exact PRF can be estimated, "SLOPE" followed by the PRF in cycles. Aerial rotation rate is reported as "BRUSH" followed by the period in seconds.

751. Violet Picture Reporting

To report R/T jamming indicated on Violet Picture, the following code is used:-

"CHATTER"
Left/Right
High/Low
Callsign

Frequency on which received if different from that on which the report is made.

The Leader's reply as for Radar.

752. Reporting of Jamming of Aircraft Radar

When jamming is received on an aircraft radar, the following reporting code is used:-

GRIDIRON (during interception of a jammer, call "TRACKING GRIDIRON" until "JUDY")
Left/Right
Angle from the bow
High/Low
Strong/Moderate/Weak
Callsign

The Leader's reply as for Radar.

DEFENSIVE TACTICAL TEAMWORK

753. One Attacked by Two

As the two come in, go to 100% and nose down to pick up high Mach. As they near firing range (1,000 yards for 30 mm) break sharply into the attack and make sure you offer no less than a 50° to 60° angle off shot at about 5G. At this stage of the attack you should see both leader and wingman sliding to the outside of the turn, or if they choose to yo-yo, climbing steeply to your rear. Your best move, if they are attempting to turn with you, is to wait until they pass through your six o'clock position then reverse. Using air brake and reducing power as required to get to the rear of the attacking wingman. Base all your manoeuvres on the attacking wingman, as long as he flies as a No.2. Do not get sandwiched between the two.

If they decide to yo-yo and pull up as you out-turn them put your aircraft into a diving turn at maximum power and keep going away from them. With the attackers going up and you going down vertically you should get sufficient distance from them to make good your escape.

754. One Attacked by Four

You are in real trouble here if the four know their jobs. Your procedure is to turn into all attacks. Keep both pairs in sight at all times and avoid the temptation of trying to reverse on one pair with the other section spaced ten seconds behind. Each time you turn into an attack lower your nose and keep airspeed up. After the initial attacks you will see that the attacks are not evenly spaced. Watch for this and after turning into the last section, continue your turn and go away at 180°. Get your nose down quickly, for the gap you are trying to create will depend on your picking up maximum speed as quickly as possible. DON'T PANIC. Keep your airspeed up. Keep your attackers at a high angle off. Watch for your chance to break away and down - get away as quickly as possible.

755. Two Attacked by One

With a good wingman your formation should never be seriously embarrassed by the attack of a single aircraft. Turn into the attack and attempt to force him outside the turn. Reverse and scissor until you force him away. If he remains in the six o'clock position the wingman should slide low in the turn. This has the effect of splitting the formation forcing the attacker to select one aircraft. The one that is free can slide back and sandwich the attacker. It is vital for the pilot who is attacked to forget about anything but shaking off the attacker behind. Keep your eye on him - keep him at a high angle off at your max G's. The free aircraft will attack as soon as he is able.

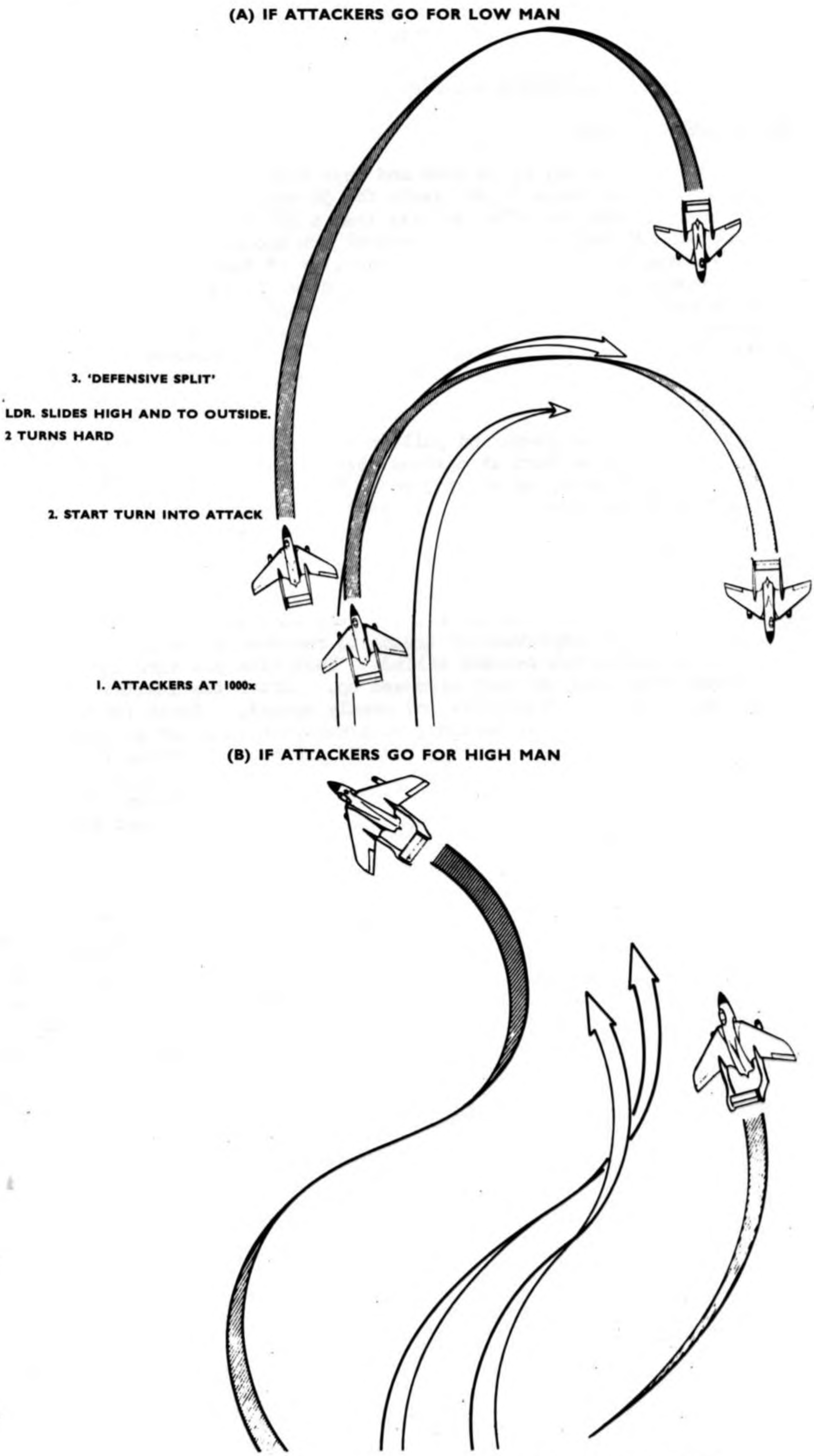


FIG. 7-24 DEFENSIVE SPLIT

756. <u>Two Attacked by Two</u>

Turn into the attack and attempt to reverse and scissor. If they pull high, roll over and dive away. If they manage to stay with you in the turn, spread out and see what they do. If they select one aircraft the free aircraft can return to the attack. If the attackers split, then the engagement is reduced to a one v. one combat.

The "Defensive Split" (Fig. 7-24) can be used in these circumstances but it must be carefully employed as it can be a most dangerous manoeuvre if used incorrectly.

This manoeuvre requires the ability to estimate ranges accurately. Furthermore, if executed prematurely it can be a definite asset to the attacking pair. Basically it will be employed only when the attackers have gained a low angle off, low rate of closure condition prior to being detected. The split must be executed outside firing range, and normally between 1,000 and 3,000 yards. Remember since this manoeuvre requires excellent judgement to execute properly and places the defenders in an extremely vulnerable position if used at the wrong time, <u>DO NOT</u> use the Defensive Split as a standard evasive manoeuvre.

Assume the enemy in your rear cone. When they get to between 1,000 and 3,000 yards start a turn into the attack (position 2).

The leader should tell the No.2 to prepare for a defensive split. The No.2 continues to turn into the attack and at the right moment the leader slides high and to the outside of the turn (position 3). The timing of the leader's move is the critical part of this manoeuvre. Done at the right time you present the attacker with an immediate problem just as he should be preparing to fire. This can affect his actual tracking and subsequent firing. Another distinct possibility of an error exists in the attacker over-concentrating on his pre-selected target and not noticing the split develop until he is over-committed. It is assumed here that the attackers have gone for the low man (position 4). When this is obvious, the high man can order him to break; the high man can then attempt to complete the sandwich (position 5).

Consider the attackers going for the high man. If range permits, the high man should reverse his turn and break, thereby giving the No.2 a chance to complete the sandwich (position 6), but if the attackers are too close, the high man will have to break into the attack.

The most common error committed in the execution of this manoeuvre is to have the defending No.2 flying too far forward. Once the turn has started, he will immediately move too far forward and away, and will be unable to support the high man if the attackers select the high man and he needs to reverse to sandwich the attackers.

An attacking pair faced with a defensive split, should detach the No.2 to feint towards the low man, while the leader takes the high. Immediately the low man is forced out of the fight, the No.2 of the attacking pair rejoins his leader.

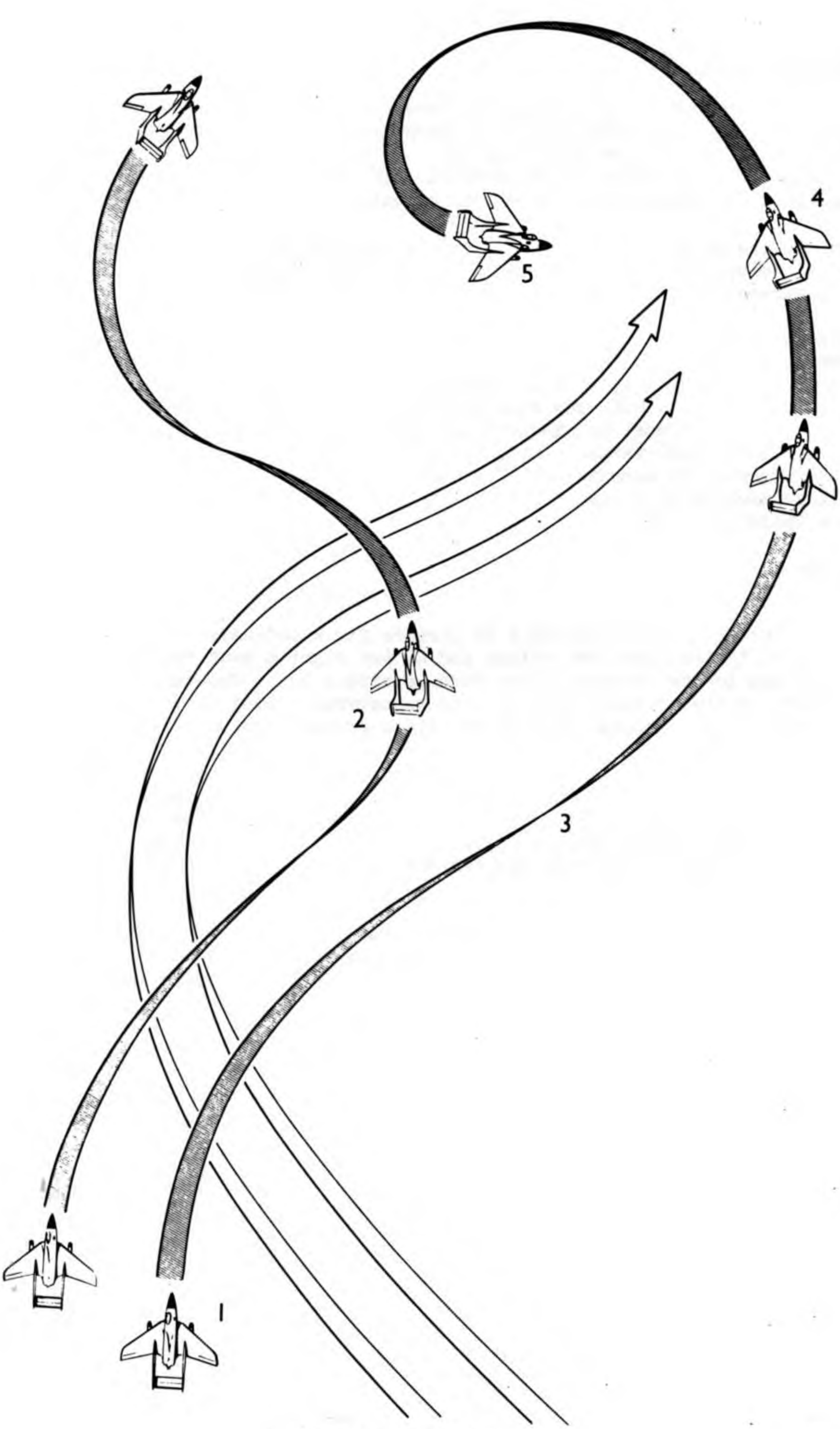


FIG. 7-25 THE VERTICAL SPLIT

757. The Vertical Split (Fig. 7-25) is a refinement of the Defensive Split.

This manoeuvre is used when a pair of attackers overshoot in an attack. This gives the leader of the defensive pair the opportunity to SCISSOR the attackers, his No.2 pulling high to a position from which he can choose to attack the enemy during the reversals.

It is imperative that the defenders draw the attackers into an overshoot condition. Do not go into a maximum rate of turn into the attack too early or the attackers will counter with a high speed yo-yo. Just enough to encourage the attackers to continue the attack and at the last moment tighten up the turn enough to ensure that they overshoot.

When there is lateral separation between the pairs, and when the defensive leader judges the correct moment he executes a hard nose high reversal and attempts to scissor the attacking pair (position 2).

As the defending No.2's wings approach the level, following his leader's reversal, he pulls hard back and converts his speed into height (position 3). As soon as the nose high attitude is established, the No.2 should immediately do a half roll so that the battle progress below can be watched. The No.2 should hang in this position (4) just long enough to enable him to barrel out and fall behind the enemy pair on their first reversal of the scissors (position 5). The No.2 must not allow his nose to fall too far behind while inverted and when barrelling out on to the enemy pair. Dropping the nose will place him below the enemy and delay his support for the leader.

The advantages of the vertical split are:-

a. It allows the defending leader to use minimum airspeed and maximum manoeuvrability without having to worry about his No.2.

b. The attacking pair are committed to a scissors, or to breaking off completely, due to the defensive leaders actions, so that the No.2 can make full use of his zoom potential.

c. The attacking No.2 will most probably never see the split. Even if he did is committed to a high G turn which kills off any zoom.

d. Once the defending No.2 has been told of an impending vertical split, there is no need for any further R.T. call. When his wings reach the near level position, he then automatically pulls high.

758. Four Attacked by Four

When in doubt always turn into the attack but if possible initiate your turn to sandwich the attackers between the sections. After the initial counter watch for the second attacking section, they may be attacking with a ten second interval and they may be staying high waiting to slide down to your six o'clock. In a situation such as this, the attackers have the advantage. Keep looking around, use your radio intelligently and use the basic principles of offence and defence as the situation may dictate.

OFFENSIVE TACTICAL TEAMWORK

759. One Attacking Two

A single aircraft with a pilot who is aggressive and well trained can successfully attack a two-or-four-aircraft formation - unless every man in that formation really knows his job - a thing that is rarely seen. When attacking two aircraft, determine the feasibility of dropping unseen below them and gradually slipping into firing range from below and behind. If they break into you then you must decide whether you can hold the evading aircraft or, if you start to slide outside their radius of turn, trading airspeed for altitude and initiating a yo-yo. If you slow down and stay, try and get the wingman first. Against good opposition as you attack one aircraft, he begins a turn into you - possibly a diving spiral away from the other aircraft. Begin the turn with him but watch the other aircraft carefully. If he turns towards you and has timed it properly he will drop into range behind you. Your only move then is to reverse into him and meet his attack. This can easily end in a scissors manoeuvre so be alert for a possible decrease of throttle and use of air brake. He may go right on by since he has accomplished his purpose of making you leave his partner alone, in which case another reversal to chase him will put you to the rear of both aircraft again. Now press your attack on the most likely of the two for they will probably be separated.

760. One Attacking Four

Your best attack here is to attack the right section from the left side or the left section from the right side. If you cannot close to G.W. firing range before the enemy break, your line of attack will make it necessary for the sections to break towards each other. This will increase your chances as the leading section will now be blind and it brings the two sections close together.

If you overshoot, do not commit the fatal error of sliding to the outside of the turn. If you cannot stay with the turn, trade airspeed for altitude. DO NOT BE PROUD - if in any doubt accelerate away from the enemy. You can always return using radar to regain contact.

761. Two Against Two

First make sure that you are not attacking one of two sections. When you are quite sure there are only two aircraft start your attack. You may prefer to keep your wingman high, giving you top cover during your attack. This has the further advantage that if the enemy breaks, the wingman may be in a better position to attack, the leader pulling up to give top cover. If you both attack, manoeuvre to put your No.2 behind the No.2 you are attacking. If they break into you and you cannot track, trade airspeed for altitude keeping to their rear using throttle and airbrake to slide back into their six o'clock position. This is the critical point, for if the opposition know their job they will make a defensive split. That is, spreading apart causing you to make an important decision:-

a. Separate with them, taking an aircraft each - accepting the loss of flight integrity.

b. Stay together and attempt to force one aircraft out of the fight, without losing your speed advantage, then switch your attack to the other aircraft. Your wingman should continue to watch carefully for the other pilot.

762. Four Against Four

This is a situation that will have to be played by ear. Is it better to keep one section high acting as top cover or committing both sections to the offensive - with say a five second interval between sections? The basic problem is to give your aircraft maximum mutual support whilst denying mutual support between the enemy aircraft by dividing then destroying. If a section is disengaged keep the engaged section in the picture - if nothing else it will be very comforting!

763. Historical Note

Most air combat kills in W.W.I and II and Korea resulted from six o'clock attacks at gun-range on non manoeuvring aircraft that never saw their attackers.

764. Historical Quote

"The fighter pilots have to rove in the area allotted to them in any way they like, and when they spot an enemy they attack and shoot him down .... Anything else is rubbish!"

This statement by Baron Manfred Von Richthofen applies equally well today; but rove as briefed.

765. Valid Chestnuts

a. No matter how good you are there is another pilot somewhere who is a little better.

b. When in the combat area keep your speed up.

c. When you've seen one, look for his No.2.

d. If you have an aircraft in front assume you have one behind.

e. Watch the sun - there may still be a very old and bold "Hun" in it.

f. If jumped when at max weight you will improve your performance by jettisoning drop tanks and ground attack armament.

g. Never reverse unless you are certain it is safe to do so.

h. When told to break DO IT MAXIMALLY.

i. Finally, DON'T PANIC.

NURTURE THE KILLER INSTINCT.

GROUND ATTACK

Introduction

The aim of any ground attack sortie is to hit and destroy a target with a selected weapon.

As a member of a Sea Vixen crew your job is to achieve this aim by ensuring that at weapon release the correct conditions are satisfied.

These are:-

1. The right sight picture (on the right target).

2. The right dive angle.

3. The right height.

4. The right speed.

5. No yaw/skid.

6. The right switches.

All the strike training you have ever done has been leading to this goal of six satisfied conditions.

There follows a fairly detailed study on weaponeering, both theoretical and practical. If you understand the theory you can apply it in practice, you may even be able to add to the theory from practical results or experience, but the two go hand in glove.

The level has been set for the aviator of average ability and intelligence, so <u>you</u> should have no trouble digesting the content.

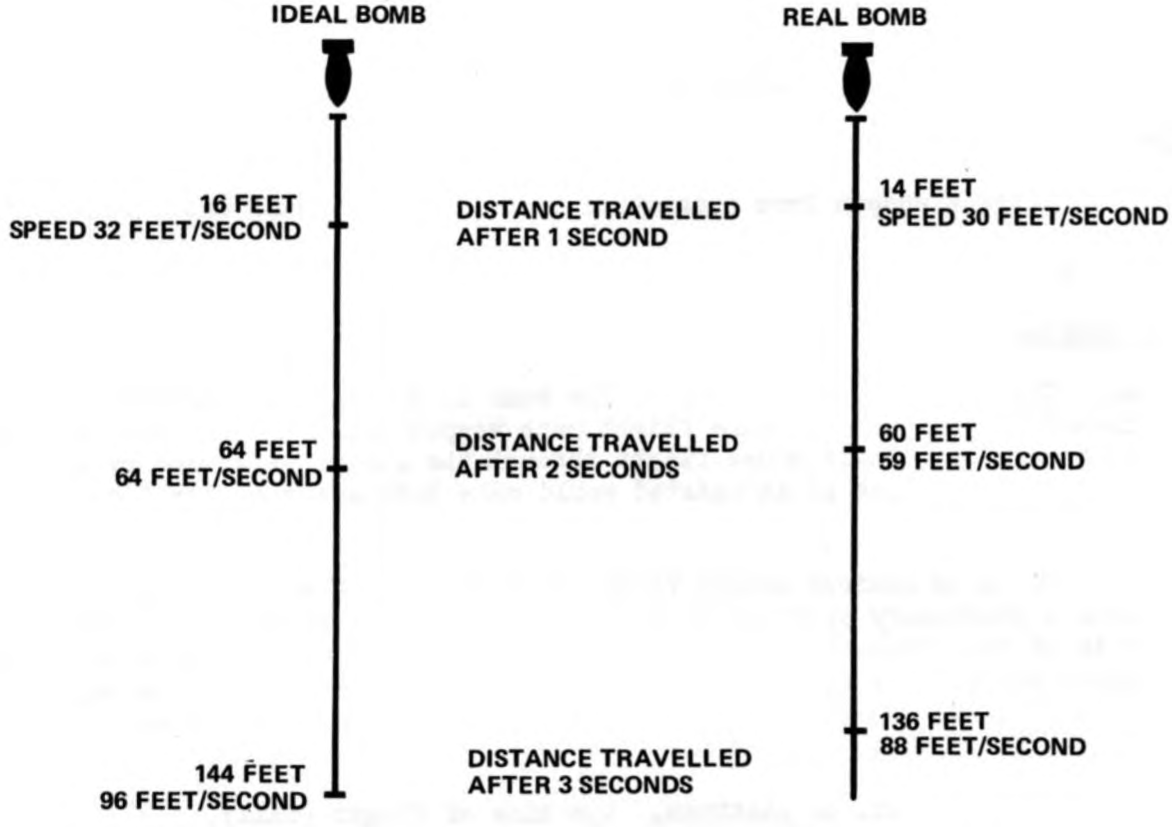


FIGURE 8–2. IDEAL AND REAL BOMBS

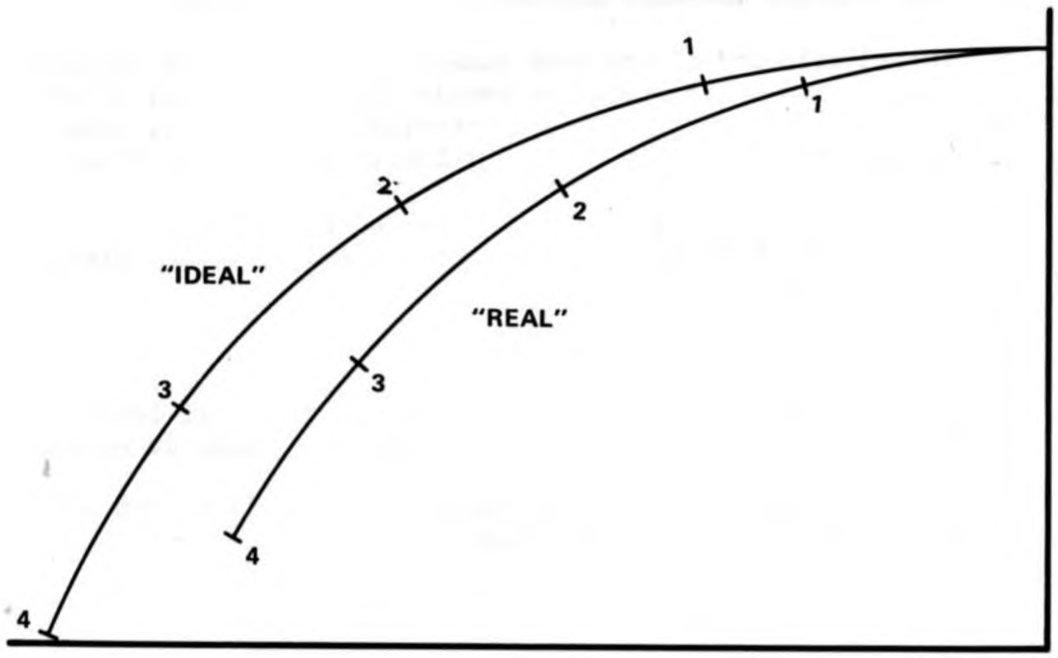


FIGURE 8–3. COMPARATIVE TRAJECTORIES

CHAPTER 8

BASIC THEORY

801. The Problem

To release a weapon from a point in space whence it will hit a target.

802. Solution

Level Bombing

a. The Ideal Bomb (Fig. 8-1) The bomb is the simplest weapon to investigate as it is a pure flight path weapon and the ideal bomb is an imaginary projectile whose flight through the air is unimpeded by air resistance; which if it existed would make life a lot easier for everyone.

It is an ancient weapon first produced by I. Newton which, if dropped from a stationary platform in space, would accelerate earthwards at a rate of 32.2 ft/sec^2 under the effect of gravity. If the platform were suspended above a target the bomb would hit it after a time lag depending solely on the height of the platform. The time of fall can be calculated thanks to Mr. Newton's formula $S = \frac{1}{2} a t^2$

Where h = ht. of platform, t = time of flight (fall),
g = gravity 32.2/ft/sec^2, $t = \frac{2h}{g}$

If the platform were travelling towards the target at a constant height when the ideal bomb was released the bomb would describe a curved trajectory the resultant of two component velocities:

(1) The speed and direction of the platform.

(2) The constant downward acceleration due to gravity.

The forward velocity of the bomb remains constant as it is unaffected by air resistance and would therefore remain the same as that of the platform. So the horizontal distance travelled by the ideal bomb in this case is the product of its forward velocity and time of flight.

Where D = Horizontal distance, t = time of flight,
Vf = forward velocity of ideal bomb (and releasing platform)
D = t x Vf

b. Wind Effect on Ideal Bomb

In this case the wind is assumed to be constant at all levels and is taken to be the wind acting on the platform and ideal bomb at release.

The distance D the bomb is blown during its fall is D = Wv x t.
(where Wv = wind velocity. t = time of flight)

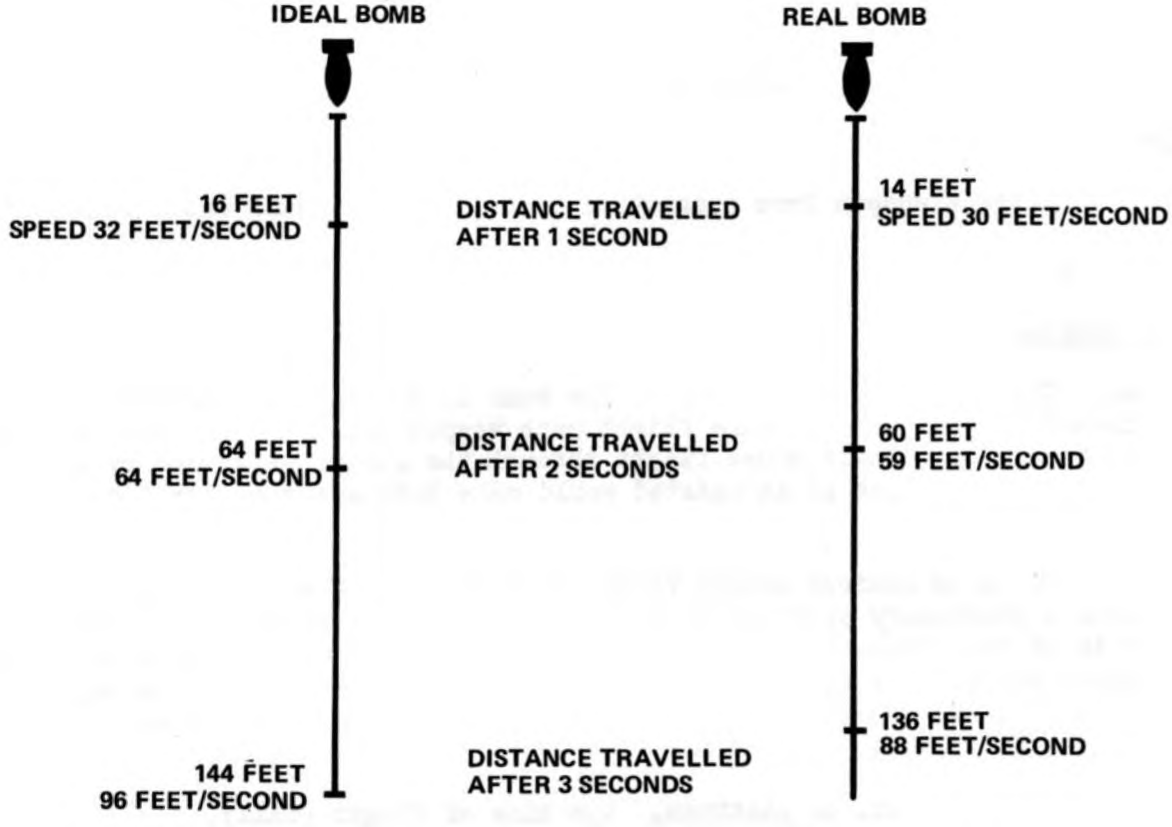


FIGURE 8–2. IDEAL AND REAL BOMBS

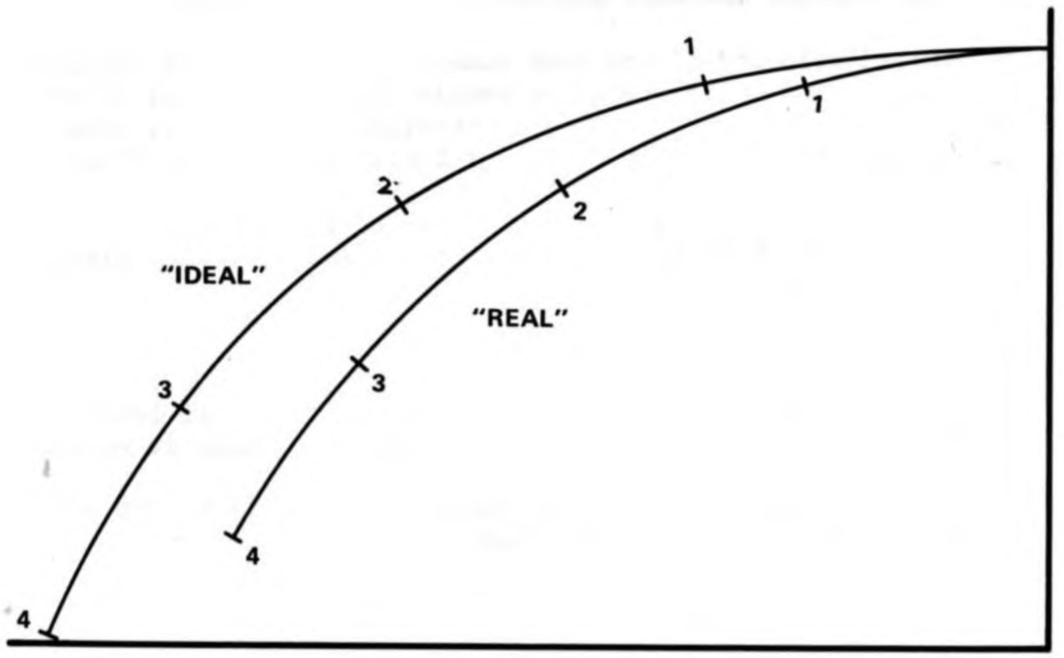


FIGURE 8–3. COMPARATIVE TRAJECTORIES

c. The Real Bomb

This has a downward acceleration less than the ideal of 32.2 ft/sec^2 (Fig. 8-2) and a reduced forward speed over its time of flight compared to the releasing platform's because of air resistance. The difference depends on its size, weight and shape and is tabulated for all bombs.

Briefly, a real bomb will always be above and lagging behind an ideal bomb (Fig. 8-3).

d. Wind Effect on Real Bomb

The wind effect is the same in principle as that of the ideal bomb, only more marked because of the longer time of flight of the real bomb for the same release conditions.

We now know the real bomb's flight path from releasing platform to impact for a given time of flight and wind velocity, the latter assumed to be constant throughout the height range.

The question that remains is how to fix this point of release in space in relation to impact point (the target) so that we can recognise it from the aircraft.

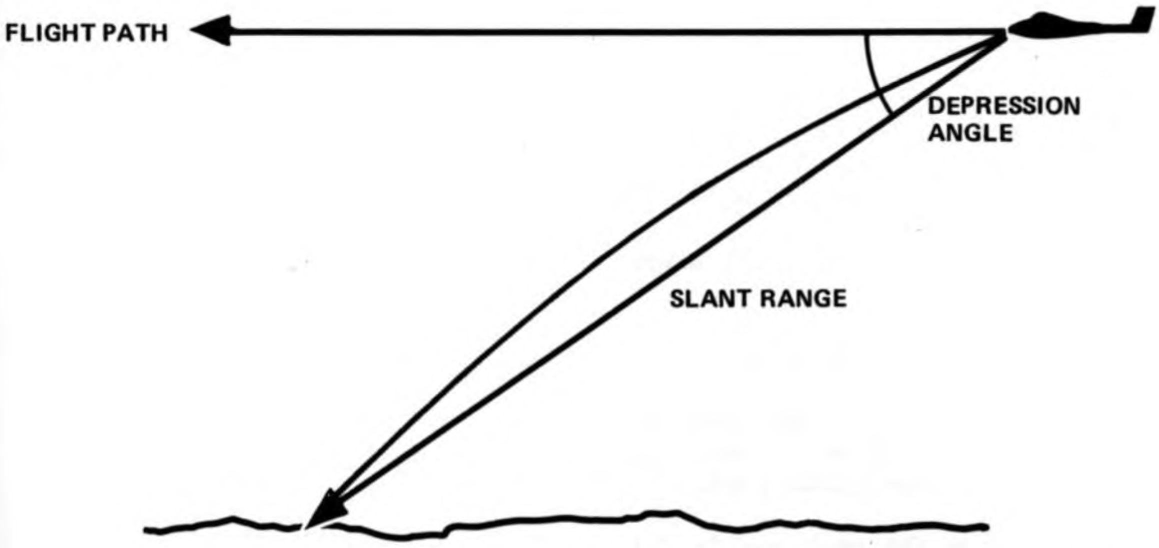


FIGURE 8–4. SLANT RANGE AND DEPRESSION ANGLE

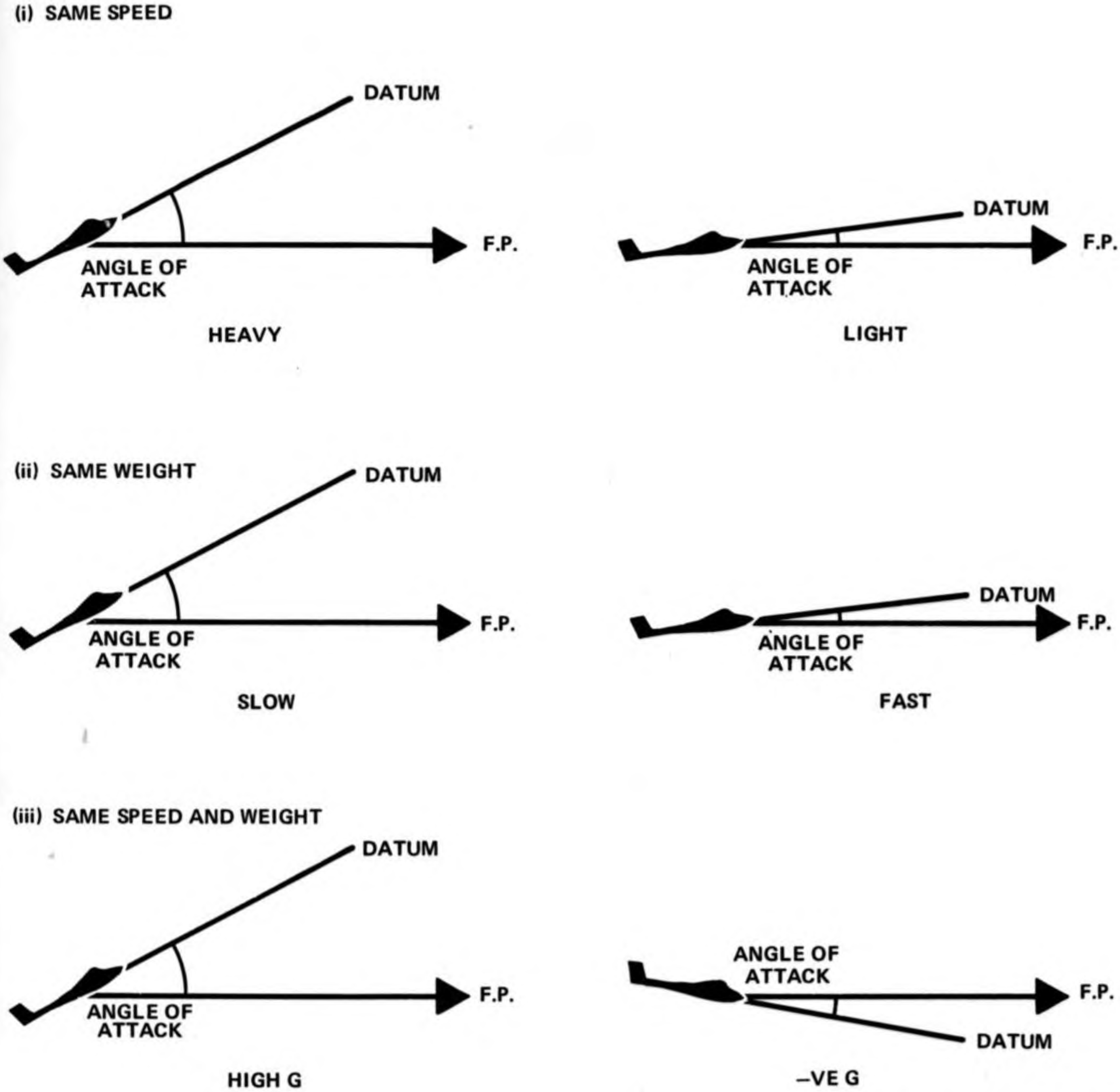


FIGURE 8–5. ANGLE OF ATTACK

e. Sighting

If one could measure the slant range (distance from releasing aircraft to target) covered by the bomb's trajectory this would be an ideal method.

There are ways of doing this, both optically and by radar, but for numerous reasons they are impractical, and the most usual, which applies to the Sea Vixen, is to convert this slant range into a depression angle below the aircraft flight path. Slant range and depression angle are entirely interdependent (Fig. 8-4).

If the aircraft is fitted with a sight, fixed in relation to the airframe, from which one can read off varying depression angles below a known datum it is a good start. If the angle by which this datum varies above and below the aircraft's flight path for various speeds and weights can be established, it is even better.

As any good Q.F.I. can tell you there is a distinct relationship between angle of attack, speed and weight, and he may even tell you that it is affected by G loading as well (Fig. 8-5). With all this knowledge we are now in business, because we can recognise the angle of the impact point (target) below the aircraft's flight path for the correct point of release to get our bomb's trajectory to pass through the target.

This depression angle, gravity drop angle or sight setting angle is what the Squadron A.W.I. works out, for a fixed set of release conditions, namely:-

A/C Weight
Speed
G
Height
Dive Angle
Type of Weapon

Variation from these parameters will produce errors as follows:-

(1) Weight

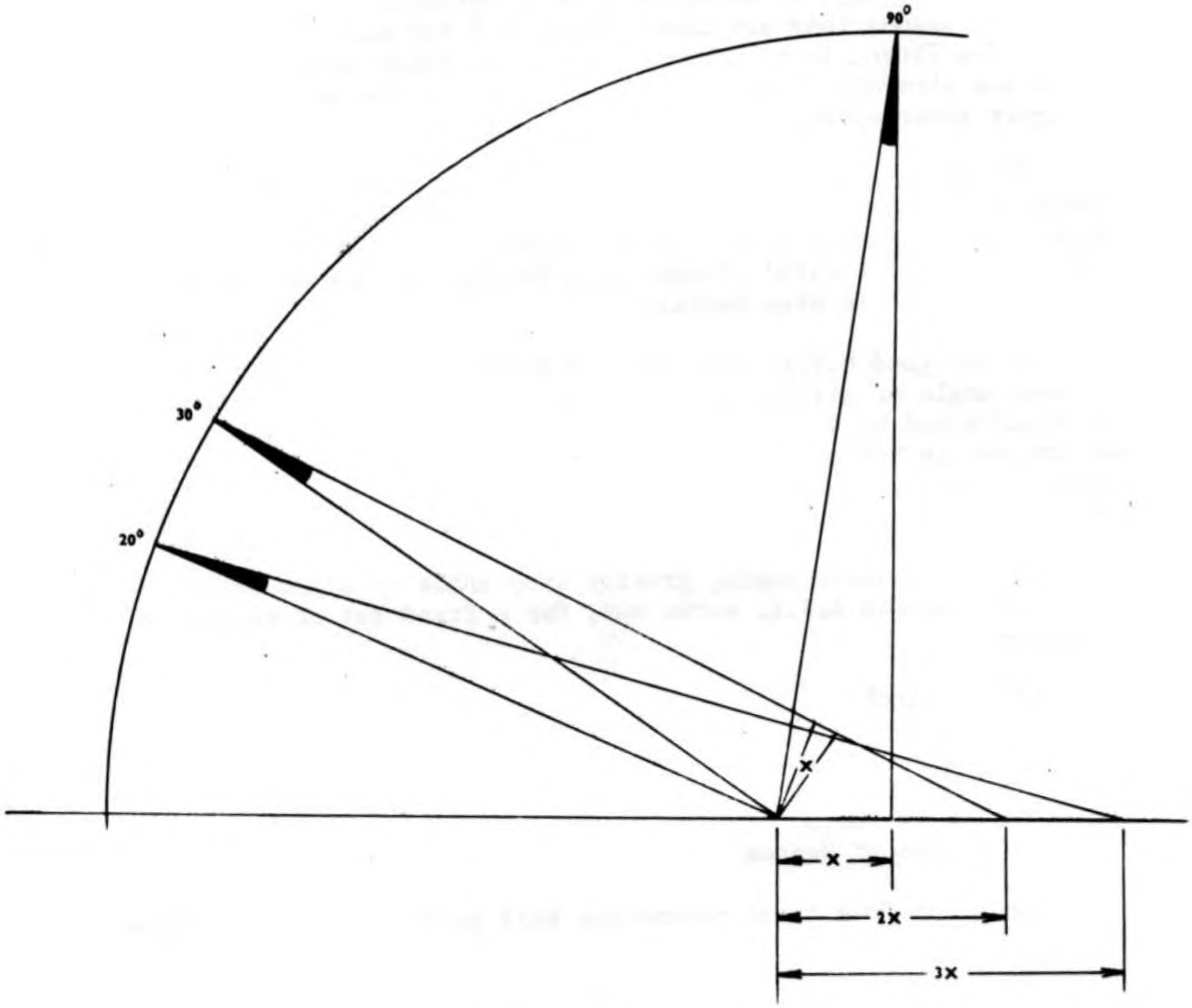
If you are heavier than calculated the lift required will have to be generated by an increased angle of attack. This puts the sight high in relation to flight path, weapon will fall short.

(2) Speed

Faster than calculated gives higher initial velocity to weapon, and reduces angle of attack required causing weapon to fall over.

(3) Height

A high release puts weapon further along and down trajectory in relation to calculated point of aim, and you release at a greater slant range than calculated causing weapon to fall short.



(1) ALL ◢ (SUBTENSIONS) ARE EQUAL

(2) X's ARE ALL SAME LENGTH

(3) 2X TWICE LENGTH OF X FOR 30 CASE

(4) 3X THRICE LENGTH OF X FOR 20 CASE

FIG. 8-6 SIGHT SUBTENSIONS

(4) Dive Angle

Effective weight of aircraft = A.U.W. x Cos Dive L.

The steeper the dive the less the effective weight of the aircraft, so the less the angle of attack required to produce the lift to support the weight.

Steep dive, less angle of attack than calculated, weapon over.

(5) G

Affects effective weight similarly. Increasing bunt reduces effective weight and angle of attack, causing weapon to fall over.

(6) Wrong type of weapon - do not pass "start" return to calculations.

If you vary any of these conditions, you will not be releasing at that point in space fixed in relation to the target from which your bomb trajectory will pass through the target - result? 40 yards at six o'clock.

f. Wind Allowance Calculations

From the formula D = Wv x t it is known how many feet/yds the bomb will travel due to wind effect during its time of flight. Hence a 10 knot wind allowance (e.g. 9 yards) may be calculated, again by the A.W.I.

g. Sighting

The sight set-up for a given attack produces a sight-picture whose angular subtensions can be calculated (A.W.I. again). The distance on the ground covered by these subtensions can also be calculated for a given slant range, dive angle and depression.

A rad. (radius) is the standard unit of measurement of a circular sight picture, as in the Sea Vixen, and you have probably heard already the phrases "A rad is worth 'N' yards horizontally and 'Y' yards vertically".

Briefly, in a vertical dive the worths would be the same. In a 20° dive the vertical is 3 times the horizontal and in a 30° dive it is 2 times the horizontal (Fig. 8-6). This is only approximate because sight depression has to be taken into account.

Allowance for target movement is calculated in the same way as for wind.

(4) Dive Angle

Effective weight of aircraft = A.U.W. x Cos Dive L.

The steeper the dive the less the effective weight of the aircraft, so the less the angle of attack required to produce the lift to support the weight.

Steep dive, less angle of attack than calculated, weapon over.

(5) G

Affects effective weight similarly. Increasing bunt reduces effective weight and angle of attack, causing weapon to fall over.

(6) Wrong type of weapon - do not pass "start" return to calculations.

If you vary any of these conditions, you will not be releasing at that point in space fixed in relation to the target from which your bomb trajectory will pass through the target - result? 40 yards at six o'clock.

f. Wind Allowance Calculations

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Allowance for target movement is calculated in the same way as for wind.

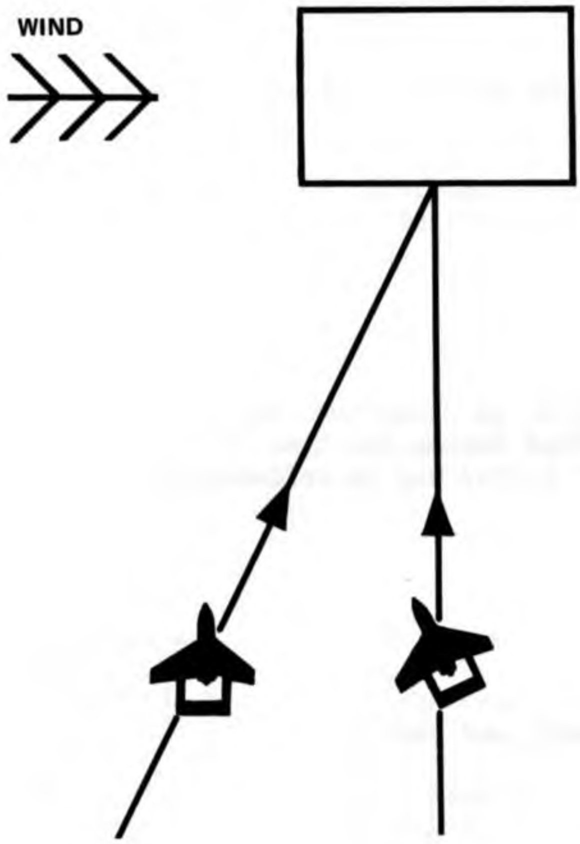


FIGURE 9–1. CROSS WIND ALLOWANCE

CHAPTER 9

LOW LEVEL BOMBING

901. Sighting

This is one application of the previous theory.

We need to know a couple more things though to get that target.

The first is height of sight above bomb, because this will produce a greater depression angle - though you may not believe it sometimes, you are looking down on the target more than the bomb is.

The other is the occasional use of E.R.U.'s to release the bomb. These impart an additional downward velocity to the bomb at release which has to be taken into account.

Both are constants and part of the course so the A.W.I. includes them in his calculations.

Achieving the correct release conditions is critical in L.L.B., because at this low altitude slant range errors are enormously magnified.

For example: Aircraft speed 450 kts. 25 lb Practice Bomb.

Release Ht.	Time of Flight	Slant Range
80'	2.34 secs	570 yds.
70'	2.11 secs	450 yds.

Target Ht.

10' There is a bracket of 0.2 secs in which to release bomb to hit the target.

At 450 knots in 0.2 secs the aircraft covers 50 yds of ground.

902. Wind Allowance

There are two ways of looking at the problem. Either you can release upwind by the amount the bomb will be blown by the wind during its time of flight or preferably you can aim the aircraft flight path at the target by crabbing, to allow for X-wind, releasing early or late to allow for tail or head winds. (Fig. 9-1)

Most pylons are offset from the aircraft centre line, so you have to make a further allowance and aim the flight path of the pylon in use at the target.

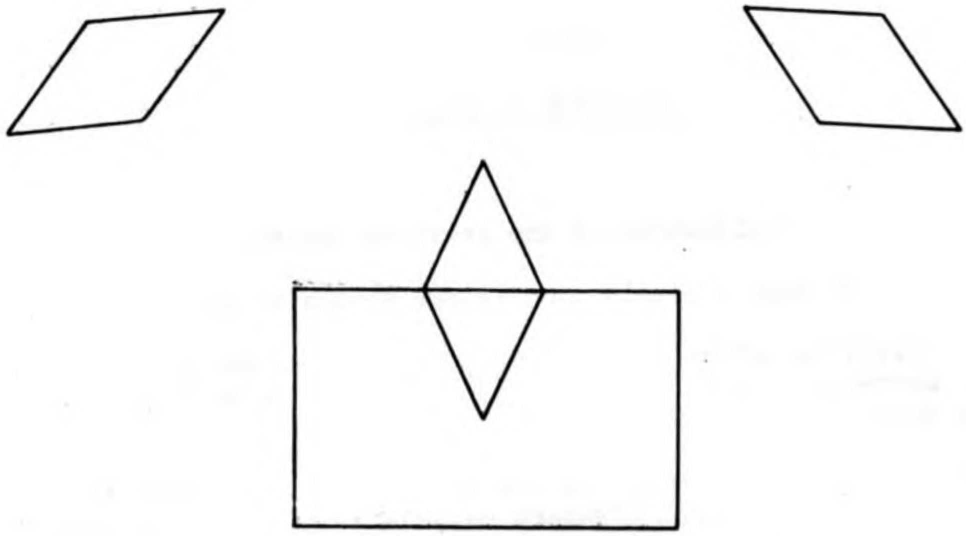


FIG. 9-2 NIL-WIND AIMING

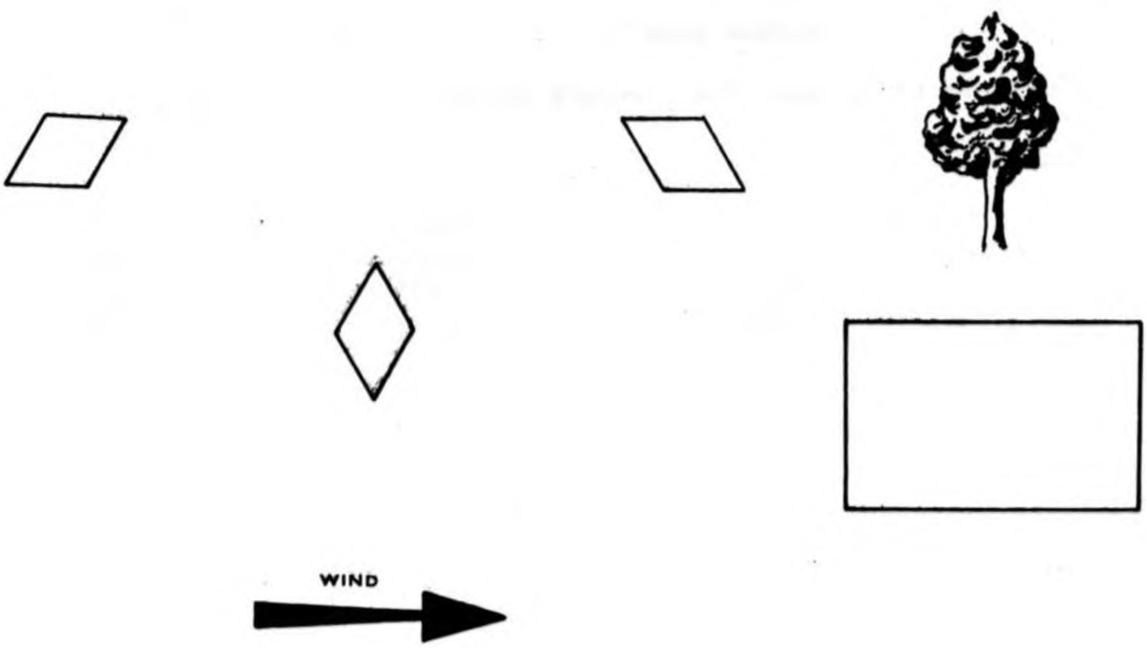


FIG. 9-3 CROSSWIND AIMING

903. Practical

From the above you should be able to see that you have to achieve the precise conditions for which the sight setting was calculated when you release your bomb for it to hit the target.

The best way to go about it is to get settled down early on the run-in at the set height, speed and line of attack, right switches and sight picture made. You can then concentrate on flying the pylon in use at the target.

Taking the case where the bottom of the six o'clock diamond is the release point of aim, there is no wind and our aircraft is modded to carry a centreline pylon. Throughout the run in you are running the bottom of the six o'clock diamond ahead of you over the ground or sea, until it runs up to the centre of the target (Fig. 9-2) when you pull the trigger. (Although your sight is just offset from the aircraft centre line we haven't bothered in this case to make allowance for it as it is such a small amount).

Simple - "Target".

Add a beam wind, and, with the same set-up you crab the aircraft towards the target. If there is a useful tree in the background by keeping the aircraft in transit with it throughout the run-in you can allow exactly for the wind. At sea the problem is greater.

Approaching the target and you find that the six o'clock diamond is way off to one side of the target! What to do? This wasn't in the brief. Release when the bottom of the six o'clock diamond is level with the centre of the target (Fig. 9-3).

The same sort of problem arises with pylons offset from the centreline.

Answer - the same.

For a headwind you have to release later, a tailwind earlier.

The 10 knot wind allowance is known for the attack, and the subtension of the aiming mark (six o'clock diamond) has been calculated; so it is a simple matter to relate the two.

Correction for a bow or quarter wind is a combination of the head and beam cases.

904. Academic Practice L.L.B.

Most range orders require a dummy attack to be carried out prior to live. It is a good idea to continue with dummies until you are satisfied that your attacks are similar and standard; because if you vary anything, release height in particular, your corrections will be invalidated.

Correction to previous fall of shot is as important as ever, and more thought than usual is required in L.L.B. to applying the correction in the right sense and making proper allowance for any errors in release conditions.

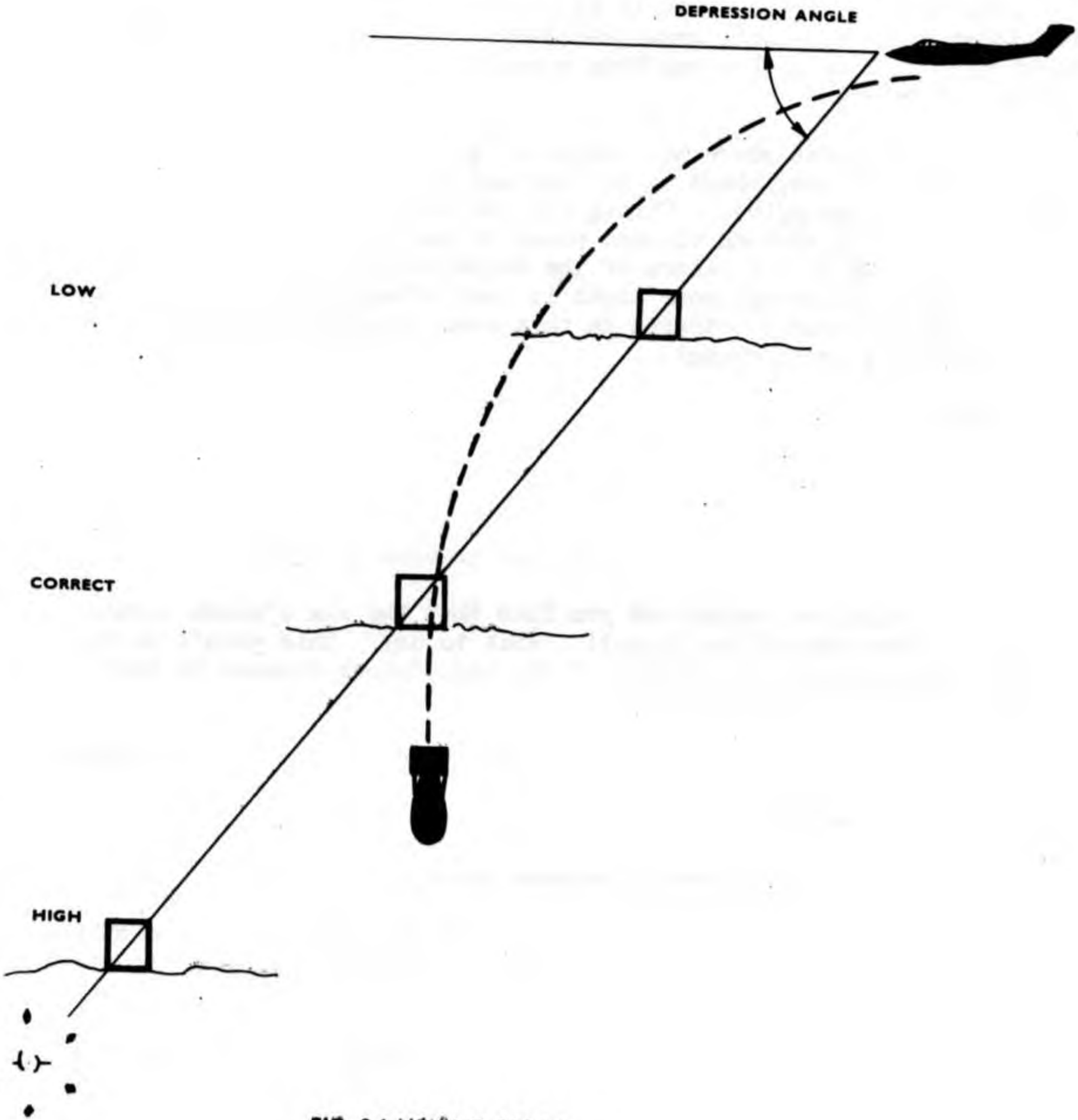


FIG. 9-4 HEIGHT ERROR

905. Common Errors in L.L.B.

Apart from the usual ones of wrong sight set up, wrong switches and forgetting to change pylons, some common errors are listed with their results to fall of shot and reasons.

RELEASE ERROR	RESULT	REASON
(1) Not flying bomb carrier/pylon at target.	L or R	Obvious
(2) High	Short	(See Fig. 9-4)
(3) Low	Over	
(4) Fast	Over	i) Extra horizontal velocity ii) A of A reduced. Sight low producing late release.
(5) Slow	Short	Reverse
(6) Bunting	Over	Sight picture down on correct position relative to flight path, so bomb is released closer to target for same forward throw.
(7) +ve G applied	Short	Converse of 6
(8) Yaw	L or R	If, though yawing, you still fly the pylon at the target this will not apply.
(9) Bank	L or R	If A/C is banked it will be turning and bomb is released at a tangent to the turning circle.

906. Occasions for using L.L.B.

a. Advantages
Low cloud base.
Very accurate form of attack.
Remain longer below radar cover.
Difficult to spot on run-in.
Near-immune to enemy G.W.

b. Disadvantages
L.L. Nav.
Target acquisition.
Tgt. must possess vertical development.

At the moment there are few live weapons that can be used in this form of attack because of the lack of a safe fuze.

However the firebomb is one useful weapon that can, and the retarded bomb will shortly be with us.

Inert bombs may cause effective damage to some targets (ships?).

907. Switches

Sight

PAS ....AG

W/S ....48'

Mod 3026 ....GW/RP

SS U 0

Throttle ....Min Range

Trim ....400 Kts.

Armament

As for Dive Bombing.

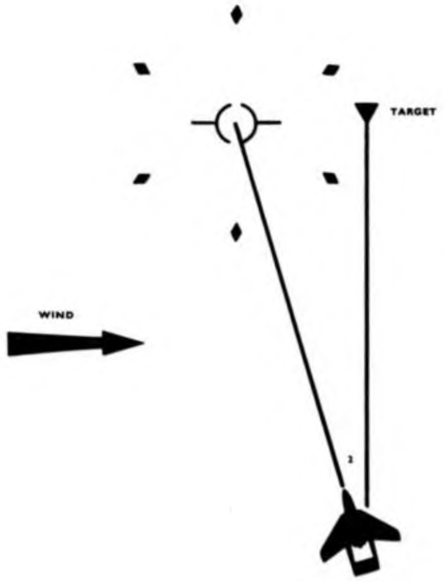


FIG. 10-4

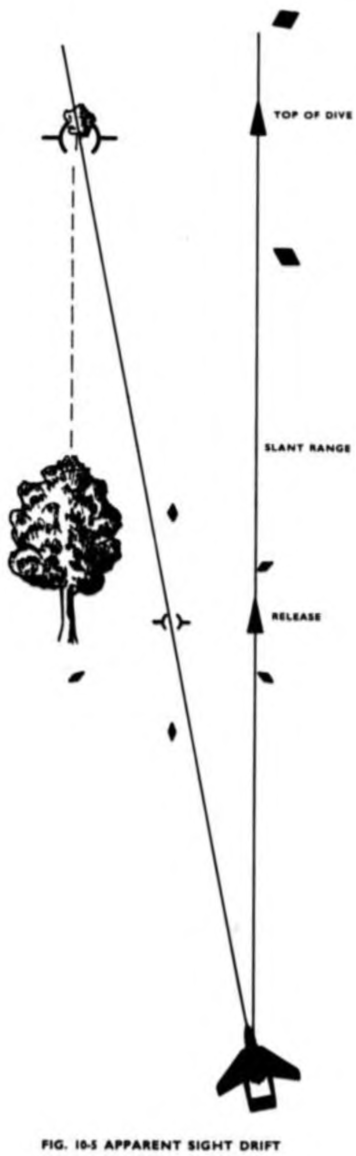


FIG. 10-5 APPARENT SIGHT DRIFT

CHAPTER 10

DIVE BOMBING

1001. Sighting

a. If you lift the L.L.B. case up to 20° hinged at the target the problems are very similar.

The horizontal distance the ideal bomb travels is still the product of its forward velocity and its time of flight. But since the aircraft is now in a dive these are different from the straight and level case (Fig. 10-1). Its forward velocity is now aircraft velocity cosine dive angle, and the time of flight (t) is the change in vertical velocity from release (Vv) to impact (Vi) divided by acceleration applied to the bomb (g).

$$t = \frac{Vi - Vv}{g}$$

The real bomb naturally varies from this, still lagging behind and above the ideal, and the correct figures are extracted from ballistic tables.

This horizontal distance travelled to the target will again give the required depression angle and slant range from the target at release.

The maximum depression required is for a level attack, decreasing to 0 for a vertical dive. So one depression is correct for one angle of dive only. (Fig. 10-2)

With any depressed sight the aircraft is bound to bunt if the target is tracked, at an increasing rate with decreasing range or increasing speed (Fig. 10-3)

This will vary the aircraft angle of attack and therefore aiming mark in relation to flight path, which is allowed for in the A.W.I.s calculations.

In dive bombing the sighting problems are different from (low) level bombing because of:-

(1) Target Tracking Instead of running the aiming mark up to the target, one tracks it.

(2) Aircraft Acceleration During the Dive

If the wind were constant throughout the height range from dive entry to target, the rate of aircraft and sight drift in relation to the target decreases throughout the dive because at release, speed is higher than it was at entry.

The effect of this is that one can now no longer crab the aircraft at the target for cross wind to aim the flight path at the target. If one carried out a constant speed dive one still could.

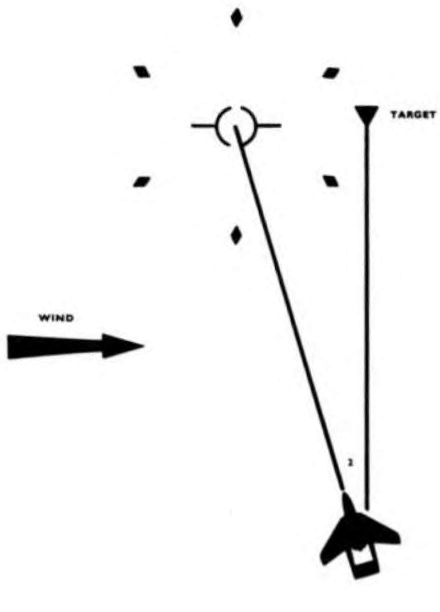


FIG. 10-4

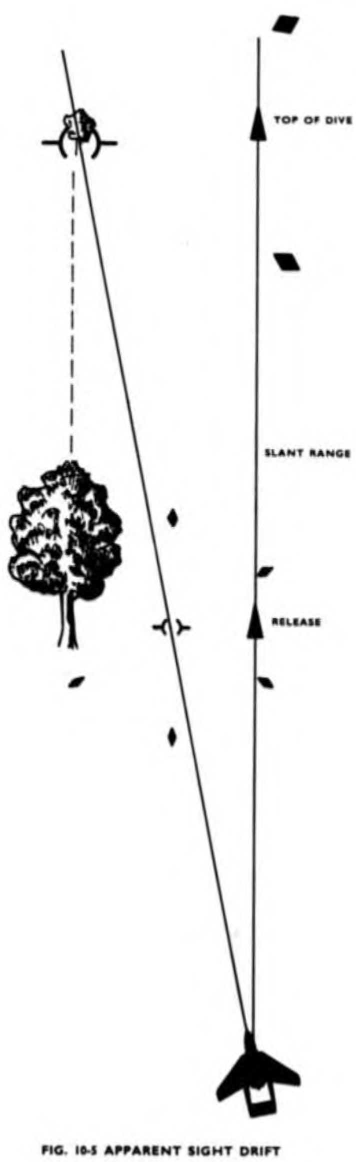


FIG. 10-5 APPARENT SIGHT DRIFT

b. <u>The Constant Speed Dive</u>

Taking your Dalton computer and dusting off the cobwebs you can see that at 350 knots with a 90° cross wind of 12 knots one needs to lay off 2° of drift to maintain track.

In a 20° (or any other) dive at a constant speed of 350 knots using a 2° rad. sight, with a constant beam wind from the left at 12 knots, one could put the " three o'clock diamond" on the target at the top of the dive, fly down the dive wings level and it would remain there until release, after which the bomb would hit the target.

By putting the three o'clock diamond on the target you pointed the nose of the aircraft, and centre aiming mark (wing circle in the case of the Sea Vixen) 2° left to allow for the 12 knot beam wind so that your aircraft flight path was pointing at the target. (Fig. 10-4)

You may have noticed the wing circle drifting in towards the target from L to R. This in fact is <u>not</u> a case of drifting the sight in, but the 2° Rad covering for example 30 yards on the ground at release height but 75 yards at entry.

The tree that was behind the wing circle at the top of the dive "moves out" to the left 45 yards during the dive giving the wing circle an apparent drift to the right. (Fig. 10-5) One has still been using the crab technique in some parts of the sight (if we could do a constant speed dive!)

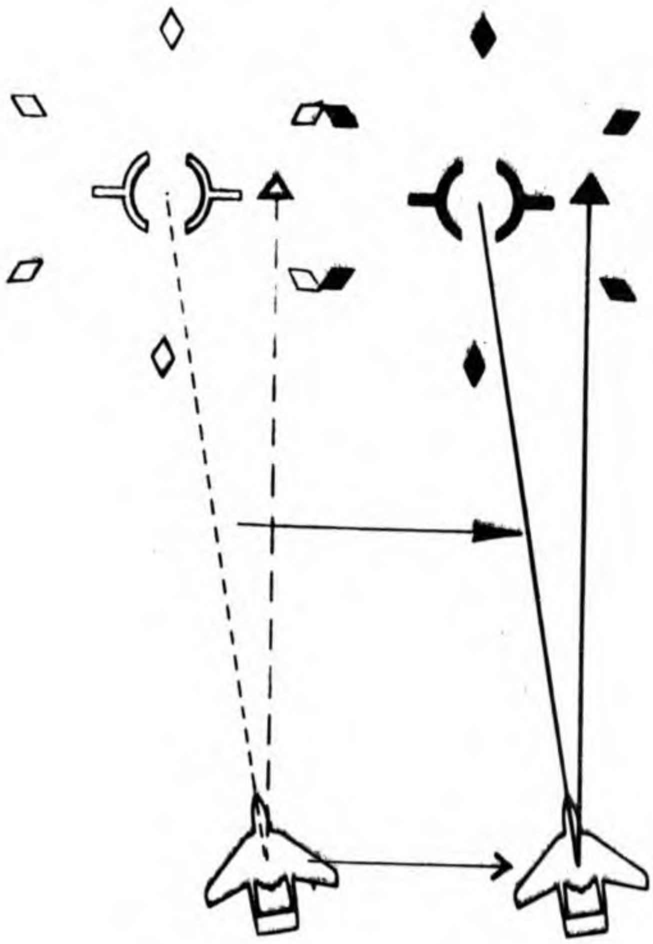


FIG. 10-6

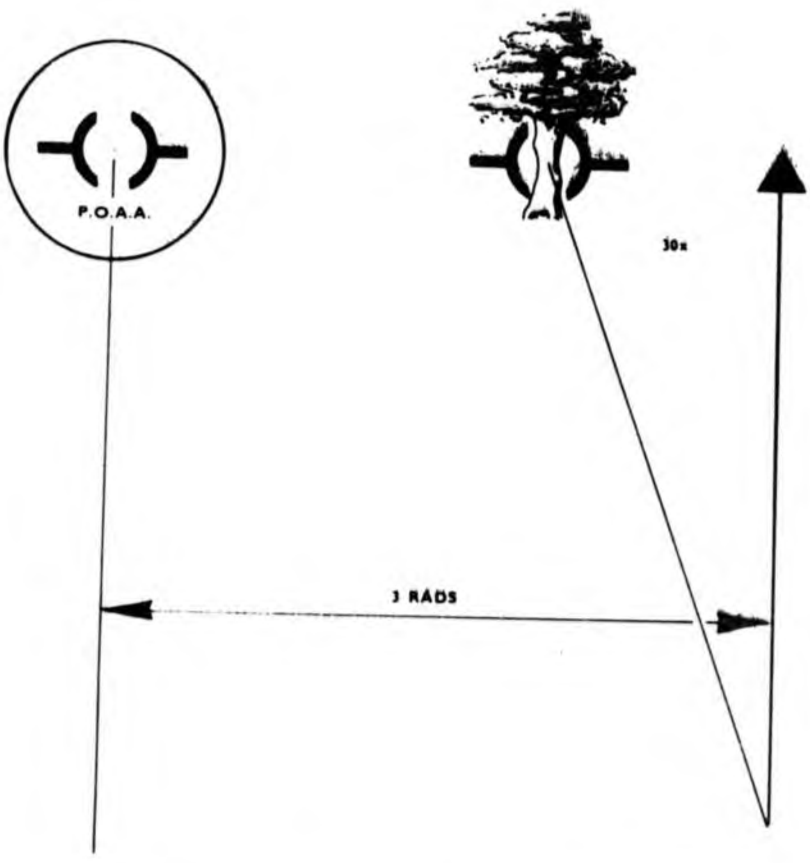


FIG. 10-7 AIMING GROUND-RELATIVE AND P.O.A.A.

c. The Accelerating Dive

One could work out all the drift angles required over the speed range for a given wind, and turn the aircraft towards the target during the dive from the larger drift angle at the top to the smaller at the bottom to maintain the flight path pointing at the target.

This has obvious disadvantages apart from the hours of calculations required, when one only wants to achieve the aircraft flight path pointing at the target at release.

The way to achieve this is to work out the required drift at release, for example 2° or the three o'clock diamond again, and put the aircraft and three o'clock diamond further upwind of the target at the top of the dive, pointing the required 2° left, knowing that it will be blown downwind during the dive because you haven't allowed a sufficient drift angle for the slower initial speed (Fig. 10-6).

d. Wind Allowance

For any wind the formula D = Wv x t holds good - the distance the bomb is blown downwind is the product of its time of flight and the wind velocity.

So if you release by that amount D upwind, the bomb will hit the target.

If for example you attack a target such that the distance D is 30 yards, with the wind from 90° left, and there is a tree 30 yards to the left of the target at right angles to your line of attack, if you release with your centre (nil wind) aiming mark on that tree, your bomb will hit the target. This is aiming ground relative (Fig. 10-7).

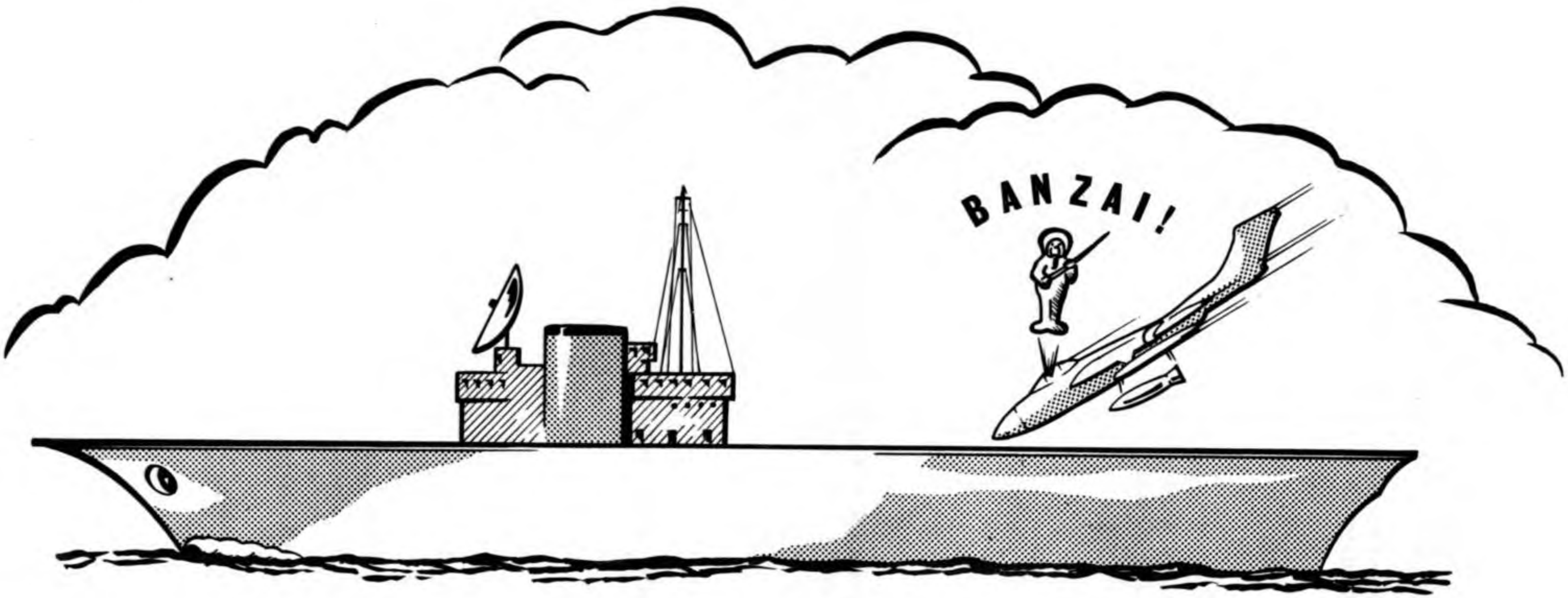
Unfortunately such aids are rarely found in the right place for shore targets, and never at sea, so a system that does not rely on ground features has to be devised; aiming sight relative.

Taking the same problem in sea borne conditions, if the sight subtends 30 yards horizontally and 90 yards vertically at release, once again you would release with the three o'clock diamond on the target. (If the tree were still there the centre aiming mark would still be on it).

No crab technique this way; simply put the sight the right amount upwind at release. To get it there you would have to let it drift down to that position during the dive.

A good guide to achieve this is that if you require the centre aiming mark a rad left (upwind) at release, you need to put it in the Push Over Aiming Area a total of three rads left at the top of the dive for it to drift down the correct amount during the dive (Fig. 10-7).

Rule of thumb is: $\frac{\text{time of flight}}{\text{time in dive}} : \frac{1}{2} : \frac{\text{Wind allowance}}{\text{drift}}$



ZERO TIME OF FLIGHT

FIG 10—8

But drifting the sight, you point out, is only apparent - it's really the tree moving the other way! So there must be a part of the sight picture that is steady on the target during the dive as in the crab technique. Correct for constant speed, constant wind, ideal bombing. But you have to drift it a certain amount to allow for the accelerating dive and the real bomb characteristics.

The actual method used is the standard British Compromise - a bit of both, drift and crab, which gives the right results.

1002. Practical

In divebombing what governs the choice of parameters?

"The shorter the time of flight of the weapon the more accurate the result" is an old Confucius saying that is equally true today.

The Japanese took this statement to its logical conclusion in W.W.II and their Kamikaze pilots carried their weapons with them to the target (Fig. 10-8) time of flight zero - results very accurate, but it is an expensive way of achieving the CDCI standard.

1003. Choice of Release Conditions

a. Height

Regulations lay down 1350 feet above target level as the minimum safe peacetime height for the releasing aircraft to descend to in its attack before the risk of ricochet damage from the fragmentation envelope becomes too great. This for live 1,000 and 500 lb bombs. In operational conditions this minimum height may be reduced in accordance with tables giving probability of damage against height of aircraft.

On the other hand the minimum release height may be raised taking into account the effectiveness of opposing ground fire for example, as was the case in Vietnam.

Considerations of entry height are that sufficient tracking time in the dive to produce accurate results must be offset against time steady in the dive as a target for the enemy.

Another factor is the cloud base likely to be met in the theatre of operations.

b. Dive Angle

One can release at a shorter slant range in a steeper dive to remain above a given minimum height over target.

The steeper the dive the greater the rate of increase in speed, and the more height required for recovery.

The steeper dive gives a greater weapon striking angle, which may for example be required for armour penetration. Similarly a target behind a hill or concrete revetments may be immune from a shallow dive attack.

The steeper the dive the higher the cloud base required.

The 20° dive has been taken as the optimum.

c. Speed

A constant speed dive is not possible in the Sea Vixen because of the nature and effects of the airbrake.

A fast approach to the target is desirable for obvious tactical reasons, which controls to a certain extent the entry speed range available to you at the top of the dive.

The higher the speed during pullup or approach to the entry point the greater the enemy's problems.

The higher the speed at release the shorter the time of flight and the less the gravity drop of the weapon. But you cover a greater height and distance during the dive for a given tracking time and require more height for recovery for a given G, which forces up the release height.

Above about 420 knots in the Sea Vixen, pilot induced oscillation becomes apparent.

As may be seen there are numerous factors to be considered in the choice of release speed.

1004. Choice of Weapon

a. The 500 lb bomb is the usual choice for the Sea Vixen which can carry four. They may be dropped simultaneously or individually. If there is a requirement for the 1,000 lb bomb it involves a role change and the loss of range involved by the removal of the drop tanks.

b. Fuzes

Both types of bomb may be fitted with instantaneous, variable delay or VT (Airburst) fuzes depending on the type of target. At present the use of VT fuzes is in abeyance.

Further details are available in the weapon effort planning leaflets.

c. Max Striking Speed

The maximum striking speed is approximately 800 f.p.s. which corresponds roughly to a release speed of 480 knots.

If this speed is exceeded against a hard target the bomb casing breaks up before the main explosion takes place and most of the effectiveness of the weapon is lost.

1005. Divebombing Technique

a. En route to the target it is important to trim the aircraft out for both pitch and yaw at the release speed. This means that you may require to hold off some of the trim until release.

b. Target or range Q.F.E. must be set.

c. Before weapon-release the correct switches have to be made. This is a statement of the obvious but it bears reiteration.

d. If the correct entry conditions are achieved the rest of the attack is comparatively simple.

e. The sight must be placed in the push over aiming area early to give maximum tracking time in the dive. You can fly it round roughly to achieve this, and then steady down in the dive. A master green smooth as silk gentle entry will only have the sight where you require it half way down the dive halving your tracking time.

f. Steady tracking in the dive leads to best results. Watching the rate of sight movement during the dive from POAA to release point of aim, and only making corrections to increase or reduce this to achieve the correct sight picture at release is the proper method of sight-handling.

g. Last minute corrections are pointless because although you may have moved the sight to the right place, the aircraft has not had time to assume the new flight path, and the bomb follows the old flight path which is pointing the wrong way.

h. You must release wings level. If you have bank on, the aircraft will be turning and the bomb is released at a tangent to the turning-circle.

i. The aircraft must be in balanced flight at release - no yaw or rudder. If the ball is left the bomb will go left.

j. Most pilots tend to enter the dive shallow. They will be assisted in achieving the correct dive angle by the depressed sight line steepening the dive as the target is tracked. But remember that if you are using a sight depressed five degrees, your dive angle must appear through the sight to be 25° at release if you are aiming for a 20° dive.

k. A headwind will tend to shallow the dive, so you must enter steeper and expect the nil-wind bunt to be reduced. Conversely a tailwind will steepen the dive and increase the bunt required.

l. Slant range and release height are directly related for any dive. Since one cannot measure slant range, one releases at a given height.

Because the sight setting angle is worked out for a given dive angle and slant range, any errors made in dive angle will give less inaccurate falls of shot if one releases at the correct slant range, instead of at the same height. For example if you recognise the dive as being shallow you would release low to achieve the same slant range at release.

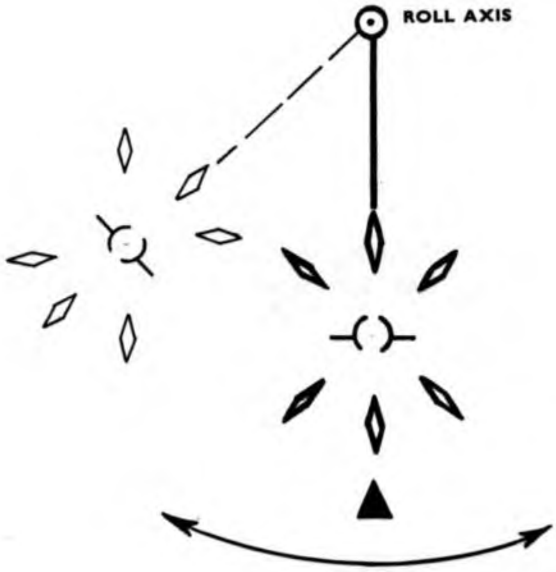


FIG. 10-9 PENDULOSITY

m. Sighting or release errors made in a shallow dive produce markedly worse errors in fall of shot than those resulting from a steep dive.

n. To drop a bomb accurately it is vital to achieve the correct release conditions - dive angle, height speed, and the all important correct release point of aim.

o. With the long times of flight involved, and large sight subtensions for operational release heights the need for accurate sight handling cannot be over emphasised. A small discrepancy in the required sight picture at release will give large errors in fall of shot.

A diamond's length aiming error can produce a fall of shot error of a fifth of the C.D.C.I. standard.

1006. Mod 1000

This sight setting unit gives the facility for selecting different depressions. In doing so it feeds in varying sight sensitivity by nature of its design rather than by choice, and this makes the sight lag to a lesser extent but in a similar manner to the Hunter G.G.S. This presents minor problems in that having for example banked to move the sight L or R there is a delay before the sight actually moves, it then lags behind the aircraft, and continues to move back to its initial position after the bank has been taken off again. With the bunted dive, the sight rides up. This is allowed for in the sight setting calculations but with the variation in bunts required for head or tail wind attacks, the amount of ride-up varies from that calculated and will produce errors in fall of shot. The sense of the variation tends to reduce the amount of this error but if by putting the sight upwind in the push over aiming area by such an amount that the nil wind bunt is flown during the dive, while still achieving the correct point of aim at release,this error will be eliminated.

1007. Pendulosity

The P.A.S. with mod 1000 is roll stabilised, so this effect is not apparent. However with a straight fixed depressed sight, the greater the depression of the aiming mark below the roll axis and flight path the more marked the effect.

If for example the six o'clock diamond is the aiming mark and the sight is drifting too slowly from left to right, starboard bank is required to increase the rate of drift. The immediate result of applying bank is to move the aiming mark left further from the target (Fig. 10-9). Only when bank is rolled off does the diamond return to a position closer to the target than it was previously and fine judgement is called for to produce accurate sight handling.

1008. Operational Attacks

Operationally an attack will most probably consist of one dive releasing all weapons simultaneously.

The sight picture for the forecast wind and expected target movement will have been briefed before departure. You are using a fixed sight with no computing capability to release your weapon to hit the target.

You may be the only aircraft to arrive at the target.

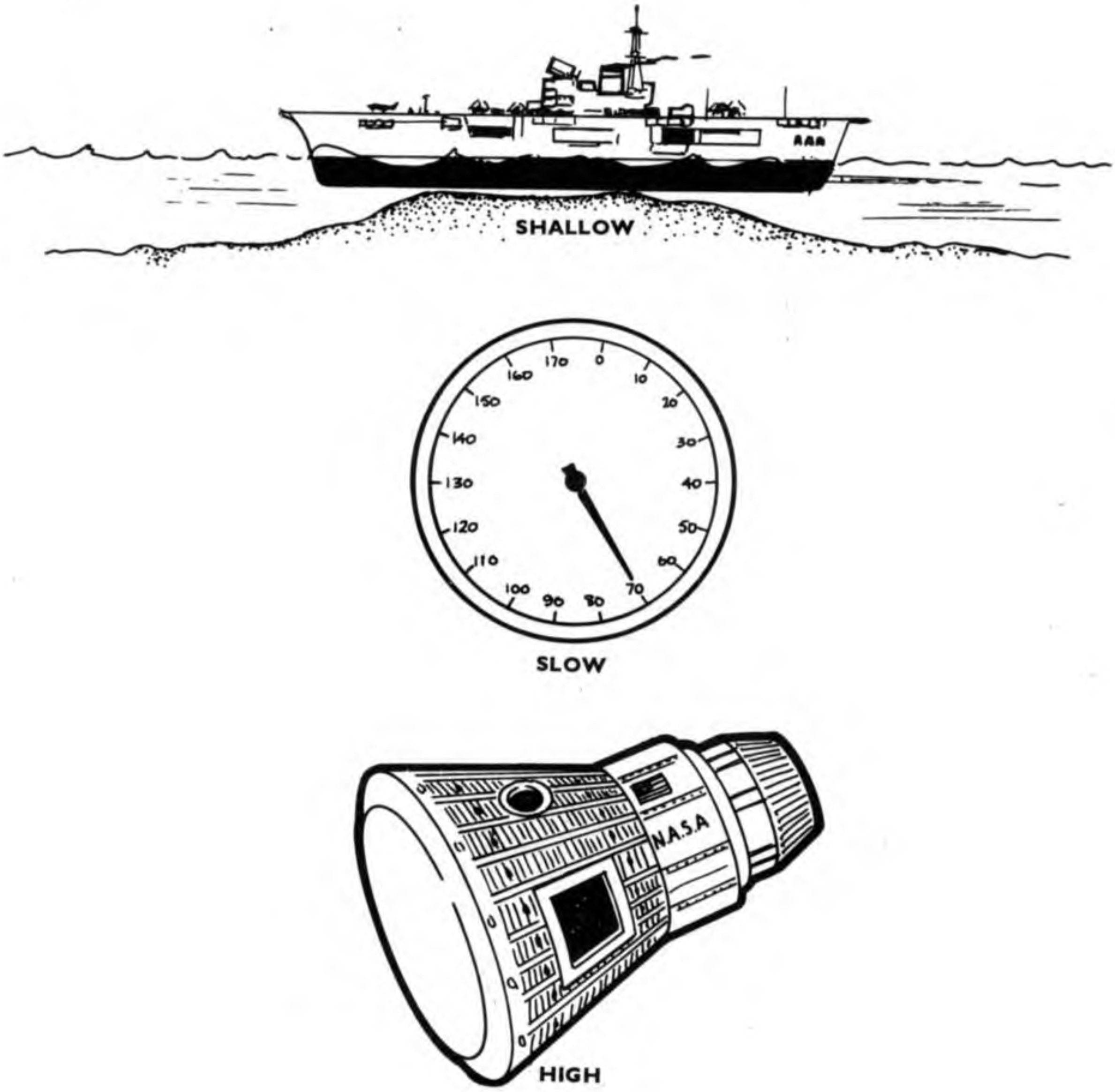
When you get there you find the target heading west instead of north and a gale instead of the forecast light warm zephyrs. It is up to you alone to achieve the correct release point of aim under these unexpected conditions to get your weapons to hit the target. This is what it has all been about!

1009. Practice Academic Bombing

This should have helped you when you find yourself in the above situation. But remember that the first bomb will be the one that will count - the one attack you will be able to make for real.

You can end up with an ace 50% C.E.P. but it's the 1st bomb 50% C.E.P. that really matters.

Everything that has been said applies equally to practice bombing, only you have the chance on these sorties to correct your previous fall of shot, and learn from your mistakes.



= SHORT

FIG. 10-10

1010. Errors in Dive Bombing (Figs. 10-10,11)

As for L.L.B. wrong switches form a high proportion of errors.

Release Error	Result	Reason
Steep	Over	i) Releasing at briefed height, slant range at release is reduced; trajectory high, bomb over. ii) Angle of attack is reduced because effective aircraft weight reduced, sight low on flight path, bomb over.
Shallow	Short	Converse
High	Short	Slant range increased, bomb further down trajectory than sight depression calculated for, falls short.
Low	Over	Converse
Fast	Over	i) Bomb leaves aircraft with higher initial velocity, goes further. ii) Angle of attack reduced because of higher speed, sight low on flight path, bomb over.
Slow	Short	Converse
Yaw	L & R	Ball L, Bomb L.
Late Correction for Sight Picture	Random	Aircraft not assumed new flight path.

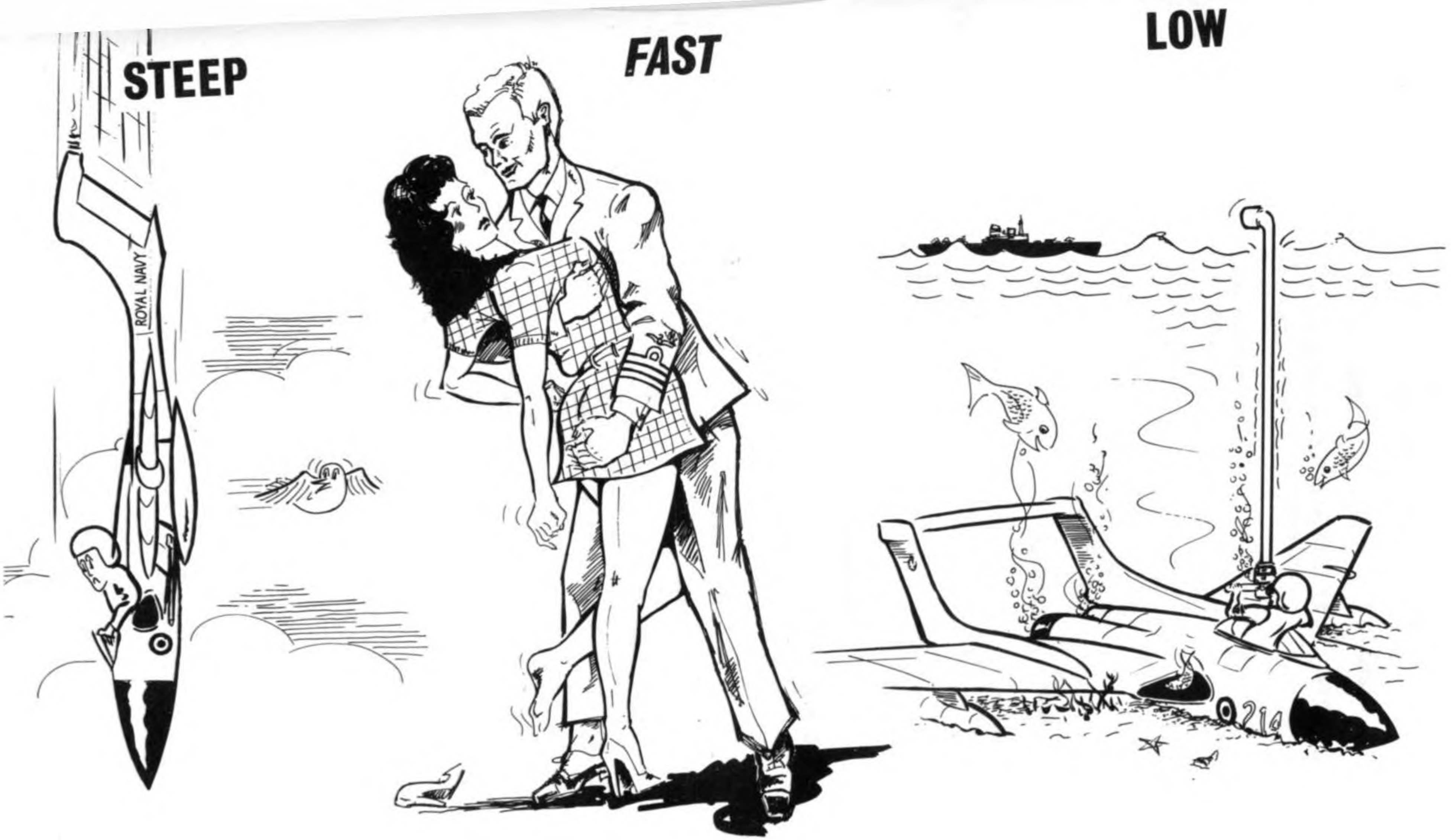
1011. Occasions for using Dive Bombing

The 1,000 lb H.E.M.C. Bomb is the primary strike weapon of the Fleet.

The 500 lb H.E.M.C. Bomb comes a close second.

The variety of targets against which they may be used and for which they are most suitable is almost limitless, and includes the following:-

Ships
Ground Installations
Personnel



=OVER

1012. Switches

Sight

PAS .... AG

SSU .... A/R

W/S .... 90'

Mod 3026 .... AG1

Throttle .... Min Range

Trim .... 450 knots

Armament

LABS/Normal .... Normal

H.P.S. .... Off

L.P.S. .... On A/R

Fuzing .... Off

A.M.S. .... Bombs

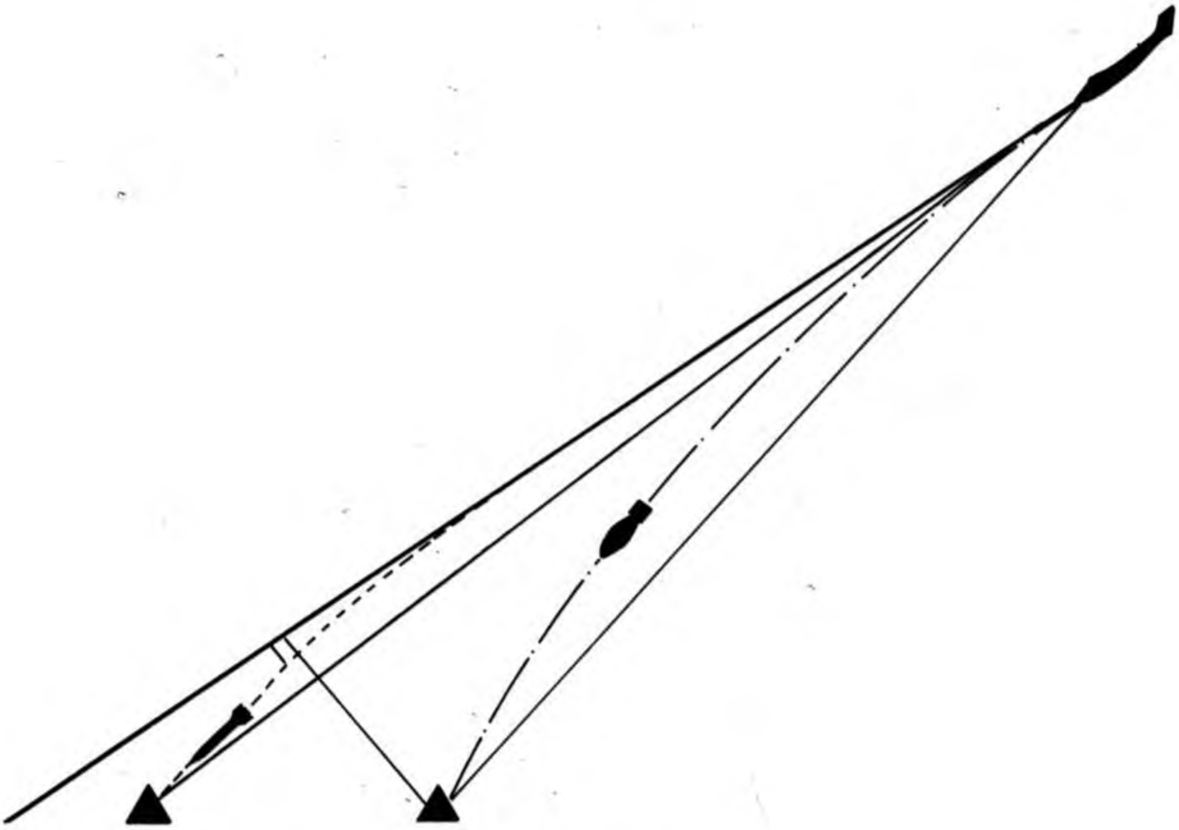


FIG. 11-1 COMPARISON OF GRAVITY DROP ROCKET AND BOMB

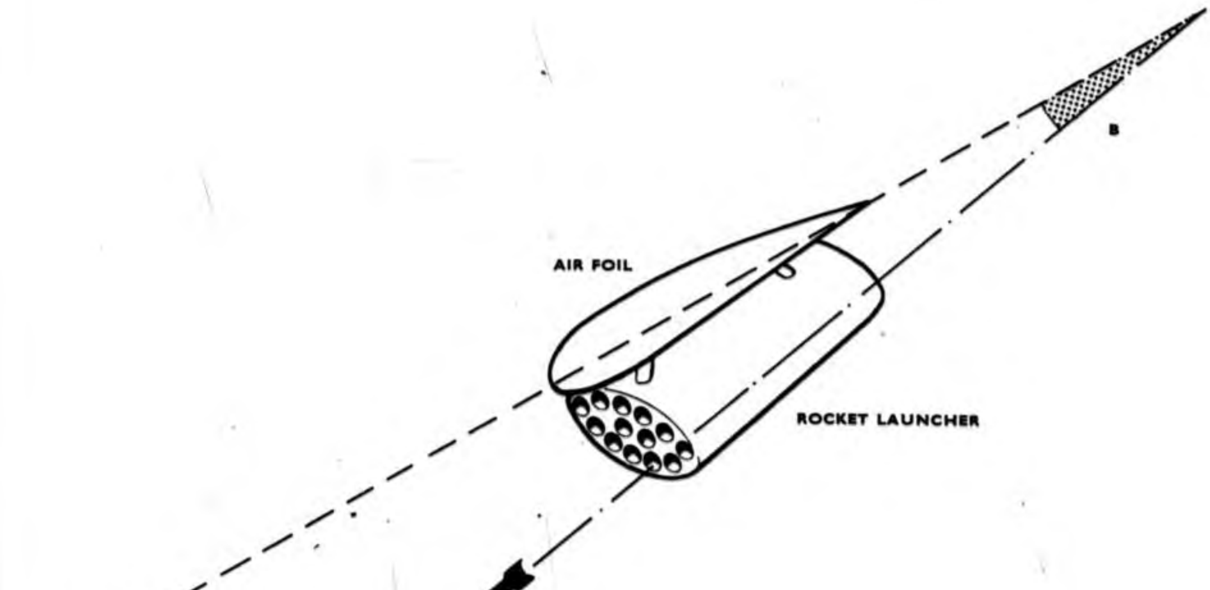


FIG. 11-2 VELOCITY JUMP

CHAPTER 11

ROCKETING

1101. Introduction

Most of the bombing theory and techniques apply equally well to rocketing.

The rocket is a fin-stabilised flight-path weapon, but not in the same pure sense that a bomb is, because it is self propelled for part of its flight.

1102. Sighting

Whereas the speed of the bomb during its time of flight is comparable to that of the aircraft at release, the rocket after firing accelerates to a maximum speed of 2100 f.p.s. above launch speed in 0.84 seconds. This gives it a much shorter time of flight in the region $1\frac{1}{2}$ to 2 seconds for a normal attack and reduced gravity drop over a given slant range compared to a bomb. (Fig. 11-1)

Because of this the amount of aim-off required for a given wind is reduced in comparison to bombing, and there is no longer the need to aim the flight path of the aircraft at the target since the rocket no longer continues along it but follows a flight path upwind of it.

For example if over a given slant range the time of flight of the rocket is half that of the bomb the amount of aim-off required is halved for the same wind.

The sight depression required for a rocket is less because of its reduced gravity drop, so less bunt is required when tracking the target.

1103. Velocity Jump

The R/P launcher on the aircraft is harmonised 1° 51' below sight datum. On firing, the rocket accelerates down the launcher tube and leaves it at a speed of 185 kts. pointing this amount below the sight datum; the fins then spread and the rocket assumes a flight path between its direction on leaving the launcher and the aircraft flight path. (Fig. 11-2)

The angular change is derived from the velocity jump L(E) formula.

$$E = \frac{Vt}{185 + Vt} \times B$$

Where Vt = Aircraft T.A.S. in knots, and B = Launcher incidence.

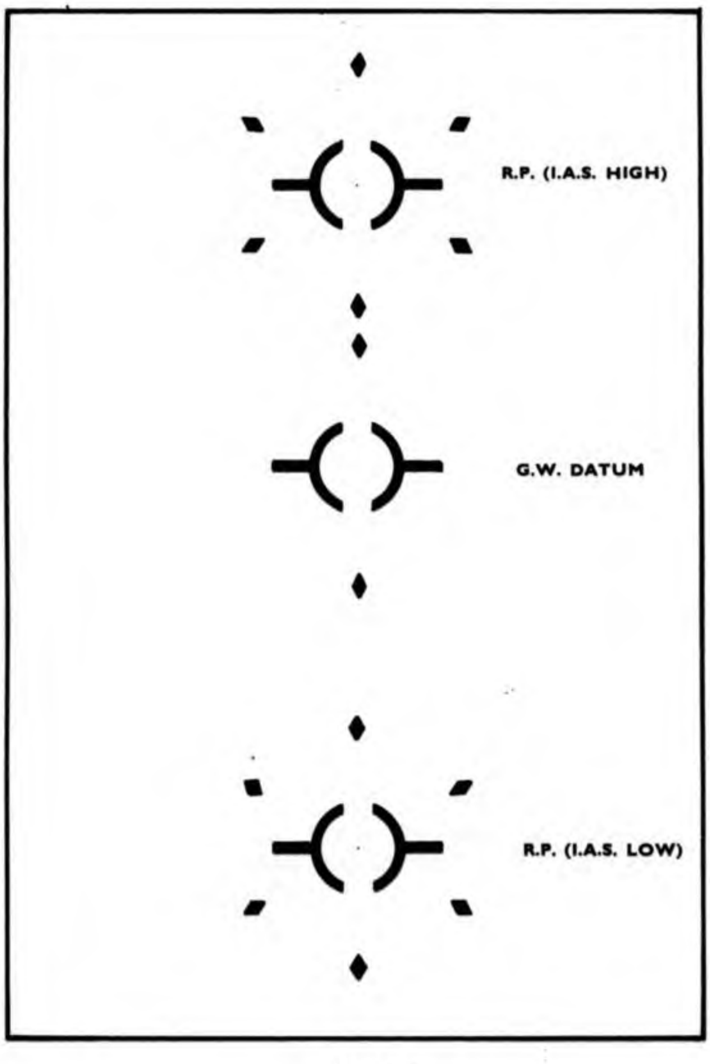


FIG. 11-3

1104. Practical

The same requirements exist as for dive bombing.

However with the shorter times of flight involved, and smaller sight subtensions resulting from the ability to release the weapon closer to the target, this is a more accurate form of attack, and the need for steady tracking during the dive is not so important as for bombing so long as the correct sight picture at release is achieved.

The same errors in the sight picture or release conditions produce smaller errors in fall of shot than they would for bombing, but in the same sense.

1105. Altitude Airspeed Unit

With the P.A.S. selected to the R/P mode this unit compensates largely for variations in airspeed by moving the sight picture vertically in relation to aircraft datum (Fig. 11-3). This reduces the effect of release speed errors.

1106. Slant Range

The minimum slant range for firing is limited to 1200 yards for safety reasons.

The closer you can release to the all burnt slant range the more accurate the attack, and the greater the weapon penetration, but from the figures below it may be seen that these are well inside the minimum laid down. However, operationally, closer firings may be permitted.

Release Speed (TAS Kts)	Approx. all burnt slant range (Yds)
300	520
400	570
450	595
500	620

Heights over target with regard to entering the fragmentation envelope bear careful consideration if one is ever to release at these sort of ranges.

1107. Firing Selections

The Sea Vixen can carry four 36 tube launchers, which may be fired individually or together.

The aircraft has a Central Timing Unit that provides the facility for firing single shot, fast or slow ripple by passing electrical impulses to each of the light stores pylons in turn at 10,10 and 40 millisecond intervals respectively in the order Port Inner, Outer, Starboard Outer, Inner.

Each pulse fires a pair of rockets from a fully loaded launcher.

By suitably half-filling a launcher, single rockets may be fired from it.

With full pods loaded the following firing selections may be made.

MODE	PYLON SELECTED	ROCKETS FIRED	INTERVAL (Milliseconds)	TOTAL FIRING TIME
i) Single shot	Single	Pair	Max delay of 30 m.secs if stbd. inner pylon selected	
	All	8 - a pair from each pod in sequence	10 between pods	30 m.secs
ii)Fast Ripple	Single	36 in pairs	40 between pairs	0.7 secs
	All	144 in pairs from each pod in sequence	10 between pods	0.7 secs
iii)Slow Ripple	Single	36 in pairs	160 between pairs	2.8 secs
	All	144 in pairs from each pod in sequence	40 between pods	2.8 secs

Variations in the number and position of pylons selected are possible. The firing sequence follows the same pattern.

The hold-on relay in the fast mode has been removed, so firing now ceases when the trigger is released in all modes (if you are quick enough)!

1108. Rocket Dispersion

Interaction between rockets as they leave the pod causes dispersion. The faster the firing interval the greater the dispersion.

The only figures available are:-

Firing pairs at 40 m.sec intervals at sea level at 400-450 knots 50% of rockets fired from a pod will fall inside a cone of semi-angle radius 17.2 minutes.

1109. Shallow Angle Attacks

When the cloud base precludes a 20° dive, it may still be possible to carry out a 10° attack. Diving shallower than this reduces accuracy markedly.

In the 10° dive very accurate sight handling is called for, particularly in the vertical plane where the rad is worth approximately 6 times its horizontal value. Releasing at the briefed slant range is vital to accurate results, since gravity drop increases with range at an increasing rate the shallower the dive angle.

It is no good trying to release at a set height because in a shallow dive the slant range is changing very rapidly for small changes in height and the barometric altimeter is not sufficiently accurate.

1110. Blind Rocket Attack

This is possible against a radar discreet target such as a ship. It is an attack that is not widely practised, but its use bears consideration since accurate results can be achieved, and there are occasions where a blind attack may be called for.

Conditions

Run in 500 ft., 400 kts., radar locked on.

Push over 1¼ n.m., track T.l. spot.

Fire minimum slant range 1200 yards.

1111. Switches

Sight

PAS .... R.F.

W/S .... 100'

Mod 3026 .... GW/RP

Throttle .... Gate

Trim .... 450 kts.

Armament

LABS/Normal .... Normal

L.P.S. .... On A/R

Firing Rate .... A/R

A.M.S. .... RB

CHAPTER 12

THE PILOT ATTACK SIGHT MARK 1

1201. Introduction

The Pilot Attack Sight Mark 1 was developed by Ferranti as a successor to the Gyro Gunsight, for fitting in fighter aircraft such as the Lightning and the Sea Vixen. Although the basic principles of the G.G.S. and the P.A.S. are the same, the latter has the following new features which bring it into phase with current and future aircraft and weapons:-

a. A Target Indicator derived from an airborne intercept radar, A.I.18R in the Sea Vixen. This Target Indicator has the capability of being converted into a Steering Signal for aircraft navigation during the approach phase of a G.W. attack, and for the optimum launch direction of a Guided Missile.

b. The capability of the sight for use with guns, rocket batteries, bombs or guided weapons.

The P.A.S. has two reflector glasses similar to that on the G.G.S. On the glass nearer to the pilot may be seen a radar controlled target indicator spot, which can be further processed by computer to produce a steering signal. On the further glass there is produced an aiming mark, correctly aligned for the weapon in use, and also supplementary information in the form of a range scale, a range rate scale and a pattern of diamonds which appear either together as manual ranging diamonds, or in pairs as event markers. The pilot makes the correct approach by tracking the target indicator or steering signal with the aiming mark. Both displays are produced by a collimated lens/mirror system, i.e. optically at infinity.

As in the G.G.S. an electro-magnetically controlled gyro produces the required aiming allowance in the graticule display.

1202. Components of the System

There are seven components of the sight system:-

a. The display unit

b. The display unit controller

c. The display unit drying cell

d. The throttle unit

e. The altitude/airspeed unit

f. The radar adaptor unit

g. P.A.S. selector switch

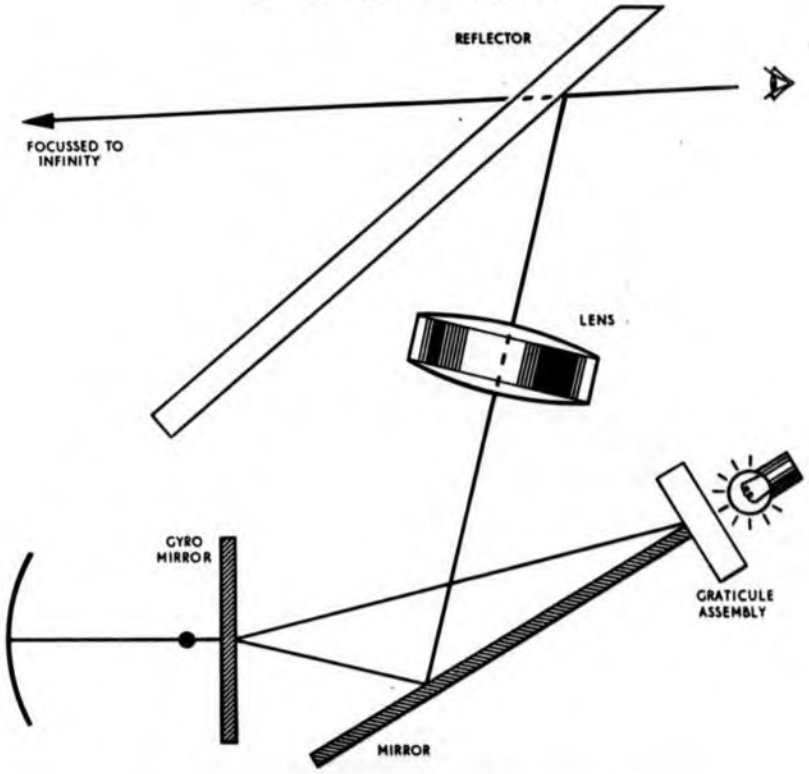
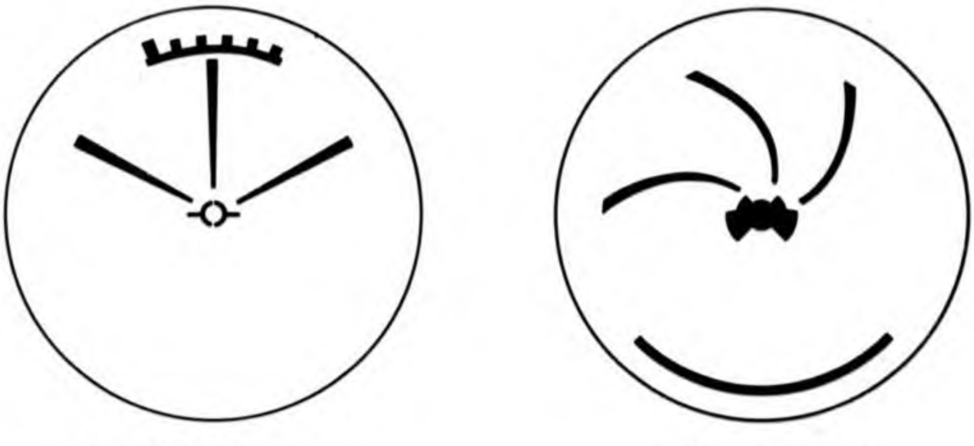


FIG. 12-1 PREDICTING GYRO OPTICAL SYSTEM



A. FIXED GRATICULE

B. MOVING GRATICULE

FIG. 12-2 FORMATION OF GRATICULE DISPLAYS

a. <u>The Display Unit</u>

The Display Unit is mounted in front of the pilot on a fixed mounting. It is as near to the pilot as his safe ejection path will allow. This distance is greater than for the G.G.S. and on occasion the pilot must move his head to keep the display in view. The sight head measures 20" x 5" x 5" approx. with the reflector glasses folded flat so that the G.G.S. camera recorder can be mounted on the unit and must be removed before a deck landing is carried out.

The Display Unit will be considered in three sections.

(1) <u>The rear section of the sight</u>, that is, the end furthest from the pilot, contains:

(a) The motor which drives both gyros.

(b) The servos for the horizon, range and range rate displays.

(c) The electrical and dry air connections.

(2) <u>The centre section</u> contains the predicting gyro and its associated optical system as shown (Fig. 12-1).

The predicting gyro (3") spins at 2,000 r.p.m. It is joined to a copper dome by a shaft which passes through a Hooke's joint so that the shaft can move in any direction. This dome lies in the electro-magnetic field set up by two pairs of poles together with gravity drop coils and a sensitivity coil. The system also contains a temperature compensating coil and an anti-topple contact limiting the gyro axis deflection to 14°.

On the underside of the central section is the trap for insertion of the lamp, and a double banked knurled knob for brilliance control of both optical systems.

<u>The Graticule Assembly</u>

It can be seen from Fig. 12-1 that the graticule assembly is bisected by the fixed mirror of the optical system. The graticule, therefore, is designed to show half a system and the remainder of the system is its mirror image, i.e. three ranging diamonds only are required to give an image of six diamonds to the pilot, and similarly, event markers always appear in pairs.

There are two separate graticules as shown (Fig. 12-2).

Graticule A is always stationary. It contains three radial lines and a range rate scale marked with 100 kt. divisions to cover closing speeds from -100 to +500 knots. This scale is deliberately kept out of the field of view of the mirror so that only one image is presented to the pilot. A range scale to give ranges from 0 to 24 miles is independent of the graticule system and appears in both manual and radar presentations. The range marker is carried on a separate transverse rack. The drawing of Graticule A also shows the aiming mark at the centre.

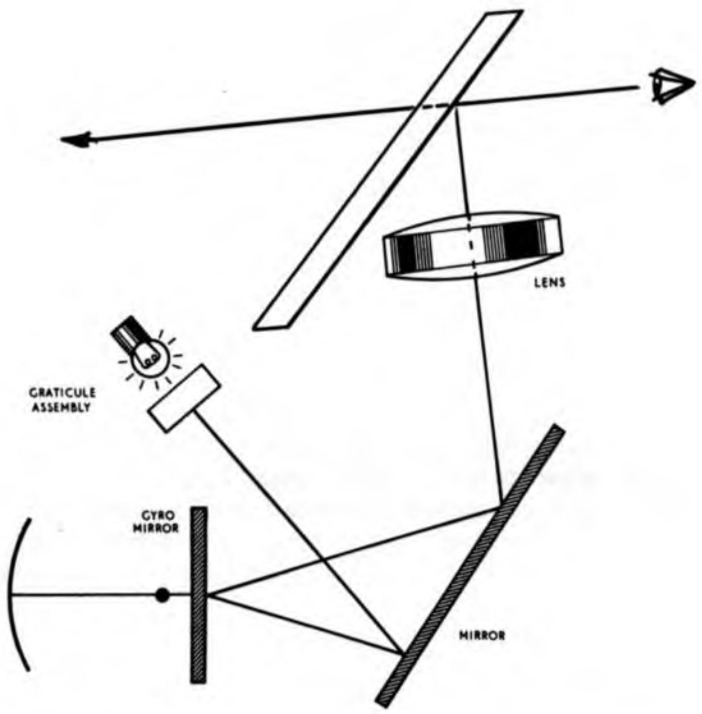


FIG. 12-3 TARGET INDICATOR GYRO OPTICAL SYSTEM

Graticule B is rotatable and contains three curved lines, two open fan-shaped apertures, a long oval aperture and a moving range rate marker. The two fan-shaped apertures are normally covered by separate shutters, which are drawn aside by solenoids to give event marker indications.

When the P.A.S. is in manual operation, Graticule B is positioned so that the curved lines cross with the radial lines to produce the ranging diamonds, as in the G.G.S. The range rate scale is covered and the range rate aperture lies below the mirror. As explained above, the pilot will now see the range scale and six diamonds. The curved lines of the Graticule B are moved by the pilot ranging through his throttle twist grip in the manual sector, i.e. out of the radar gate. This movement has been modified electrically to allow for the wingspan set. However, there is no drive to the range marker which stays at the 4 mile mark and there is no other range indication. The movement of the throttle twist grip is supplying a range input to the sensitivity computer and controls the movement of the gyro mounted mirror.

When the P.A.S. is in radar operation Graticule B turns back through 180° so that the curved lines disappear below the mirror and the radial lines are blanked off. The range rate scale is now visible and the rotation of this graticule is controlled by the range rate output of the A.I. radar and the marker moves appropriately along the scale. A thermometer presentation is used with the line decreasing in length as the range rate decreases. When the solenoid operated shutter is withdrawn from the left hand fan-shaped aperture, light passes through the radial line of Graticule A and through this aperture causing a small oblique bar of light to appear, and similarly for the right hand pair.

(3) The Front Section contains the target indicator gyro and its associated optical system as shown (Fig. 12-3).

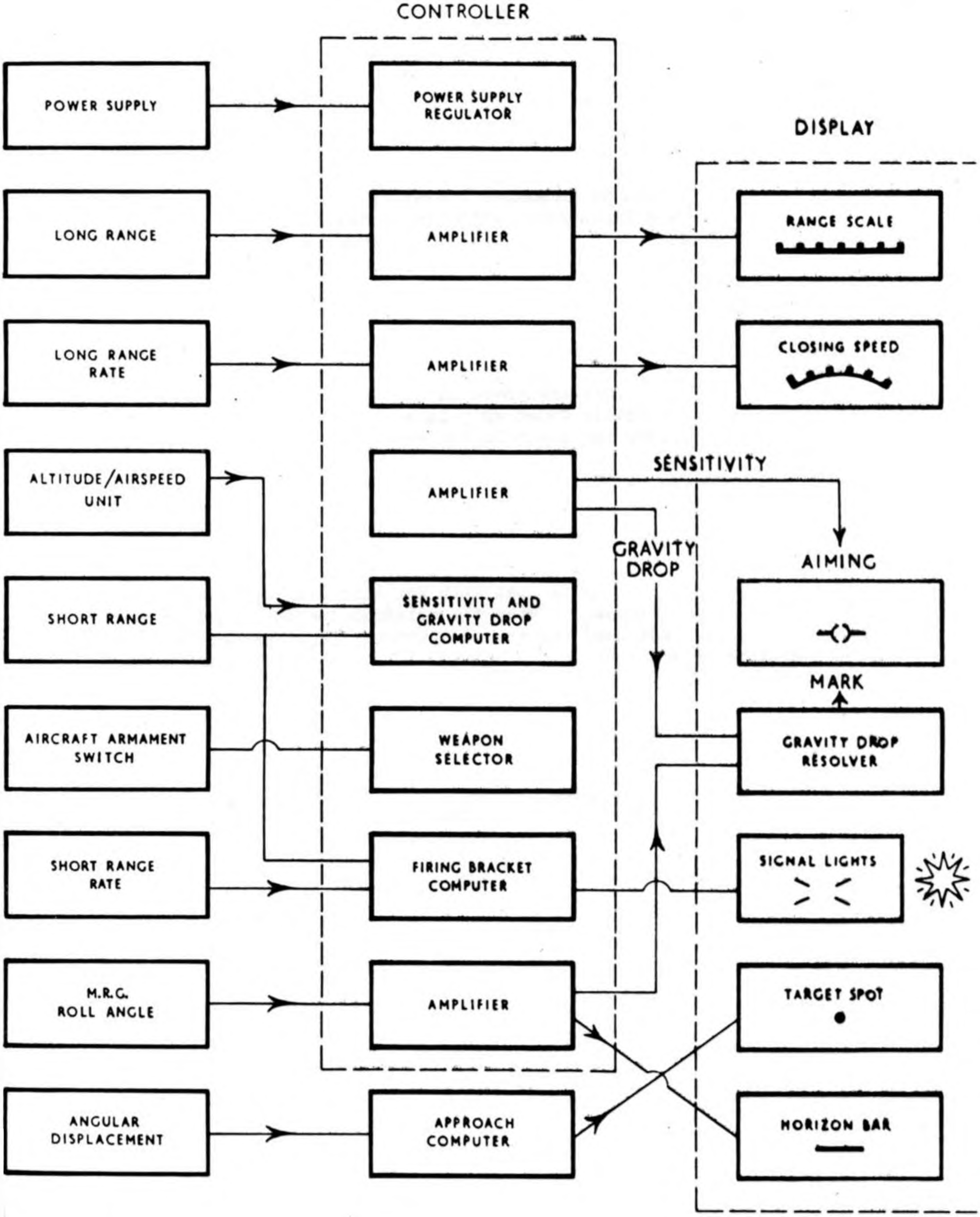
The gyro (1.65") spins at 4,000 r.p.m. and is in most respects similar to the predicting gyro. There is no temperature compensation and the anti-topple contact is incorporated but not connected.

The graticule assembly is a simple central spot with a straight bar beneath it. This graticule is rotated by the horizon bar servo to give pilot indication of bank angle fed from the M.R.G.

The target indicator system employs the principles of the G.G.S. in a different manner. The control coils are the equivalent of the trail coils of the predicting gyro but are fed with azimuth and elevation signals from the A.I. radar. The gyro axis and hence the target indicator will be deflected so as to show the position of the target relative to the attacking aircraft or to produce the correct steering signal for a Red Top attack. The use of the gyro also reduces the effects of target jitter and airframe vibration. It does, however, introduce a lag in the T.I. spot during a turn.

The trap for insertion of a small lamp is on the top of the unit just behind the small reflector glass. To the right of the glass is a small uncollimated light - the break off light. Near it is the wing span selector knob, marked linearly from 20 to 100 feet.

The control for brilliance is double banked with that of the predicting gyro. Finally there is a rubber collision pad at the



THE LONG RANGE FEED OF THE A.I. RADAR IS USED FOR THE RANGE SCALE, AND THE RATE OF CHANGE OF THE LONG RANGE, I.E., THE LONG RANGE RATE, FOR THE CLOSING SPEED, WHEREAS THE SHORT RANGE AND SHORT RANGE RATE ARE FED TO THE SENSITIVITY, GRAVITY DROP AND FIRING BRACKET COMPUTERS AND HENCE TO THE AIMING MARK AND THE FIRING BRACKET INDICATORS. THE CHANGE FROM LONG RANGE TO SHORT RANGE OCCURS AT 2,500 YDS. APPROX., ALTHOUGH THE LONG RANGE OUTPUT CONTINUES BELOW 2,500 YDS. FIG. 12-4.

narrower end of the display unit.

b. The Display Unit Controller

This unit provides the appropriate control currents to the Display Unit derived from instrument and radar inputs. It contains an attack computer for rocket attacks, giving sensitivity and gravity drop outputs to a firing bracket computor, a power pack and voltage regulator and various servo amplifiers. The system is shown diagrammatically in Fig. 12-4.

A separate computer is required in the Sea Vixen in association with A.I.18R for the Red Top missile. Firestreak attacks are not computed.

c. The Display Unit Drying Cell

A silica gel drying cell is attached to the display unit by a tube 15" in length which acts as a dry air reservoir. The drying cell itself is a box 5" x $2\frac{1}{2}$" x $1\frac{1}{2}$" with an air inlet, a dry air outlet and an inspection window.

d. The Throttle Unit

The port throttle incorporates a twist grip which can be used for stadiametric ranging as in the G.G.S. When the twist grip is rotated fully forward, i.e. to max. range, it can be engaged in a detent called the Radar Gate. This makes radar information available to the Display Unit Controller.

e. The Altitude and Airspeed Unit

This unit is connected with the aircraft's starboard pitot and static lines. Airspeed and Altitude are derived as functions of dynamic and static pressure. The unit provides these in the form of electrical inputs to the controller, where they are used to compute ballistics and incidence.

f. The Radar Adaptor Unit

This unit is for use with the A.I.18R. It provides connections between the radar and the P.A.S. controller for signals of range and range rate. In addition it amplifies and modifies signals of azimuth and elevation, and passes these to the coils of the target indicator gyro.

g. P.A.S. Settings Switch

This provides the facility for selecting the G.W. R/P or Air to Ground Modes. Surrounding the switch body is the Air to Ground Sight Setting Unit, which gives variable sight depression for bombing.

Air to Air

1203. Computation of Sensitivity, Gravity Drop and Firing Bracket

a. Guided Weapons - this is the simplest case, as the predicting gyro is kept caged, i.e. there is no sensitivity computation required. Similarly no gravity drop allowance is necessary. The firing brackets are not computed by the P.A.S. controller, but by the Red Top Computer.

The meaning of the event markers in a Red Top attack is as follows:-

Left hand markers - Launch warning. 2 seconds to O.R.B.

Left and Right - Outer Range Bracket.

Markers go out - Inner Range Bracket.

The Armament Master Switch must be selected to G.W. (and RT F.S. inner/outer to RT), for these to appear on the P.A.S.

NOTE:- For Firestreak attacks the event markers do not appear, and firing range must be computed by the crew.

b. Rocket Launchers - the sensitivity computer is inoperative until the short range input starts at 2,500 yards range. The predicting gyro should be completely uncaged and controlled by the correct sensitivity by 2,000 yards range and the computing section of the controller continues to provide current, dependent on ranges from 2,000 to 200 yards. The principal allowance required is for change in incidence, which is made by the flight path graticule. The firing bracket computer now compares range and range rate and determines from a preset condition the last moment at which a salvo could still be effective before the break off is necessary. This is indicated by the right hand event markers. When there is 8 seconds left before collision, or at 250 yards - whichever is sooner - the event markers disappear and the break off light comes on.

However, in the 2" Air to Air mode it has been established that the errors in the computation of incidence, velocity jump and rocket ballistics are such that firings at medium or high angle off targets tail are not recommended.

c. Manual Operation

In the event of radar, or radar lock failure, no event markers will appear on the P.A.S. Even with manual ranging range will have to be estimated visually, as there is no range drum. In the R.P. mode the break-off light will still work if the twist grip is operated in such a way as to convince the controller that it has 8 seconds or less to collision.

Air to Ground

1204. Rockets

R/P is selected on the Sight Setting Switch, the throttle in the radar gate and wingspan normally to 90'. This gives the largest suitable sight picture, that is as nearly fixed (caged) as possible. It has in fact some sensitivity, so there is a very slight lag. It is roll-stabilised.

The Altitude Airspeed Unit inputs are present, so the sight moves in relation to aircraft datum with varying speed, which largely compensates for errors in release speed.

1205. Bombs

a. A/G is selected with the required setting on the Sight Setting Unit to give depressions of the centre aiming mark between $5\frac{3}{4}$ and 8 degrees. Since the diamonds subtend 2° radius from the aiming mark maximum, an aiming point can be selected for depressions between $3\frac{3}{4}$ and 10 degrees. Sensitivity increases with depression. Errors in depression are common and vary between aircraft for a given S.S.U. setting. Corrections to briefed sight picture or S.S.U. setting may be necessary for each aircraft.

b. A modification is being introduced to overcome this problem of sensitivity, but at the expense of roll stabilisation.

1206. Serviceability Checks

a. Ground

(1) The sight should be switched on in dispersal, so that any faults found may be investigated. The M.R.G. must be switched on for correct sight presentation.

(a) Check dimmers; fit spare bulbs if necessary.

(b) Selecting R/P, the sight should drop well below the G.W. position.

(c) Selecting A/G θ the sight should be in approximately the same position as R/P. It should drop further with settings up to 6.

(2) A warm up period of five minutes should be allowed before using the sight in anger.

b. Air

(1) With R/P selected the sight rises by a known amount in relation to aircraft datum or the GW aiming mark with an increase in airspeed because of inputs from the altitude airspeed unit. Comparison of the R/P picture in relation to the G.W. aiming mark should be made at a set speed in straight and level flight.

(2) If the predictor gyro fails, or the sight is obviously U/S in the R/P mode, rockets may be fired with the PAS selected to G.W. and suitable allowance made for the different sight picture. In this case the sight is caged but release speeds have to be accurate, because no altitude airspeed unit correction is fed in.

(3) Alternatively the T.I. spot may be used in similar manner.

(4) If the P.A.S. is U/S in the A/G mode, the G.W. aiming mark or the R/P picture are useless as alternatives because the required depression is too great. In this case it is back to the chinagraph cross on the windscreen.

CHAPTER 12 APPENDIX A FIG.1 - P.A.S. PRESENTATION - R.P.

Presentation	Radar/ Manual	Target Indicator	Aiming Mark	Range	Closing Speed	Event Marker	Remarks
1.	Radar Searching or Manual Ranging	Caged	Caged	Nil. held clear of end stop (4 nm) till lock on.	Nil	Nil	Aircraft wings level. If radar is selected but not locked on, no manual ranging is available as the throttle grip is in the radar gate.
2.	Radar lock on provides Long Range and Long Range Rate	Uncaged following radar	Caged	Indicating from 24 nm in.	Indicating	Nil	Aircraft turning under Observer control.
3.	Radar (as above)	As above	Caged	As above	As above. Pilot will adjust speed to give suitable firing bracket.	Nil	Pilot tracking target or target indicator.

CHAPTER 12 APPENDIX A FIG.2 - P.A.S. PRESENTATION - R.P.

Presentation	Radar/ Manual	Target Indicator	Aiming Mark	Range	Closing Speed	Event Marker	Remarks
4.	Radar. Providing short range and short range rate.	As above	Uncaging from 2500 yds to 2000 yds range, to correct sensitivity	As above	As above	Nil	Range now less than 2,500 yds. Track true target if visible.
5.	Radar as above	As above	Uncaged fully since 2,000 yds range	1,200 yds.	As above	Left hand markers	Maximum effective range.
6.	Radar as above	As above	As above	Range and closing speed together determine end of firing bracket.		Right hand markers	Pilot must fire now for effective fire.

CHAPTER 12 APPENDIX A FIG.3 - P.A.S. PRESENTATION - R.P.

Presentation	Radar/ Manual	Target Indicator	Aiming Mark	Range	Closing Speed	Event Marker	Remarks
7.	Radar as above	As above	As above	Range and closing speed together determine break off time of 8 secs. Or range = 250 yds		Both pairs disappear. Break off light appears at the same time.	Pilot breaks away from the target.

NOTE A In a Rocket attack the whole of the aiming mark system will be moving relative to the centre line of the aircraft.

NOTE B If radar lock-on is lost the presentation immediately reverts to 1.

CHAPTER 12 APPENDIX A FIG.4 - P.A.S. PRESENTATION - G.W. AUTO

Presentation	Radar/ Manual	Target Indicator	Aiming Mark	Range	Closing Speed	Event Marker	Remarks
1.	Radar Searching	Caged	Caged centrally throughout	Held clear of end stop (4 n.m.) till lock on.	Nil	Nil	Aircraft wings level. One pair of diamonds showing.
2.	Radar Locked on	Uncaged. Acting as a Steering Signal from the Red Top computer	As above	Indicating from 24 miles in.	Indicating	Nil	Aircraft turning under Observer control
3.	As above	As above	As above	As above	As above	Nil	Pilot tracking Steering Signal

CHAPTER 12 APPENDIX A FIG.5 - P.A.S. PRESENTATION - G.W. AUTO

Presentation	Radar/ Manual	Target Indicator	Aiming Mark	Range	Closing Speed	Event Marker	Remarks
4.	As above	As above	As above	2 seconds to the max. aerodynamic range of the missile (from the Red Top Computer)		Left hand brackets	Launch Warning
5.	As above	As above	As above	Computed max. aerodynamic range of the missile		Left and Right hand brackets	Outer Range Bracket
6.	As above	As above	As above	At computed min. range of missile		Brackets disappear	Inner Range Bracket. Break off light comes on. If F.C.B. is already pressed missile will fire.

CHAPTER 12 APPENDIX A FIG.6 - P.A.S. PRESENTATION - G.W. SEMI-AUTO

Presentation	Radar/ Manual	Target Indicator	Aiming Mark	Range	Closing Speed	Even Marker	Remarks
1.	ALL AS IN G.W. AUTO .....1. UNTIL AFTER RADAR ANGLE LOCK HAS BEEN DEMANDED						
2.	Radar locked on jamming spoke	Uncaged. Acting as Steering Signal from Red Top Computer	Caged centrally throughout	Held clear of end stop (4 n.m.)	Nil	Both left and right hand brackets	Event markers will not indicate firing bracket unless full radar lock can be obtained. In this case the system will revert to AUTO.
3.	As above	As above	As above	As above	As above	As above	Pilot tracking Steering Signal.

NOTE:- A. If Range Break Through is not achieved, the pilot must fire on Acquisition (Head on attack) or when within the estimated firing bracket (Stern attack). For Stern attack MANUAL must be selected before firing for correct K factor and fuze volts.

B. If 'FIRESTREAK' is selected in AUTO or SEMI-AUTO and Starboard or all on arming selector the target indicator will revert to a T.I. spot (as in R.P.) In the case of an AUTO attack the event markers will not appear and the firing bracket must be estimated.

The P.A.S. presentation in G.W. MANUAL is as in 1. above throughout, except that when the trigger is pulled the left hand event markers appear.

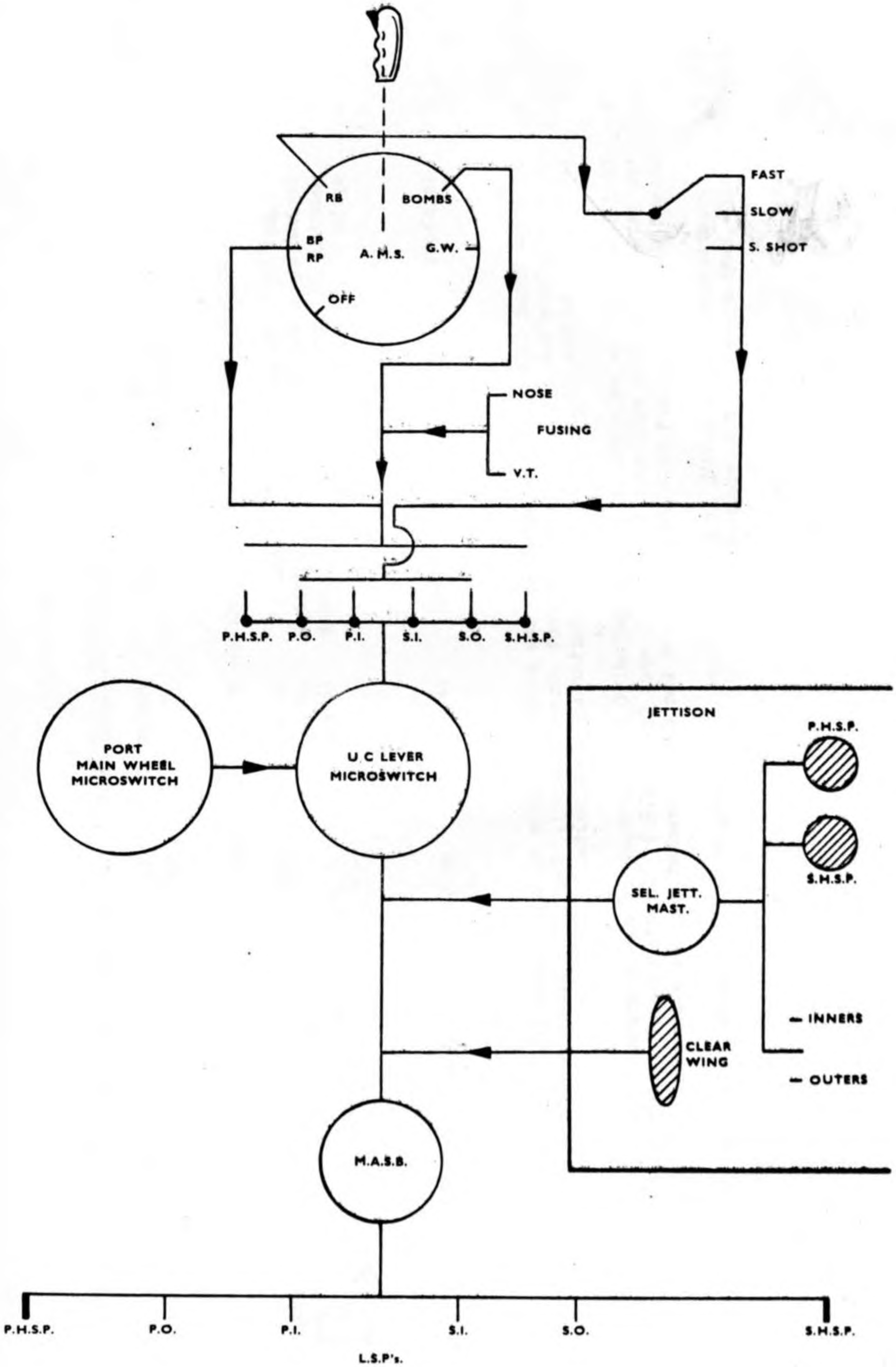


FIG. 13-1 SEA VIXEN ARMAMENT SWITCHES

CHAPTER 13

ARMAMENT SWITCHES

1301. The diagrams should be self-explanatory. (Fig. 13-1)

1302. Bombs

Tail fuzing takes place when Bombs is selected on the A.M.S.

To jettison bombs "Safe", the armament master switch should be selected OFF.

1303. Ground Test Key

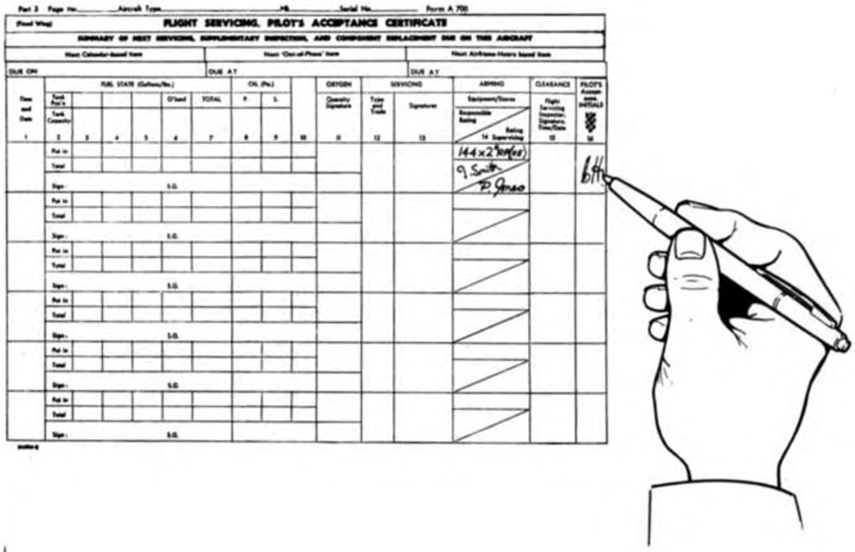
When this is inserted armament circuits may be tested on the ground. However it bypasses the undercarriage lever microswitch, which is a known cause of hangups. The full circuit functional test may be carried out by fitting undercarriage ground locks, gagging the port main wheel microswitch and raising the undercarriage lever without inserting the ground test key.

1304. Switch Selection

Incorrect switch selection prevents successful weapon release.

Making the wrong switches is not simply a mistake; it shows a lack of professionalism and is

AN UNFORGIVABLE SIN



Part 3 Page No. Aircraft Type Mk. Serial No. Form A 700

(Fixed Wing) FLIGHT SERVICING, PILOT'S ACCEPTANCE CERTIFICATE

SUMMARY OF NEXT SERVICING, SUPPLEMENTARY INSPECTION, AND COMPONENT REPLACEMENT DUE ON THIS AIRCRAFT

Next Calendar-based Item	Next 'Out-of-Phase' Item	Next Airframe-Hours based Item
DUE ON	DUE AT	DUE AT

Time and Date	FUEL STATE (Gallons/lbs.) Tank Pos'n / Tank Capacity				O'load	TOTAL	OIL (Pts.) P	S		OXYGEN Quantity Signature	SERVICING Type and Trade	Signature	ARMING Equipment/Stores / Responsible Rating / Rating Supervising	CLEARANCE Flight Servicing Inspector, Signature, Time/Date	PILOT'S Acceptance INITIALS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Put in												144 x 2" RP(HE)		
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	Sign.				I.O.										
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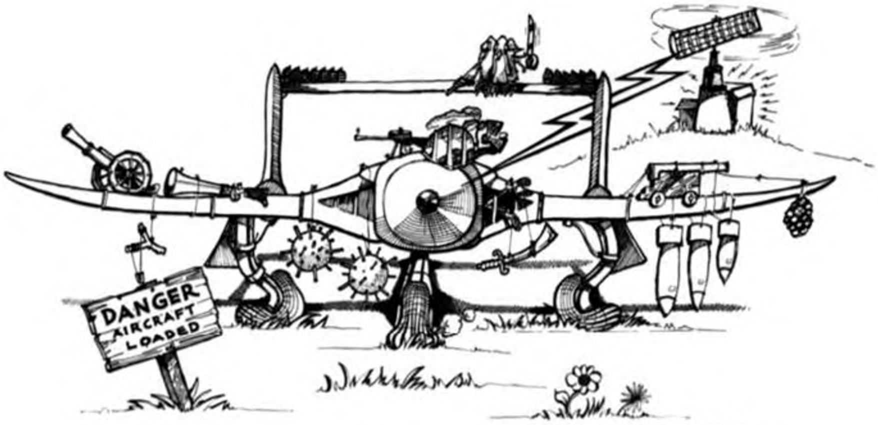


FIG 14—2

FIG 14—3

CHAPTER 14

ARMAMENT SAFETY

All armament is safe until it is forgotten that it is designed to kill.

1401. Responsibility

a. Responsibility for the weapons and explosives carried by an aircraft is assumed by the pilot when he accepts the aircraft for flight (Fig. 14-1) and is relinquished after flight when he hands over to the supervisory air ordnance rating in charge after reporting the state of the armament. Responsibility should not normally be relinquished until all weapons and explosives have been checked and rendered safe.

b. Regulations concerning responsibility for air weapons and explosives are contained in:

Queen's Regulations	
AP(N) 76	Regulations for the Fleet Air Arm
BR 862	N.M.E.R.

1402. Arming and De-arming Aircraft

a. This is not an aircrew responsibility but they should be conversant with the procedures involved and capable of making the necessary checks (Fig. 14-2) e.g. firmness of bomb crutching, fuzes fitted, fuzing wire and arming lead correct attachment and routeing, fuze settings (screws and window in V.T. fuzes) correct, heavy stores pylons practice/normal switch position correct, lepus timer correctly set and glow-worm head caps eased etc.

b. They should be aware of the implications and dangers of Radhaz.

c. Before manning, aircrew should ascertain that the state of the armament on the aircraft is as briefed and suitably fuzed and set for the sortie.

1403. Precautions to be Observed Concerning Armed Aircraft

a. Maximum safety devices must be employed on the ground and in the air until the start of an attack.

b. Armament loaded notices should be placed and replaced when aircraft are static.

c. Passage in front of forward firing weapons is prohibited except for operational reasons. Don't wander around in front of a loaded 2" R/P pod when you can pass behind. And remember that the area behind any rocket motor is filled with flames and hot gases when the motor fires.

d. Aircraft armed with forward firing weapons must remain pointed on the established safe heading when static. When taxiing every effort should be made to maintain the greatest safety in the event of inadvertent firing.

FIG 14—4

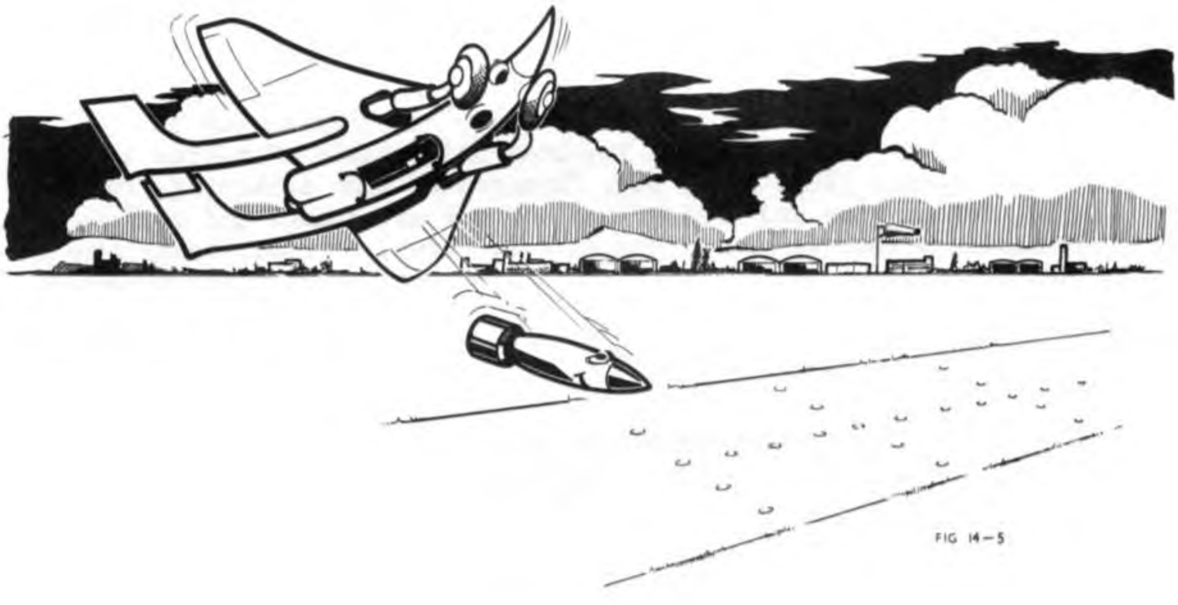


FIG 14—5

FIG 14—6

e. Safety devices removed from weapons before flight must be carried in the aircraft.

f. The master armament safety break should be made as late as possible before take off, namely when pointing down the runway ashore and when loaded on the catapult embarked.

g. Transit to and from ranges should be along established routes clear of populated areas.

h. Aircraft returning to base with undischarged weapons must inform Air Traffic Control of their weapon state before joining the circuit (Fig. 14-3).

1404. Range Safety Procedure

a. When joining the range, the armament master switch should only be selected live at the top of the first firing dive, with the aircraft pointing at the target area. It may remain made until completion of the final firing dive, when it should be returned to safe. The trigger guard is used as the final safety factor for all dives, and should be returned to safe as soon as practical after firing or pullout is completed.

b. The usual rules of good airmanship apply. There is always the possibility of inadvertent weapon firing or release when switches are made, so the aircraft should be in such a position that no damage to persons or property would result if this occurs.

1405. Irregular Weapon Release (Fig. 14-4)

a. If a weapon impacts outside the recognised danger area, the following action must be taken by the aircraft captain:-

All relevant switches to SAFE
Inform range or Air Traffic Control of:-
Type and fuzing of weapon
Time and position of impact
Any further important details.

b. Return to base via safest route
Prepare a written report on the incident and forward to Commander (Air) and the Gunnery Officer.

1406. Accidental Weapon Release (Fig. 14-5)

The accidental release of a weapon inside or outside range danger areas must immediately terminate the exercise and be reported to range or Air Traffic Control. Action then as for irregular release.

1407. Unexploded Weapon (Fig. 14-6)

Any live weapon dropped that fails to explode must be reported to the range officer with position and type details. After landing a detailed written report must be submitted to the Gunnery Officer.

1408. Misfire or Hangup Procedure

If a weapon fails to leave the aircraft after an attempt to fire has been made with the right switches selected it is a misfire or hangup. The following procedure should be followed:-

a. Trigger guard to Safe, and A.M.S. OFF.

b. Fly the aircraft in such a manner that no danger would ensue if the weapon subsequently detached.

c. Fly on a safe heading for the following periods:-

(1) 2" or 3" R/P - 1 minute.

(2) Guided Weapon - 10 minutes.

d. Inform range officer of action taken in c.

e. Ensure correct switch selections had been made before attempt to fire.

1409. Subsequent Action

a. R/P

At the end of the safe heading period report the armament state to the range officer and request instructions.

Normally the exercise may be continued, and on completion armament state reported to Air Traffic Control before joining the circuit.

When firing multiple 2" R/P, hangup procedure should be followed even on successful firings because of the possibility of misfires remaining undetected in the Pod.

b. Bombs

(1) Attempt to release hangup so that it falls inside range danger area.

(2) If unsuccessful and with 25 lb bomb carriers exercise must be abandoned. (Note: for further guidance, see local range orders).

(3) All switches to SAFE, inform range officer.

(4) Return to base via safest route, informing Air Traffic Control on arrival.

c. Guided Weapons

If the misfire is not due to wrong switch selection, put all relevant switches to safe, inform range officer and return to base informing Air Traffic Control.

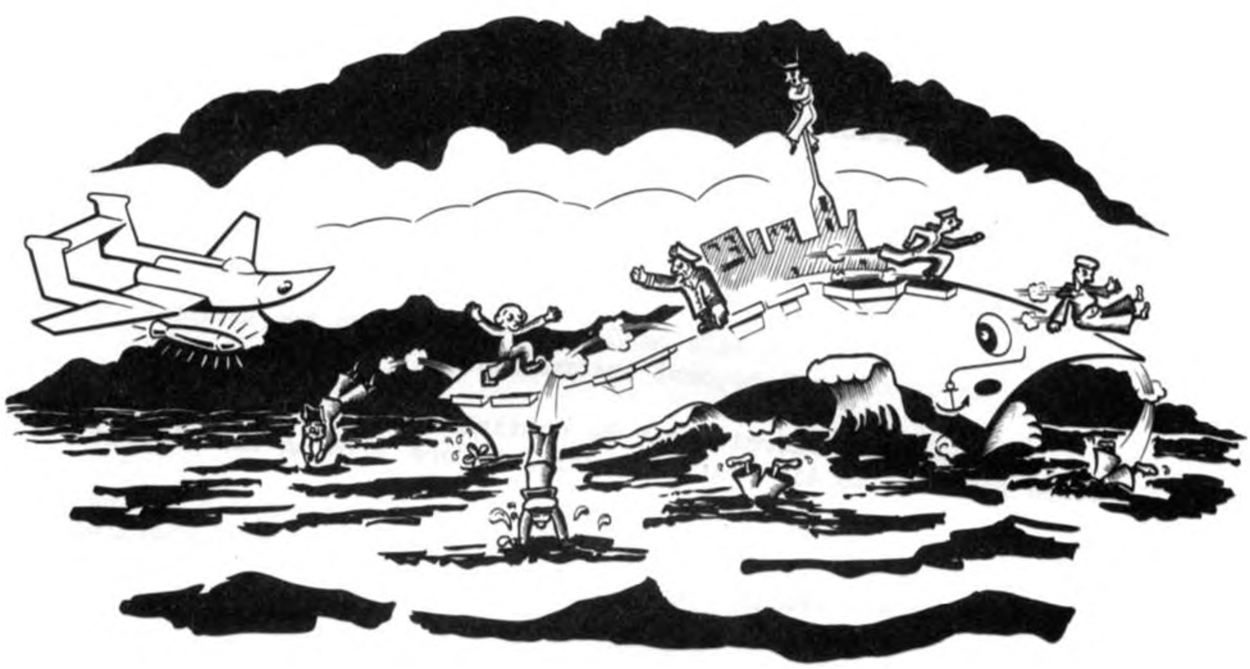


FIG 14—7

After landing the missile should be removed with the aircraft pointing in a safe direction at the arming point.

1410. Recovery With a Hangup or Misfire

a. Ashore

Air Traffic Control must be informed of weapon state before aircraft join the circuit, and aircraft should return from the range with all switches safe via the recognised safest route avoiding populated areas, and flown in such a manner as to minimise the risk of inadvertent weapon release.

A straight-in recovery should normally be planned.

The greatest risk of the weapon becoming detached exists at touchdown when it could embarrass the crew by continuing along the runway in close proximity to the aircraft.

However, if full jettison action has been attempted before recovery this risk is slight.

After landing the weapon should be removed or rendered safe depending on type at the end of the runway on the safe heading.

b. Embarked

Normally aircraft with hangups or misfires are recovered last, and action to render them safe taken at the end of wire pullout before moving them further.

All current weapons are recoverable with the following exceptions in normal circumstances.

(1) 2,000 lb bomb - the bomb would foul the arrester wires.

(2) Firebomb - various reasons.

Again, the final decision depends on circumstances at the time.

1411. Recovery with Live Bombs (Fig. 14-7)

Usual action taken on board is to reduce flight deck manpower to a minimum, and clear the rest of the ship's company below the hangar deck while assuming ABCD state 1Z. This naturally takes time, so maximum notice of the requirement should be given.

Even if the bomb comes off and the fuzing wire pulls out the safety pin in the arming vane, the vane will not rotate to arm the tail pistol at speeds below 120 knots for current bombs, and speeds in the 250 knot range with the future 114 and 116 tails. So the safety factor remains quite high.

1412. Forced Landing

The action to be taken covering weapons carried if a forced or emergency landing becomes imminent rests with the pilot. The following general principles serve as a guide.

a. Generally it is better to land without weapons.

b. If you have to land still carrying weapons, all relevant switches should be set to SAFE.

c. If you can jettison do so, safe in the case of live weapons, such that life or property are not endangered.

d. If weapons can only be released live do so if life or property is not endangered.

e. If time permits, guided weapons should be launched to impact in a safe area.

1413. Subsequent Weapon Safety

If a forced landing is made carrying weapons it is the pilot's responsibility to ensure their safety on the ground, particularly if no qualified ground personnel are available. So the necessary equipment and safety devices should be carried in the aircraft at all times bearing in mind the existence of this possibility, and aircrew should be fully conversant with their use.

These guidelines applied with good airmanship, common and weapon sense will cope with most situations one is likely to meet.

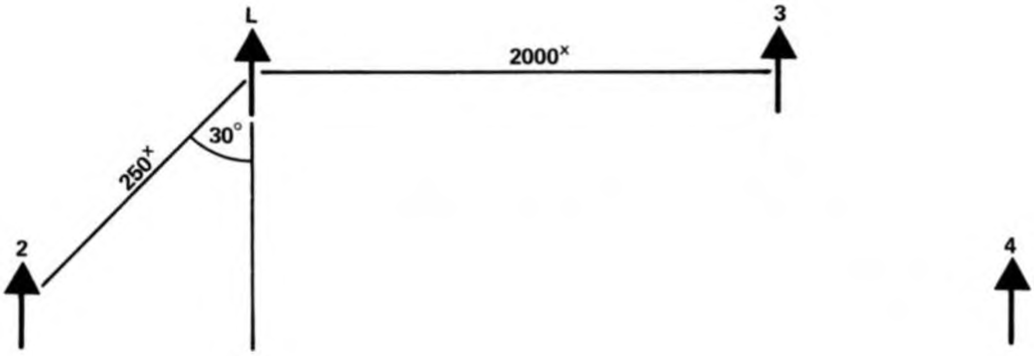


FIGURE 15–1. DEFENSIVE BATTLE

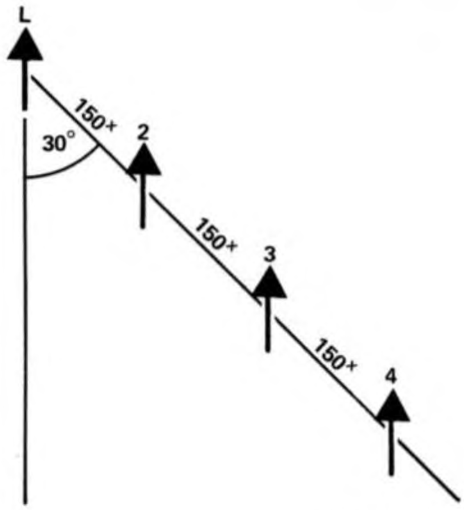


FIGURE 15–2. ATTACK ECHELON

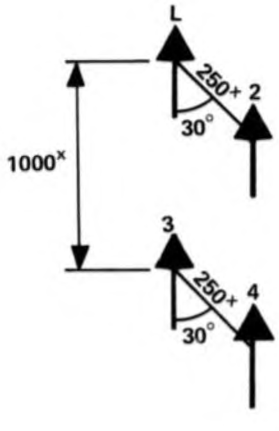


FIGURE 15–3. SECTIONS LINE ASTERN

CHAPTER 15

DIVISIONAL ATTACKS

1501. Reasons for Use

a. Fighter Threat

With an air threat it is essential to maintain a tactical formation for mutual support to and from a target.

b. A A Defences

To saturate the A A defences and prevent them engaging each aircraft in turn, all aircraft must be got through the target as quickly as possible.

c. Surprise

To maintain surprise giving a target less time to move or escape, or for the defences to return accurate fire.

When none of these reasons apply, academic attacks may prove more accurate and easier to execute. In the case of inexperienced aircrew this may not be so as they may benefit from being put in the correct dive on the target by their leader.

1502. Formations

a. Defensive Battle (Fig. 15-1)

Gives good lookout, mutual support, manoeuvrability and control up to pull up.

b. Attack Echelon (Fig. 15-2)

(1) Advantages

Larger number of aircraft attacking target simultaneously. Larger angular spacing in division.

(2) Disadvantages

Less manoeuvrable, more difficult to fly.

or c. Sections Line Astern (Fig. 15-3)

(1) Advantages

Manoeuvrable, easy to fly, target easily identified, can correct leader's entry condition errors if any.

(2) Disadvantages

Fewer aircraft on target simultaneously. Aircraft flying down the previous section's flight path with the inherent risk of collecting the flak that missed them. Other formations such as low level battle, low level strike may be used as conditions dictate.

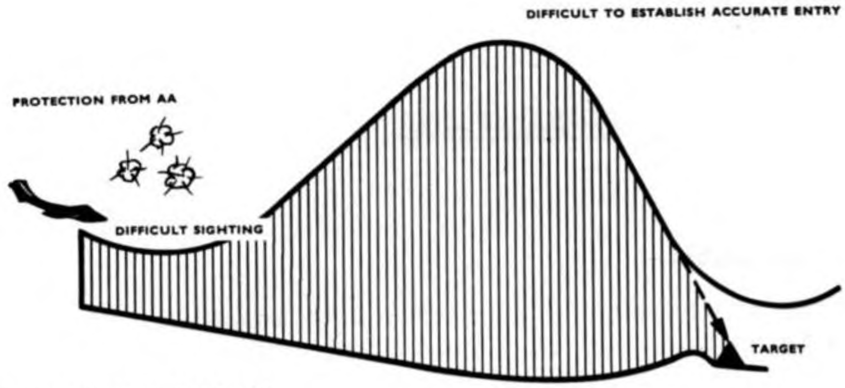


FIG. 15-4 LOW LEVEL APPROACH

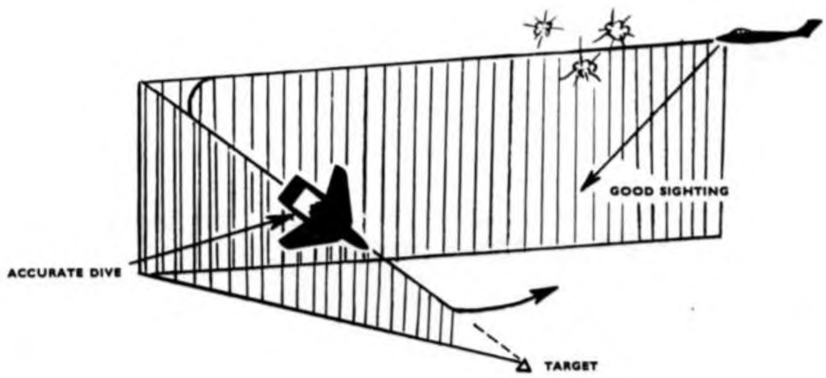


FIG. 15-5 MEDIUM LEVEL APPROACH

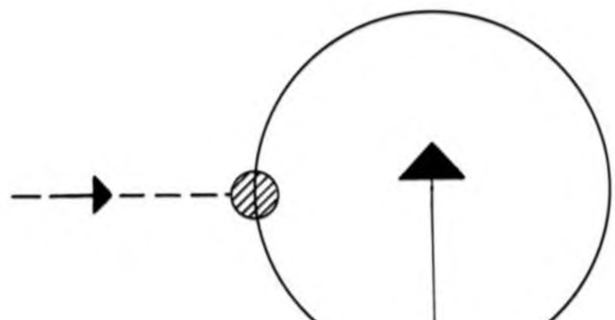


FIG. 15-6 CHOICE OF ENTRY POINT

1503. The Approach

a. The Problems Involved

(1) Target sighting and identification.

(2) Avoidance of fighter threat by mutual support.

(3) Avoidance of AA defences.

(4) Setting up an accurate dive.

b. Types of Approach

(1) Low Level (Fig. 15-4) must have sufficient energy to achieve entry conditions.

(a) Advantages. Late acquisition by the enemy.
Difficult target for enemy aircraft
S.A.M.s and ground fire.

(b) Disadvantages. Fuel Consumption.
Navigation.
Target Sighting.
Difficult to establish accurate entry.

(2) Medium Level (Fig. 15-5)

Advantages and disadvantages converse of (1).

(3) High Level

As (2) but weather conditions must be even better, and it is difficult to establish an accurate entry.

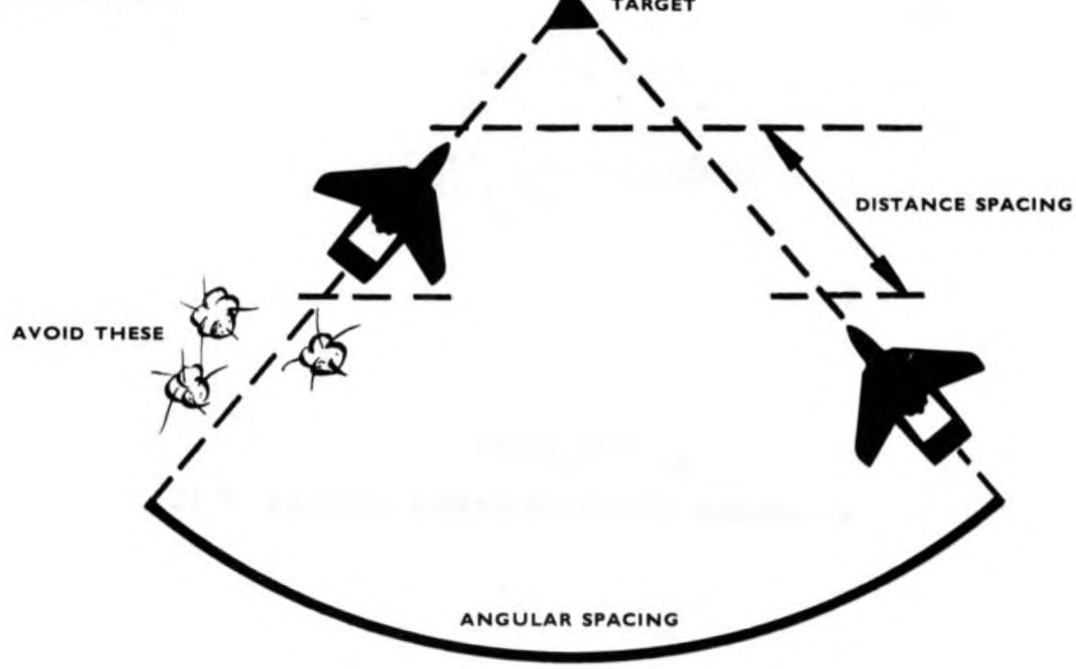
1504. Choice of Approach

This will depend largely on operational conditions. The entry point for any dive requires a displacement from the target depending on dive angle and entry height. This displacement forms the radius of a circle round the target at any point on whose circumference the dive may be correctly entered.

The approach should be so designed as to form a tangent to this circle (Fig. 15-6). This gives maximum latitude for any errors in entry and allows best spacing to be achieved without successive aircraft being forced shallow or steep. An approach at 90° to the line of attack is the optimum, but up to 30° either side of this is acceptable.

Over enemy territory approaching the target all aircraft should weave, and the leader should call for switches to be made in good time, the target clock code when sighted and any deviation from the briefed dive angle.

FIG. 15-7 SPACING



1505. The Entry

Accurate weapon delivery depends on achieving conditions which are listed in order of priority:-

a. Correct release point of aim.

b. Correct dive angle.

c. Correct release height.

d. Correct release speed.

e. No yaw/skid.

Dive angle, the second most important condition can be adjusted slightly during entry, but not when committed to a dive. Second and subsequent aircraft should never pull higher than the leader, or they will be steep, and will still have the aircraft ahead in their sight glass when they wish to fire.

1506. Spacing

Accurate spacing of aircraft in the dive is essential to accuracy. Correct spacing ensures that each aircraft can make an individually aimed attack. If worries regarding other aircraft in the dive pertain, aiming suffers.

a. Angular Spacing (Fig. 15-7)

This presents separate targets to the AA defence. 10° is sufficient. Never follow directly astern of another aircraft or you will collect his flak, even if you don't shoot him down.

b. Distance Spacing (Fig. 15-7)

This also allows each aircraft to aim individually without hazarding the aircraft ahead. Distance required depends on type of weapon being fired, and length of burst; less for bombs than R/P or guns. For bombs see para d., for R/P generally 500-1000 yds. Closer than this and successive aircraft are forced to fire later and lower to allow the next ahead to clear. Speed and distance between aircraft on the approach control the intervals at which aircraft break on entry to achieve the correct spacing.

c. Common Errors

Breaking with leader - loss of spacing.
Hard turn in - end up line astern.
Extended break - further from entry circumference, shallow, excessive spacing.

d. 1,000 lb Bomb Fragmentation Envelope

The 1,000 lb and 500 lb bomb fragmentation envelopes are considered to be similar until evidence to the contrary is forthcoming.

When a bomb explodes the fragment pattern expands radially for the first five seconds until gravity and air-resistance take effect to give each particle a parabolic path. The particles are of various sizes ranging from "dust" to the largest 32 oz. fragments which go furthest reaching a height of 4,200 ft. Because of the construction of the bomb and the shape of the charge the fragments rise in the form of a cone whose axis is at right angles to the fore and aft line of the bomb. The striking angle of the bomb released from a 20° dive is approximately 30° from the horizontal, and this "tilts" the cone forward by approximately that amount in the direction of the line of attack, variations depending on the nature of the ground struck.

After impact the envelope expands for approximately 10 seconds, when the fragments reach their zenith, and while still expanding horizontally collapses earthwards, the last fragments landing approximately 34 seconds after bomb impact. The volume-density of the fragments decreases progressively during the envelope's expansion.

An aircraft in a 20° dive releasing at 2,000 ft above target at 450 kts, pulling out with 4 G indicated into a 20° climb so that it's flight path never approaches closer to the target than 1,350 ft, remains safely ahead and clear of the fragments.

A second aircraft following more than approximately 2 seconds behind his leader will enter the leader's bomb fragmentation envelope.

Divisional live bombing attacks with aircraft following the leader at intervals greater than 2 seconds and less than 30 seconds must not be practised. Any aircraft passing over the leader's bomb impact point in the dive conditions mentioned inside this 28 second period is exposed to an unacceptable risk.

1507. The Dive

Provided the correct approach and entry have been achieved, concentration may be applied to aiming; put the sight in the push over aiming area early, track smoothly.

Never lose sight of the other aircraft ahead.

Never fire if the aircraft ahead is below the level of the top of the sight glass.

Never fire low - it forces the aircraft behind lower, or precludes their firing.

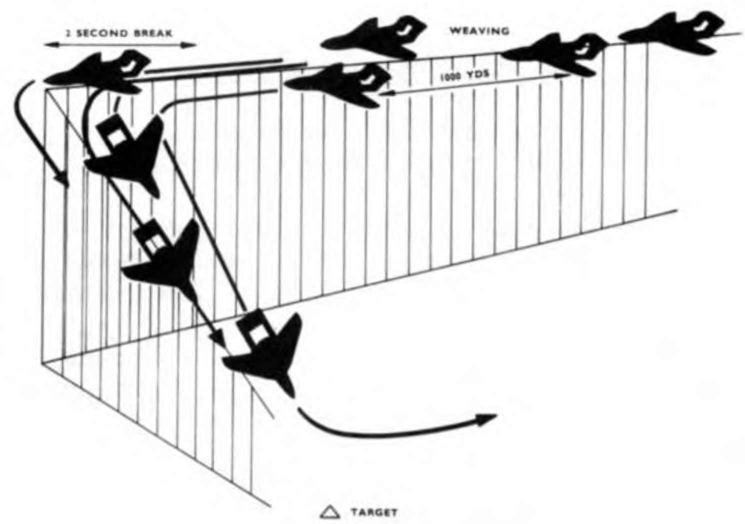


FIG. 15-8 TYPE X RAY

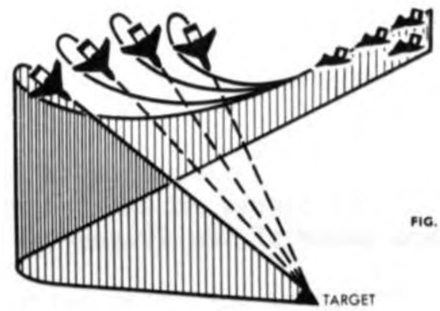


FIG. 15-9 TYPE ALPHA

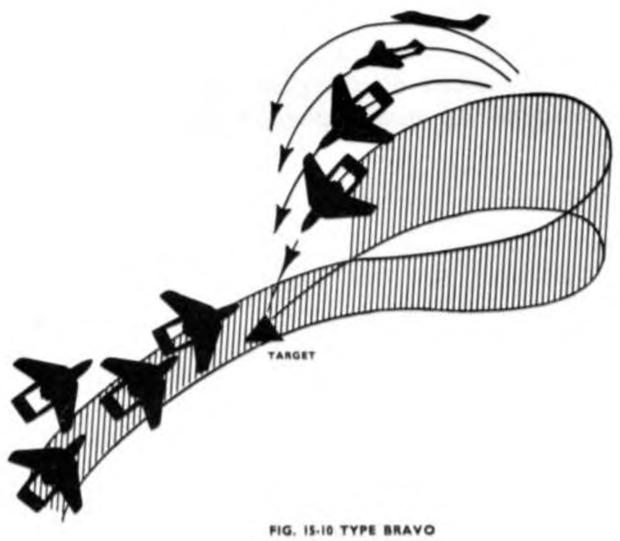


FIG. 15-10 TYPE BRAVO

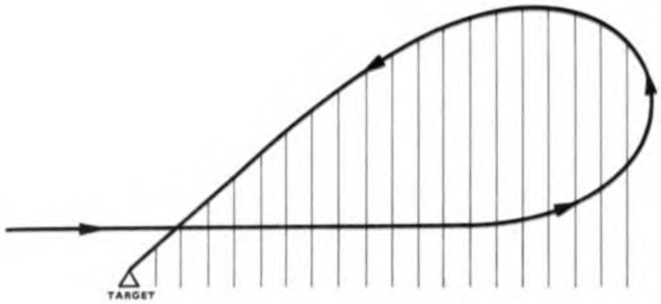


FIG. 15-11 TYPE CHARLIE

1508. The Recovery

Recovery should be commenced immediately on completion of firing for the usual reasons and also to clear the line of sight of the next astern.

Apply the briefed G.

Recover directly ahead, or in a turn in the same direction as the entry was made without exceeding aircraft limitations.

After recovery aircraft should tell off.

1509. Basic Types of Attack

There are three basic attacks:-

a. Type X-ray (Fig. 15-8)

The approach is made at entry height and speed in Defensive Battle Formation or sections line astern, which gives early target sighting and facilitates dive entry.

It gives accurate results, but is vulnerable to enemy fighters and AA fire.

b. Type Alpha (Fig. 15-9)

The approach is made at low level in Defensive Battle, Low Level Battle or Low Level Strike, pulling up to achieve the correct entry conditions at turn-in to the dive.

It is more difficult to fly and to hit the right entry conditions, so practice is required to produce results comparable to an X-ray's, but it has the advantages gained from a low level approach, and will probably be the type of attack most commonly used.

c. Type Bravo (Fig. 15-10)

The approach is made low level in Defensive Battle or Sections Line Astern, the target overflown and a climbing dumbell turn made to attack the target from the opposite direction to the approach.

It is a more difficult attack than the X-ray again, and is normally used against opportunity targets, for armed recce, or when target sighting is made too late to carry out an Alpha.

d. Type Charlie

In addition a fourth, Type Charlie (Fig. 15-11) may on occasion be used. From a low level approach in Sections Line Astern, the target is overflown. After a delay depending on speed, dive-entry conditions and wind the leading section pulls up, the second section subsequently following their flight-path, into a loop. As the nose is pulled through from the inverted on to the target, both aircraft in the section roll out the same way, track and fire. This attack may be used as an alternative to the Type Bravo.

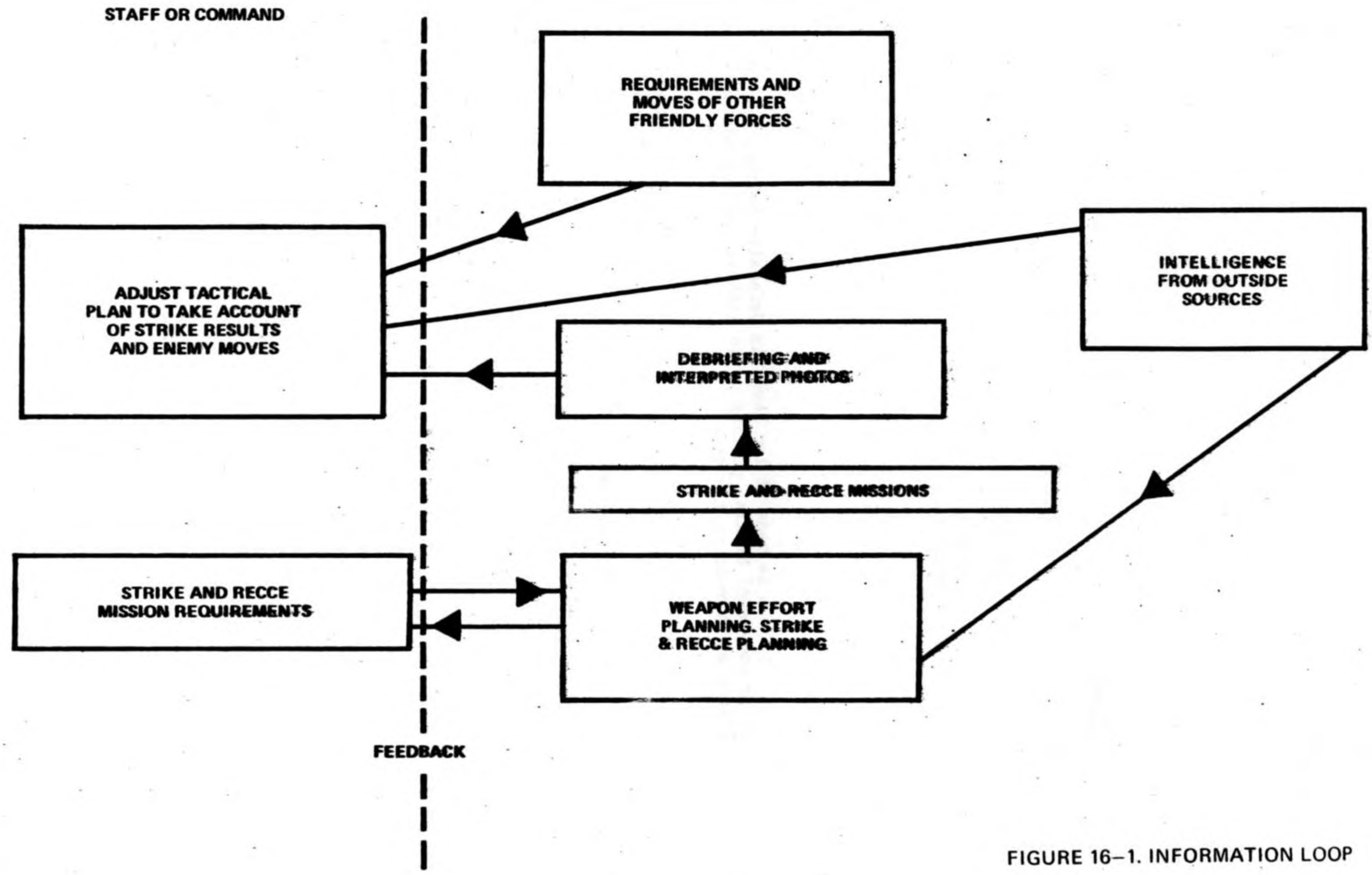


FIGURE 16–1. INFORMATION LOOP

CHAPTER 16

STRIKE

1601. Intelligence

Offensive air action, to be effective, must be based on sound intelligence of the enemy's equipment, methods and dispositions. This applies just as much to the execution of operations by aircrew as to the planning of operations by the staffs.

Some knowledge will be gained in the course of the campaign by Reconnaissance, but the whole intelligence background must be learned by the aircrew before the start of hostilities. Experience of limited war shows that, once the issue is joined, aircrew are fully employed in flying, briefing and strike planning, and have little time to study background information.

Intelligence rooms provide indexing facilities and ready access to intelligence information. An organisation within each aircraft carrier ensures that aircrew are able to keep abreast of current intelligence, and have the basic knowledge on which to build a detailed picture of the adversary as soon as hostilities are imminent.

Peacetime training in the application of intelligence to Strike tactics is of great value in maintaining a realistic attitude to such problems.

Lists of intelligence publications are published in CDCIs and Aircraft Carrier Squadron Memoranda.

1602. Conduct of Offensive Air Operations

The aim of intelligence, TAC-R, photographic reconnaissance and debriefing is to ensure that strikes will be effectively employed. This may appear to be entirely up to the Staff of Ship's organisation, but since the majority of the information will have originated from the aircrew, who alone get into contact with the enemy, the responsibility of the latter for the efficient conduct of the campaign is predominant, especially in conventional war.

Much has been learnt (and probably more forgotten) about the conduct of offensive conventional air campaigns. Any campaign lasting more than a few hours can only be run with the aid of an information loop as shown in Figure 16-1. The faster and better the loop can be run, the more efficiently the campaign will be conducted, and the less strike effort will be wasted.

The three main snags which can occur in running the information loop are:-

a. Slow handling of information; this can lead to the enemy moving faster than we can react. Hence rapid and accurate debriefing and photographic interpretation is required, and rapid transmission of the results.

b. Incomplete use of information: If the organisation cannot handle the volume, important bits will be overlooked. Hence debriefs must be concise, and filing systems efficient.

c. Unrealistic mission requirements. These requirements must first be formulated before the weapon and strike planning teams can show their feasibility and chance of success. Hence a continuous feedback is required, as shown between the bottom two blocks of the diagram, to allow mission requirements to be altered, extended or cancelled as necessary.

Offensive air campaigns often suffer under the disadvantage that those who plan them cannot see them carried out, apart from the routine activities which occur in the ship. It is therefore essential that as much of the decision making as possible should be delegated to the aircrew who will fly the mission, and aircrew should take full advantage of it. They should also ensure that the Staff and Command remain aware of the tactical problems and opportunities experienced during operations, so that a realistic overall tactical plan can be maintained.

The ability of aircraft to attack practically anything on land or sea can lure an air striking force into attacking classes of target whose destruction will contribute little or nothing to the successful conclusion of the war or campaign. This can happen in two ways:-

a. By mistaken policy, due to:-

(1) Attempting a task too big to produce any worthwhile effect before the issue of the campaign is decided.

(2) Choosing a class of target with which the enemy can afford to dispense.

b. By planning error, through not nominating worthwhile alternative targets within range for strike aircraft which:-

(1) Have been on armed reconnaissance and found nothing.

(2) Have weapons remaining after destroying their primary target.

In either case, the probability of misapplied effort may first become apparent to the strike aircrew, and should be reported without delay. Misapplied effort can lose a campaign (c.f. the Luftwaffe's attacks on London in September 1940 before Fighter Command's radars, Sector Stations and airfields had been destroyed).

Apart from the general considerations referred to above, there are some specific points which arise from previous experience. These may not necessarily apply in different circumstances in a future conventional war.

a. Daylight Armed Reconnaissance. This can often be a wasteful type of mission in terms of destruction achieved against sorties flown, since an enemy who is vulnerable to such action will probably move by night and camouflage by day. Targets which can't move are best dealt with by planned strikes.

Daylight interdiction is a contest against camouflage, and may be achieved more profitably by using PR to inspect likely camouflaged lie up positions, followed by strikes the same day, while the enemy is prevented from moving by occasional road surveillance. The latter can be carried out by returning strikes, if they have fuel. Armament is not essential, the aim being to maintain a threat.

b. Strikes on Several Targets in Succession. Frequently aircraft can carry more ordnance than is required for a one-pass attack on a given target, but the target defences are too strong to allow successive attacks after the element of surprise is lost. The best plan, if fuel permits, is to attack as many different well separated targets in succession as are required to use the warload efficiently. Mission requirements should allow the option of following this policy, which also allows a check to be kept on the progress of enemy dispersal and camouflage measures at more targets than would otherwise be kept under observation.

c. Alternative Targets. Targets which have to be destroyed eventually but don't need to be taken in the next few hours should be selected as alternative targets. Each strike should have an alternative in case it cannot get to the primary target, or has weapons remaining after the primary target is destroyed. The alternative should be compatible with the type of weapon being used, and with the amount of fuel available on leaving the primary target.

d. Aircraft and Vehicle Counts. An offensive aimed at destroying aircraft on the ground, or concentrations of vehicles, can only be carried out efficiently if a running tote is kept of intact and destroyed targets, and their positions. This will:

(1) Indicate whether the enemy is taking action to disperse the targets.

(2) Allow strikes to be briefed to attack specific intact targets and ignore damaged ones. The latter may well appear intact until too late in the aiming dive to allow a change of target.

The tote of aircraft and vehicles can only be compiled from accurate strike aircrew reports, frequently supplemented and confirmed bv PR. Any reduction in the visible number of targets means, in the case of aircraft, that a runway is serviceable, or that, in either case, some targets have been dispersed and are probably now under camouflage.

e. Familiarity with Targets. As with most other things, the more familiar aircrew are with their targets, the more detail they will be able to pick out and the more effective their attacks will be. Where a particular target complex, e.g. airfield or section of battlefront, is likely to need repeated attention, it is preferable to use the same crews to attack on successive missions. This will also improve the accuracy with which aircraft and vehicle totes (d. above) can be maintained.

f. Damage Assessments. A target is not effectively destroyed until the whole of it (and its contents where applicable) has been made unusable and irrepairable. Since any enemy expecting intensive air attack may be wise enough to prepare an efficient repair organisation, destruction beyond repair may be difficult to achieve. It is therefore essential not to report a target destroyed when it in fact requires a re-strike or a visit at a later date after it has been repaired. This is not to say that total destruction is required in every case: partial damage may well meet the needs of the campaign equally well, and be much less expensive in effort. Some types of target may be very deceptive: it is for instance quite easy to collapse a large area of the roof of a building without inflicting severe damage on the contents.

Organisation and Preparation of Strikes

1603. The Aim

A strike is not worth launching unless it has a clearly expressed aim. Since air warfare abounds in uncertainties, the achievement of the intended purpose is primarily in the hands of the Strike Leader. He must, therefore, be given a clear statement of the aim of the strike, and the background knowledge to enable him to conform to the tactical policy of the Command when meeting unexpected difficulties or opportunities. He must also be informed of all relevant intelligence, and the intended movements of the force.

1604. First Decisions

As soon as the aim of the strike is known, it is necessary to reconcile the four main factors affecting initial planning:-

a. The tactical plan, produced by the Strike Leader.

b. The weapon effort requirement for the task, produced by the Gunnery Officer.

c. The maximum launching weight of the aircraft, and hence their maximum fuel and war loads: estimated by Lieutenant Commander (Flying).

d. The availability of aircraft and their role configuration.

Conflict between these factors will be resolved by Commander Air and the officers involved. The launching weight is a fixed limitation: the remaining factors interact.

The tactical plan demands a certain fuel load, governing the weight available for weapons, and limits the types of weapons according to the delivery methods which are possible in the circumstances. The weapon effort requirement further defines the type of weapon, and the number of aircraft needed. The availability and existing roles of the aircraft may conflict with the above factors and force a compromise.

1605. Role Changes

A change of role will impose considerable delay. In addition to removing and fitting weapon carriers, a considerable amount of electrical testing will be required, with rectification of any unserviceability. It is necessary to balance the merits of suiting the weapon to the job against the time lost by doing so.

For most limited war purposes, where a high sortie rate is required standard role configurations will be decided in advance and maintained, accepting occasional inability to use the optimum weapon load. Standard configurations for some purposes are laid down in Aircraft Carrier Squadron Memoranda.

1606. Weapon Effort Planning

The Gunnery Officer determines the best weapon to use according to the characteristics of the target, the best aiming point and the number of weapons required for a specified probability of success. The latter is mainly dependent on the expected accuracy, which itself is greatly affected by the Operational Factor.

In limited war the need to maintain a high sortie rate may lead to a temptation or necessity to skimp weapon effort planning. Conspicuous failures have, in the past, been caused thereby. It may be better to wait for a full analysis (perhaps from reconnaissance photographs) rather than to strike immediately on the basis of inadequate information. On the other hand, a slow analysis and late decision may prevent aircraft being ready by launch time, and a role change if required would cause further delay. This problem can only be alleviated by a firm understanding between all concerned on weapon loads and delivery methods for the general run of targets, leaving only the more difficult or important ones for detailed analysis. Strike leaders should beware of overestimating the probable effect of their explosives.

1607. Nuclear Strike Planning

a. For a nuclear target, weapon effort planning is replaced by target analysis, conducted by a team headed by the Gunnery Officer, who establish the optimum DGZ, burst height and fuzing instructions. The tactical plan devised by the Strike Leader is included in the planning sequence detailed in paragraph 1608 below.

b. The planning of nuclear strikes is a long process if done properly. Times for the full planning sequence may be up to:-

Ship targets - $2\frac{1}{2}$ hours
Shore targets - 5 hours

An attempt to carry out a "snap" nuclear attack will produce a less than optimum result. Exercise "Grand Slam" detailed in Aircraft Carrier Squadron Memoranda, provides training in the planning of nuclear strikes, but naturally cannot fully simulate a war situation.

1608. Nuclear Strike Planning Sequence

Information Supplied to Aircrew	Aircrew Actions
a. From Lt. Cdr. Operations: Maps, photographs, positions of launch and approximate DGZ. Tactical Situation, defences etc. (see para below). Availability of flight refuelling, spare deck, diversions and ditching positions.	Squadron Commander details Strike Leader, strike and tanker aircrew.
b. From Lt. Cdr. Flying: Maximum launch weight expected.	Determine fuel weight of strike and tanker aircraft.
c. From Met. General weather and winds en route.	Quick appreciation of the situation. Work out approximate navigation and decide if mission is feasible. Report to Command via Lt. Cdr. Operations. Command decision may be required on "one way trip" or to provide tankers. Approximate sortie length and F.R. tanker requirements passed to Ops.
d. From Met: General weather and wind structure in the target area. Accurate winds and temperatures for climb, cruise and descent.	Select I.P. (if required), plan run-in and carry out en route navigation.
e. From Target Analysts: Position of DGZ, burst height and fuzing instructions.	Commence accurate LABS calculations with run in and release heights: pass to Met.
f. From Met: Winds, temperature and pressure at approach and release heights.	Complete LABS calculations and pass settings to the A.C.R.
g. From Ops: Final full briefing including communications, codewords, own and enemy forces, CBGLO escape and evasion.	

1609. Conventional Strike Planning

In limited war the first strikes of a new campaign or operation may well decide who is to hold the initiative; they should therefore be planned in great detail by crews and strike leaders assigned two or three days in advance. The planning of succeeding strikes will inevitably be curtailed, but by then the "form" will be known and many unknowns eliminated. For a difficult target the Strike Leader's crew at least should be given two hours for planning and, in all cases, however tight the flying programme he must be given the target and the aim of the strike before the final briefing. It is idle to expect Strike Leaders to produce good tactical plans instantaneously, at will, like rabbits out of a hat. The sequence of planning is shown in the next paragraph, but many of the actions may be combined.

1610. Conventional Strike Planning Sequence

Information Supplied to Aircrew	Aircrew Actions
a. From Lt. Cdr. Operations: Target, aim of strike, photographs, position of launch.	Squadron Commander details strike leader and aircrew.
b. From Met. Officer: Weather on route and at target.	
c. From Gunnery Officer: Weapon effort requirement.	Strike Leader formulates rough tactical plan, consults G.O., Lt. Cdr. (F), Cdr. (Air).
d. From Lt. Cdr. Flying: Maximum launch weight.	
e. From Cdr.(Air): Number of aircraft, warload (first decisions, para b. above)	Elaborate tactical plan: form up, formation, action on meeting opposition, evasion, E.W. policy, strike direction.
f. From Intelligence/Operations Officer: tactical situation, defences, etc., (see paragraph 1611 below) own forces.	Decide exact approach track, direction of attack, flak suppression, method of attack. Select height to fly. Plot route on map and study it. Decide getaway method.
g. From Met. Officer: Accurate winds, temps and pressures en route and at target.	Complete navigational flight plan. Calculate sight pictures, release heights.
	Make contingency plans: bad weather, unserviceability, drop tank policy, deputy leaders.
h. From Briefing Officer: Final full briefing to all aircrew. Escape and evasion.	Strike leader briefs all aircrew.

1611. Tactical Information

The Operations Officer, Intelligence Officer or CBGLO as appropriate, provide the following information and equipment to allow strike planning to be carried out:-

a. Maps

b. Photographs of target area and target, and of landfalls as requested.

c. Description of target, situation, vulnerable points.

d. Enemy air situation.

(1) Current order of battle, types of aircraft.

(2) Airfields and serviceability.

(3) Early warning and GCI state: location, frequencies, PRFs, rotation rates, serviceability.

e. Enemy sea situation.

(1) Forces at sea, composition, PIMs.

(2) EW information as for d (3) above.

f. Enemy flak situation.

(1) SAM sites, type of missile, coverage, serviceability. EW information as for d (3) above.

(2) AA gun sites, type of gun and control system, EW information as for d (3) above.

(3) Mobile AA: availability, type, probable disposition.

g. Enemy ground situation

(1) Order of battle, disposition.

(2) Operations in progress.

(3) Bomb line.

h. Friendly air situation.

(1) Operations in progress en route and near target.

(2) Procedure for entering own air defence zones, communications.

j. Friendly sea situation.

(1) Forces at sea, composition, PIMs.

(2) Recognition, safe approach sectors, Tomcats, Pickets, Birdogs.

(3) Communications.

k. Friendly ground situation.

(1) ASOC, FAC organisation, communications.

(2) Operations in progress.

(3) Identification.

l. Communications security: codewords, coding.

1612. Briefing

The following should be placed on the briefing boards:-

a. Large area map showing significant landmarks etc.

b. Very large target area map showing direction of attack, pull up points, target itself, escape route, flak guns etc. Plenty of recognisable topographic detail to assist identification. Use Photographs.

c. Courses - times - heights - speeds - fuel.

d. Formations - leaders and deputies.

e. Callsigns and R/T channels.

f. Emergency courses.

g. The attack, including all armament and sight switches, sight settings and include a sight picture at release. Show entry and release heights and speeds. Don't forget to allow for target height above sea level and barometer.

h. Alternative attack (e.g. shallow angle).

j. Maps should where possible be prepared in advance for each crew.

1613. Briefing Sequence

a. (1) Tell off to check all are present - including if necessary Ops., 'D', Guns, Met., CCA team etc.

(2) Brief outline of task (by strike leader if possible).

(3) Met. Briefing.

(4) Operation Officer's briefing.

(5) Composition of strike, leaders, deputies, callsigns.

(6) Start up and tell off, including any plugging in of weapons etc.

(7) Take off and form up.

(8) En-route navigation, changes in formation etc.

(9) The approach to the target, E.W. methods.

(10) The attack, including bomb line if any.

(11) Alternative attack.

(12) Getaway and R/V.

(13) Return to base - navigation etc.

(14) Let-down to base and landing.

(15) Reporting enemy aircraft, fighter tactics.

(16) Fuel reporting.

(17) R/T silence policy, E.W. policy.

(18) Escape and evasion.

b. <u>Emergencies</u>

(1) Change of lead and R/T failure.

(2) Single aircraft detached from formation.

(3) Unexpected weather conditions.

(4) Jettisoning drop tanks or weapons.

(5) Friendly forces between base and enemy, planeguard destroyer or ditching position.

c. <u>Reminders</u>

(1) Any SOPs which are particularly important.

(2) R/T discipline.

(3) Empty pockets: do not take information of use to enemy.

(4) Time check and questions.

Strike Execution

1614. Form-up

After getting airborne, aircraft should assume their initial transit formation before departure from the ship or airfield if weather permits. If conditions are unsuitable the earliest opportunity should be taken to get into formation, so that the advantages gained thereby may be realised.

1615. Navigation Considerations

Strike aircraft approaching defended targets are vulnerable to attack by enemy fighters, AA gunfire and surface to air missiles. It is essential therefore that target approach routes avoid as far as possible enemy defences but, at the same time, do not make the navigational problem too great. Avoiding radar detection will be of primary importance to deny the enemy warning and tracking time on in-coming strikes. It is recommended that approach to targets should therefore be carried out low level and planned to avoid known radar coverage.

1616. Low Level Flying

Flying strikes at low level, which may be the only means of avoiding radar detection, presents certain disadvantages. The more important of these are: high fuel consumption, the difficult navigation problem, crew and airframe fatigue and the hazards of flying low in poor visibility and at night. On the other hand the advantage of denying the enemy early warning of strike aircraft by approaching at low level outweighs all its disadvantages, and is likely to be the only method of survival in heavily defended areas.

1617. The Low-Low Sortie Profile

The low-low profile has the advantage that at all times the strike aircraft is at the worst height for early detection by enemy radar. It is also, at low level, presenting a difficult target to fighter aircraft, AA guns and missile systems.

The disadvantages of this profile are:-

a. Increased fuel consumption compared with the High-Low-High profile.

b. Navigational difficulties at low level.

c. Poor radar and visual search conditions.

d. Poor UHF communications.

e. Aircrew and airframe fatigue.

This profile may prove suitable against targets at relatively close range to the carrier when navigation is not difficult.

1618. The High-Low-High Sortie Profile

The High-Low-High profile sortie consists of a climb to the optimum height for range, a descent below radar cover and a low level target approach followed by a low level run out and return to base at high level. In the practical sortie, fuel allowance must be made for combat, recovery at base and a safe landing margin.

a. The advantages of this profile are:-

(1) The high level outbound and inbound legs permit greater fuel economy and search capability than with the low-low sortie.

(2) UHF communications are improved.

(3) Navigational fixes by radio means are more readily available.

b. Disadvantages

(1) It is difficult to navigate accurately due to the timing and execution of the "under-the-lobe" descent and the low level passage. This is particularly so in the case of single seat aircraft.

This profile will prove suitable for the majority of ship and inland strike sorties. The radius of action may be increased by replacing the "under-the-lobe" descent with a descent inside the radar horizon when enemy radar cover is known to be deficient.

1619. Navigation Requirements

The requirement for accurate navigation in strike operations cannot be over-emphasised. Insufficient time for pre-sortie calculation and study can lead to abortive sorties. The individual requirements for each target and each aircraft type will vary considerably, but are broadly as follows:-

a. Radius of Action. Knowledge of the target's position and own ship's position must be accurately known in order to assess whether the target is within range, and which sortie profile is to be employed.

b. Navigation Calculations. Fuel, time and distance calculations for the entire profile must be made, including calculations for alternative routes and diversions.

c. Met. Forecast. Accurate meteorological information will be required for the target area and the outward and homeward routes, and its likely effect on navigation.

1620. Navigation to and from the target

Consideration should be given to the employment of AEW and ECM strike direction aircraft for ship strikes and direction of aircraft to landfalls.

It is vitally important to make accurate landfalls on inland and coastal strikes. Landfalls must be selected for their visual and radar prominence when viewed from the approach height of the aircraft. At low level certain inland features may be of more use for landfall identification than coastal features.

On coastlines lacking prominent landfall features it may be advisable to "aim off" so that, on failing to sight the landfall, the aircraft can be turned in the more probable direction. It may also be prudent to proceed via a good landfall which is not on the direct route to the target in order to achieve a good coastal fix.

Formation to Fly

1621. The Air to Air Threat

The threat to a defensive formation from fighter aircraft may be divided according to the type of weapons that might be encountered.

a. Ahead Sector Guided Missiles. These have a long range capability in the ahead sector of up to 16 miles and a secondary astern sector capability of up to 10 miles. Types include Anab, Ash, Awl, Sparrow and Red Top. These are complex and expensive weapons and may not be encountered in a limited war.

b. Astern Sector Guided Missiles. These are relatively less complex and cheaper than ahead sector weapons and include Alkali, Atoll, Firestreak and Sidewinder. It should be assumed that these missiles will be found wherever there are aircraft with a capability to carry them. They can therefore be encountered in a limited war. The first generation of these missiles have a maximum range of 3 miles and the second generation a maximum range of up to 8 miles.

c. Guns and Unguided Rockets. It is considered that the maximum effective range of these weapons is 1,000 yards and they are mainly restricted to the astern sector. Although some form of head-on or collision course attack may be attempted it is considered that it would have little chance of success.

1622. Countermeasures to the Air to Air Threat

Since the fire control systems of ahead sector weapons depend on a firm radar lock, accurate range rate, and in many cases early radar detection, and the success of an astern sector attack by missiles or guns depend on an accurate set-up, it appears that the primary countermeasures are:-

a. To keep out of G.C.I. radar coverage as far as possible to prevent early detection and the possibility of an accurately set-up attack.

b. To fly as low as possible to increase the difficulties of detection and lock-on.

c. To fly under the protection of jamming; this has the disadvantage that it draws attention to the formation.

1623. <u>Countermeasures to Ahead Sector Guided Missiles</u>

Assuming that the above countermeasures have failed or cannot be applied, the next consideration is whether the attacking aircraft can be detected as it, or they, approach the firing range. Visual detection may be possible in favourable circumstances but cannot be relied on. Passive electronic detection is quite effective. Active radar detection may be effective if the attacker can be detected outside firing range, but this will draw attention to the formation.

Therefore, where an ahead sector guided weapon threat exists

a. If passive warning is available on the enemy's probable A.I. frequency it should be used as the primary method of detection and the formation should remain as far as possible radar silent.

b. If passive warning is not available active radar search is worthwhile provided it does not draw attention to a formation which would otherwise remain undetected.

c. Visual search must be continuous with more attention than usual paid to the ahead sector.

d. Standard defensive formations are based on coverage from astern sector attack which is always a threat even from weapons primarily designed for use in the ahead sector. There appears to be no way of modifying these formations to give earlier detection of the ahead sector threat. Hence standard defensive formations should be used.

On detecting or sighting an enemy aircraft which intelligence suggests may be armed with ahead sector weapons the possible countermeasures are:-

(1) If it is certain that the enemy is well outside his maximum missile firing range turn away and dive to the sea or ground.

(2) If it is not certain that the enemy is outside his maximum missile firing range turn towards the threat and dive to the sea or ground to prevent the enemy's radar holding lock.

(3) Close the throttles to prevent I.R. homing and fuzes functioning.

(4) Dive through cloud to reduce I.R. and possible radar performance.

(5) If the enemy is moving into a position that will shortly enable him to fire a weapon, get into close combat to prevent him breaking away for an attack.

1624. Countermeasures to Astern Sector Guided Missiles

The limitations which affect the enemy's ability to fire a lethal round in the astern sector are:-

a. Range.

b. Angle Off. The area behind an aircraft in which an I.R. weapon can detect a high temperature source forms a cone. The hotter the temperature source, or the more advanced the weapon, the larger the limits of the cone will be.

c. Crossing speed. A high crossing speed may cause the attacker or the missile or both to exceed their manoeuvre limitations.

The defensive formations can, therefore, be based on the principles of:-

(1) Detection outside firing range.

(2) Manoeuvring to keep the enemy out of the stern cone.

An attacker with a long range weapon that can be fired at the limits of visual detection, or beyond, must of necessity range by radar and should be detected by passive equipment. In the absence of a tail warning device the enemy may be detected before he passes the beam on the approach to an attack, by Wide Band Homer, and this is possibly the best insurance against a long range attack from astern. However, the only method that can cope with an enemy approaching from astern is to detect him visually. The Defensive formation should therefore be designed to give cover astern to the maximum distance.

1625. Countermeasures to Guns and Unguided Rockets

If there is no missile threat the defensive formation should again be designed to deny the enemy the ability to reach a position where he can fire effectively, and this is based on the same principle as defence against astern sector guided missiles being:-

a. Detection outside firing range.

b. Manoeuvring to keep the enemy at high angle off, presenting him with the problem of a target with high crossing speed and preventing his armament system from computing the lead required for accurate shooting.

As the maximum range of these weapons has already been stated as 1,000 yards, and the enemy will probably not be using radar, all round visual search is required out to a maximum of 4,000 yards.

1626. Formation Requirements

a. Defence against attack by fighters governs the type of formation flown, and detection of potential attackers is the first essential.

The detection methods used are visual, radar, and passive electronic. The latter two can be used regardless of the formation flown therefore defensive formations are designed to provide the best visual cover for all aircraft.

b. The basic defensive formations are battle formations, the main considerations being:-

(1) All round visual search.

(2) Mutual support.

(3) Manoeuvrability.

(1) Visual Search. The main aim is to achieve all round visual cover. Since every aircraft has a blind sector immediately astern, cover is provided for all aircraft by flying in a formation that gives a lateral separation so that individual blind sectors can be covered by other aircraft in the formation. The greater the lateral separation the further back the cover extends. The necessity to provide tail cover dictates the primary search sector for each aircraft, and this is, that they should devote most of their attention towards the other aircraft in the formation. However, this does not relieve all aircraft of the responsibility for all round search.

There is a limit to the lateral separation that can be achieved dictated by the maximum detection range of an enemy approaching. If the maximum detection range is assumed to be 8,000 yards, then maximum lateral separation is 4,000 yards.

(2) Mutual Support

(a) Lateral Separation enables one aircraft to come to the assistance of the other by virtue of the fact that the enemy can be sandwiched in a turn.

(b) The most effective mutual support depends on the range of the aircraft's air to air armament, and the rule of thumb for lateral separation when considering mutual support is:-

Guns - separation = 2 x maximum effective gun range

Missiles - separation = $1\frac{1}{2}$ x best missile firing range

(3) Manoeuvrability

(a) In order that all the aircraft in a formation can be given the maximum amount of cross cover it is essential that the units remain abeam of one another whenever possible, this is easiest to achieve when the lateral separation is a minimum.

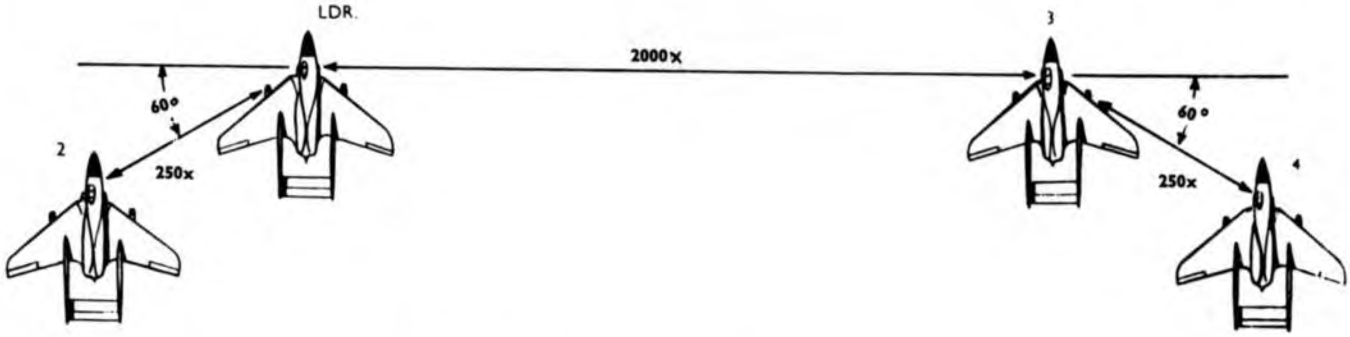


FIG. 16-2 DEFENSIVE BATTLE FORMATION

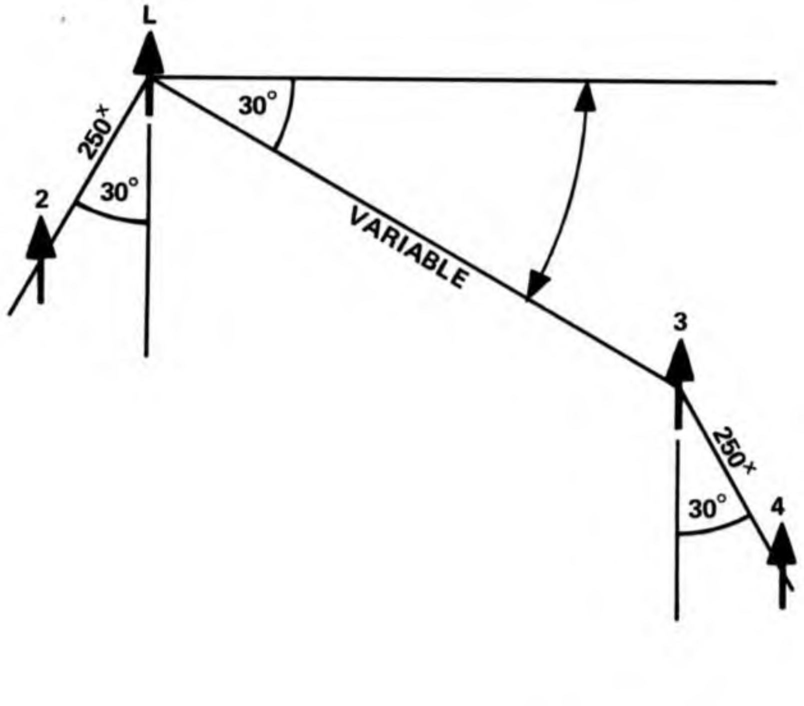


FIGURE 16–3. LOW LEVEL BATTLE FORMATION

(b) There is a maximum distance apart beyond which it is impossible to maintain formation in a turn without increasing the radius of the turn to the point where it becomes impracticable. In general the lateral separation between units should not exceed one third of the radius of the turn to be employed.

(c) If the leader uses the maximum rate of turn it will be impossible for the other section to remain in formation, this should always be born in mind particularly at altitude.

1627. Defensive Battle Formation

a. The requirements of all round visual search, mutual support, and manoeuvrability are satisfied if the formation fly in Battle Formation. The basic unit for Battle Formation is a division of four aircraft. (Fig. 16-2)

b. The distance apart of the sections depends on the threat as already discussed. The position of the section number two's is designed to be:-

(1) Close enough to manoeuvre with the section leader.

(2) Far enough away to be able to concentrate on good lookout without risk of collision.

(3) In a position where he can be seen at all times by the leaders.

c. If the formation consists of only two aircraft they should fly abeam to provide maximum lookout and mutual support.

1628. Low Level Battle Formation (Fig. 16-3)

a. The basic unit for low level battle formation is again a division of four aircraft and the consideration of all round visual search, mutual support between sections, and the manoeuvrability still apply. The primary object being visual search.

b. The lateral separation between the leader and the number three should be adjusted to suit the terrain that is being overflown. Over the sea it would be possible to fly out to a distance of 3,000 yards, while in mountainous terrain or in conditions of poor visibility the number three would have to move in, and, inside 1,000 yards, back, to avoid a collision risk and achieve manoeuvrability. The number three therefore must have freedom of movement to achieve the best compromise.

c. As with normal battle formation, if there are only two aircraft the number two should fly in the position normally flown by the number three.

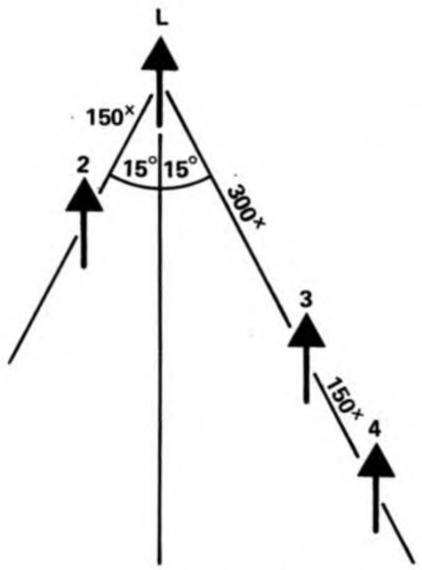


FIGURE 16–4. LOW LEVEL STRIKE FORMATION

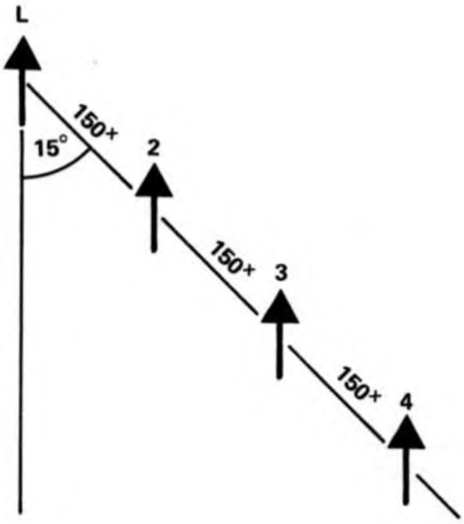


FIGURE 16–5. ATTACK ECHELON

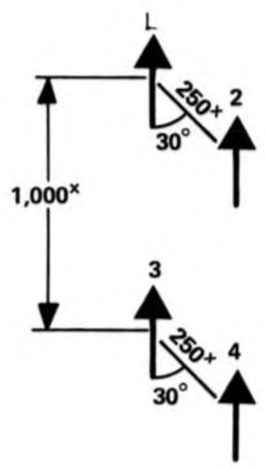


FIGURE 16–6. SECTIONS LINE ASTERN

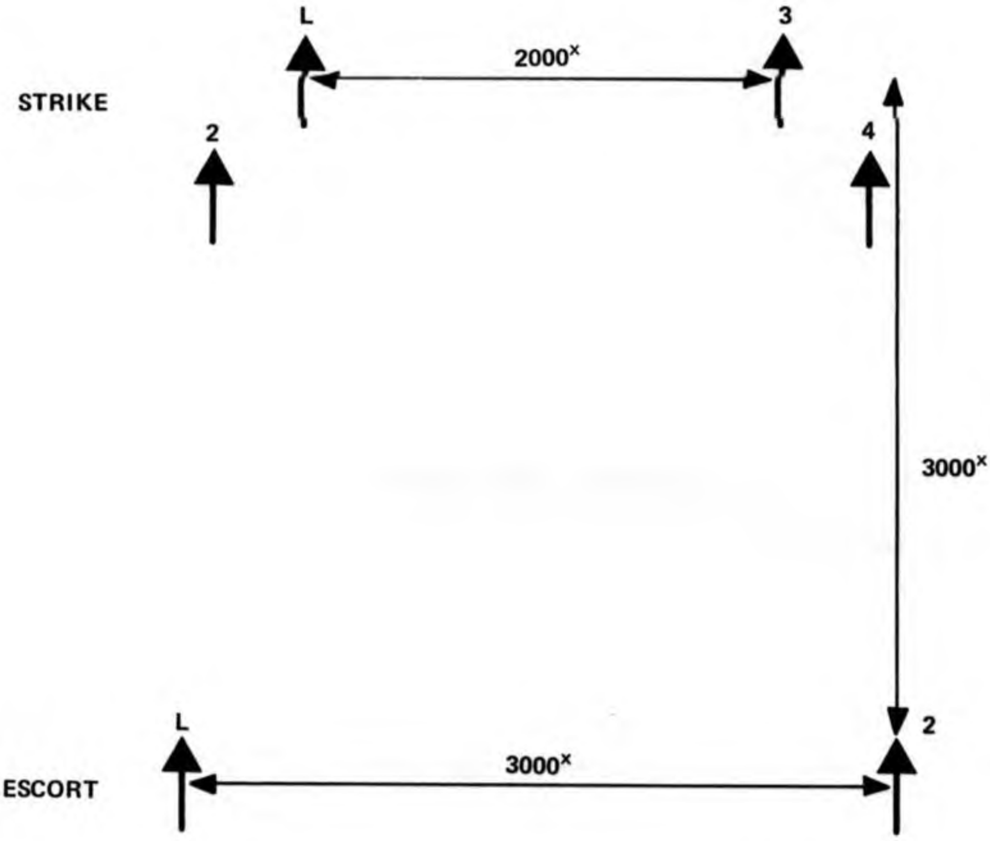


FIGURE 16–7. STRIKE ESCORT

1633. Defensive Manoeuvring

a. In planning defensive manoeuvres the objectives of keeping the potential attacker out of a firing position and placing as much distance as possible between the strike and the enemy along the mean line of advance should be borne in mind. Once an enemy has threatened the strike and is committed to an attack, the best initial manoeuvre is to counter towards the threat aiming to pass the enemy head on, then resume on to track thus giving him a turn of 180° to make before he can threaten again. With the possibility of the enemy losing contact in the turn and not being able to regain it, or of putting sufficient distance between the strike and the enemy to out-run him.

b. If the enemy has been spotted late and is about to achieve or has achieved a threatening position, a counter or break should be made towards him with the intention of making him disengage by forcing him to fly through and the threat of a sandwich.

c. The enemy should be watched carefully as he may be expected to transfer his attack to the section on the outside of the turn. If he does this, an immediate reversal will again achieve a sandwich and force the enemy to break off the attack, when the strike will be able to resume on M.L.A.

d. The enemy should then be watched for signs of a re-attack. If he does attempt a new attack the previous manoeuvres should be repeated. A mistake that is frequently made is for the strike to be too anxious to get back onto M.L.A. and this apparently timid attitude encourages the enemy to stay and harass, where as really aggressive handling of the strike menacing the enemy will either destroy him or force him to break right away.

e. A Formation's best defence against an enemy is to maintain divisional and sectional integrity. If this integrity is allowed to break down individual aircraft are left without tail cover or mutual support, and become easier prey for the enemy. Should a single aircraft become engaged in combat with an enemy with superior performance who proves impossible to out-fight some form of last ditch manoeuvre may be necessary if he achieves a firing position.

1634. Close Escort of Strikes

a. The escort should be positioned astern of the strike as shown in Fig. 16-7. The distance astern will depend on the armament of both the fighters and the potential enemy, and the altitude. The distances shown give a basis to work from.

b. The conduct of the escort will depend a great deal on the amount of fuel available for combat, and depending on this, the decision will have to be made whether to manoeuvre the strike and escort together if a threat develops or whether to detach members of the escort to deal with the threat. Two main points should be borne in mind:-

(1) It is essential for the strike to reach the target and if too much fuel is used en route this will be impossible.

(2) Once members of the escort are detached they are lost to the strike as it will be almost impossible for them to join up again.

METHODS OF ATTACK

(a) CO-ORDINATED

(a) APPROACH LOW LEVEL IN STRIKE FORM

(b) SECTIONS SPLIT AND PULL UP, TO ATTACK RADIUS

(c) 3 AND 4 ROLL INTO ATTACK WHEN THEY SEE LEADER TURN

ADVANTAGE—SPLITS DEFENCE FIRE POWER

USE—ATTACKING SHIPPING

(b) STREAM

(a) APPROACH LOW LEVEL IN STRIKE FORMATION

(b) SLIDE INTO ATTACK ECHELON DURING PULL UP

(c) FOLLOW LEADER INTO ATTACK "FANNING" IF REQUIRED

ADVANTAGE—CAN BE COMBINED WITH FAST LOW LEVEL APPROACH

USE—GENERAL

(c) SECTIONS ASTERN

(a) APPROACH MED LEVEL BATTLE

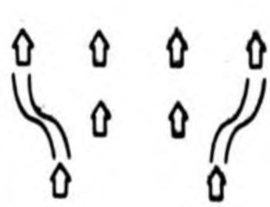
(b) LEADER AND 2 TURN ALONG ATTACK RADIUS

(c) 3 AND 4 FOLLOW 1,000' BEHIND L & 2

ADVANTAGE—ACCURATE ATTACK

USE—LIGHTLY DEFENDED SHIPPING

(d) LINE ABREAST



(a) APPROACH IN BATTLE FORMATION

(b) WINGMEN UP TO LINE ABREAST

ADVANTAGE – INDIVIDUAL TARGETS

USE – AIRFIELD, TROOP CONVOY

FIG. 16-8 METHODS OF ATTACK

1635. The Attack (Fig. 16-8)

Considerations regarding the attack have been covered earlier. It is worth restressing however that this stage of the strike - the release of weapons to hit the target - is all important. If the attack is not carried out successfully the purpose of the strike is negated and the aim is not achieved.

1636. Alternate Attack

The necessity for briefing an alternate type of attack, and for a missed approach procedure should be obvious.

Consideration should be given to the allocation of a secondary target for the strike in the event of the early destruction of the original without expenditure of all weapons, or if weather precludes any attack on it.

1637. Return

The return from the target to base should be by another route from that taken on the way there, where the strike's presence has already been advertised, and defenders will be ready. This applies particularly to coast entry and exit points.

Divisional integrity should be maintained, with escorts still in attendance.

1638. Stragglers

Any aircraft that have become detached from the main formation are particularly vulnerable. It is usually the separated singleton who is shot down. To increase his chances of survival he should maintain high speed, with a constant weave clearing his own tail continuously and with all his senses tuned to the highest pitch to detect enemy aircraft.

1639. Rendezvous Points

These are designed to enable aircraft that have become detached en route to or from the target to rejoin the formation. They should be lettered or numbered and never referred to as geographical positions in the air for obvious reasons of security.

1640. Conclusions

Throughout the planning and execution of a strike the achievement of the aim should always be the primary consideration. Any tendency for it to be submerged in the welter of subsidary details should be vigorously avoided.

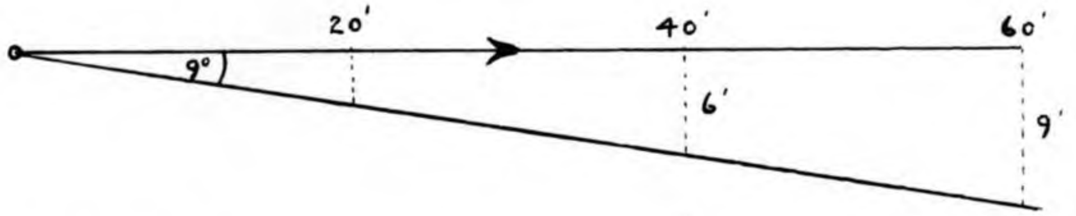
APPENDIX A TO CHAPTER 16

PILOT NAVIGATION

1. **One in Sixty Rule**

$$\frac{\text{Distance off Track}}{\text{Distance run}} \times 60 = \text{Degrees off track}$$

Example



$$\frac{6}{{}_{2}\cancel{40}} \times \frac{\cancel{60}^{3}}{1} = 9^\circ \text{ off track}$$

2. **Calculation of T.A.S. from I.A.S.**

5,000	=	I.A.S.	+	7.5% I.A.S. or roughly	10
10,000				16	20
15,000				26	30
20,000				37	40
25,000				50	50
30,000				64	60
35,000				80	80
40,000				100	100

Example

I.A.S. 300 Altitude 25,000

$$\text{T.A.S.} = 300 + \frac{50}{100} \times \frac{300}{1} = 450 \text{ kts.}$$

3. **Effect on Heading** / **Ground Speed**

Effect on Heading			Ground Speed
Beam 90°	effect	Full	Effect Nil
75°	effect	97%	25% of wind
60°	effect	87%	50% velocity
50°	effect	75%	70%
45°	effect	70%	75%
30°	effect	50%	87%
15°	effect	25%	97%
0°	effect	Nil	100%

Drift Calculation

$$\frac{\text{W.V.}}{\text{T.A.S. in miles/min}} \times \text{percentage drift} = \text{degree drift}$$

Example

W/V = 205/70 T.A.S. = 300 kts. HDG = 265
(5 miles/min)

Wind is 60° abeam

∴ wind has 87% effect (approx 9/10)

∴ drift = $\frac{70}{5} \times \frac{9}{10} = 12\frac{1}{2}^{\circ}$

Ground Speed

$\frac{50}{100} \times 70 = 35$ kts.

∴ Groundspeed = 300 - 35 = 265 Kts.

4. Alteration of Speed to Gain or Lose Time

To gain $\frac{1}{2}$ minute in 5 increase speed by 1/10 i.e. 360 k becomes 396
To lose $\frac{1}{2}$ minute in 5 decrease speed by 1/10 i.e. 360 k becomes 324

To reach E.T.A.

Example 1. When running late.

Distance to run = 300 n.m. T.A.S. = 300 Kts.

∴ Time = 60 mins.

The first 100 miles takes 21 mins.
Then 1 min. in every 39 must be gained.
increase speed by 1/39 (1/40)

New T.A.S. = $300 + \frac{300}{40}$ = 307 K for arrival on E.T.C.

Example 2. When running early.

Distance to run = 300 n.m. T.A.S. = 300 Kts.

∴ Time = 60 mins.

The first 100 miles takes 18 mins.
Then 2 mins. in 42 must be lost.
Decrease speed by $\frac{2}{42}$ $\left(\frac{1}{20}\right)$

New T.A.S. = $300 - \frac{300}{20}$ = 285 Kts.

5. Unforseen Diversions

It may be necessary to avoid high ground in bad weather. This need not cause the flight plan to be abandoned if a pre determined dog leg is used.

a. If an aircraft alters course by 60° in direction for a certain time and then alters course 120° in the opposite direction for the same time, track will be regained and E.T.A. will be increased by $\frac{1}{2}$ the time spent in the dog leg.

b. If a 30° dog leg is employed the E.T.A. will be increased 1/7 the time of the dog leg.

6. Turns

All turns must be calculated.

a. Use nomogram

b. At high I.A.S. the diameter of the turn is approximately equal to 2/3 of the speed in miles per minute.

CHAPTER 17

WEAPON EFFORT PLANNING

1701. A summary of the planning stages is listed:-

Major overall Air Staff Policy
Target Selection
Ultimate aim of attack
Analysis of target structure and vulnerability
Evaluation of operational factors
Weapon selection and fuzing
Determination of density
Accuracy of delivery
Force requirement calculations
W.E.P. graphs
Over target requirement
Aircraft required
Ineffective allowance
Aircraft to be despatched

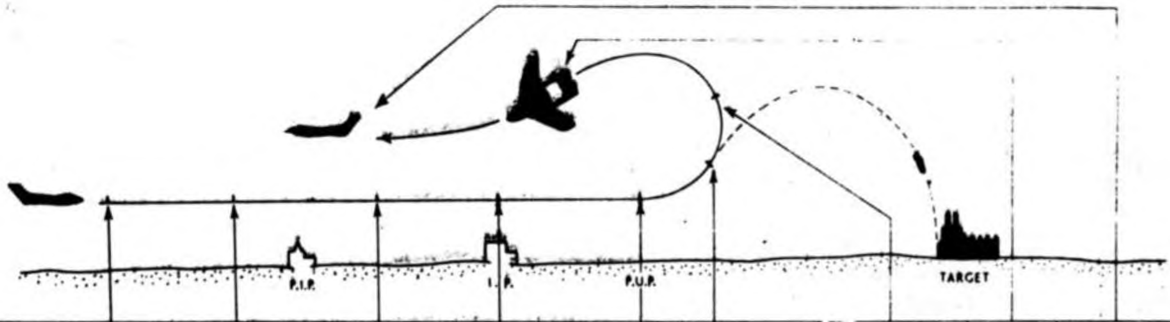
1702. The effort required to hit a target is inversely proportional to the square of the accuracy of delivery. If the fall of shot errors are halved only a quarter of the weapons are required.

1703. Accuracy of delivery is 50% C.E.P., your's affecting the Squadron's. The standard achieved by the Squadron in practice is multiplied by an operational factor which allows for all the things that may degrade accuracy, such as lack of recent practice, attacking an unfamiliar target, inaccuracies in forecast wind at distant targets, and experiencing enemy reaction. This factor has been found to be as high as 2.5 in past limited operations. On this expected operational accuracy depends the remainder of the calculations culminating in the number of aircraft to be launched.

So it may be seen that the main aim of practice weapon training is to increase accuracy so that prospective war effort may be minimised.

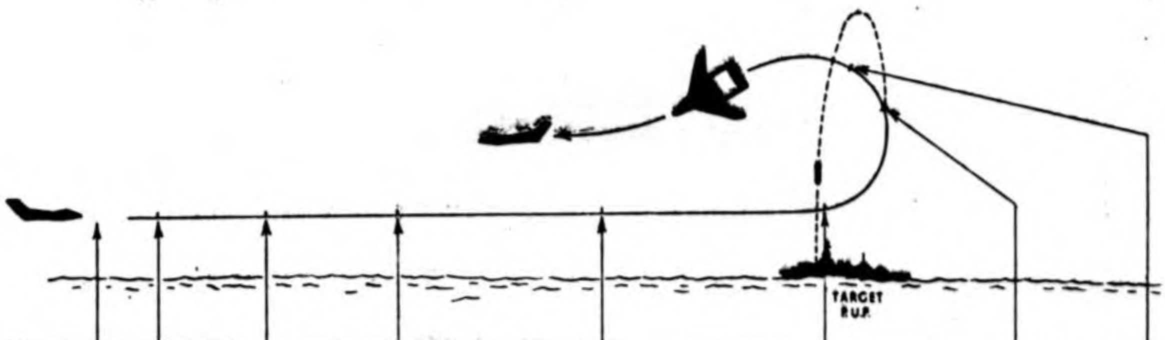
1704. Standards

The standards required for all forms of attack are contained in C.D.C.I. 16/68.



SWITCH SEQUENCE	POWER ON	LABS. SIGHT	LABS. START	PRESS 'PICKLE'	←	→	RELEASE 'PICKLE'		RE-CYCLE (LABS. START-OFF)
LIGHT			ON ←		→ OFF	ON ←	→ OFF		
PILOTS TO NOTE		MINIMUM OF 2 MINS. FOR GYRO RUN UP BEFORE MAKING LABS. START SWITCH	BE LINED UP AND STRAIGHT AND LEVEL		PULL UP AND 'ZERO THE HORIZONTAL NEEDLE'	BOMB RELEASED AUTOMATICALLY AT PRE-SET ANGLE OF CLIMB		ROLL OFF THE TOP AFTER 185°	MUST BE WINGS LEVEL FOR 30 SECS.
TIMER				STARTS ←	→ STOPS				
GYROS ETC.	LABS. INVERTORS RUN UP 115V 400C A.C. 28V D.C.	POWER TO SYSTEM. GYROS CAGED BUT RUNNING UP. INDICATOR LIVE BUT VERY LIMITED MOVEMENT	VERTICAL GYRO UNCAGED (AFTER 3 SECS.) HORIZONTAL GYRO PARTIALLY UNCAGED (PIN IN) IF NOT STRAIGHT AND LEVEL THEN VERTICAL GYRO ERECTS AT ONLY 4°/MIN.		HORIZONTAL GYRO UNCAGES TO REPRESENT YAW/ROLL ON THE VERTICAL NEEDLE. ACCELEROMETER SHOWS 'G' ON HORIZONTAL NEEDLE. VERTICAL GYRO ERECTION SYSTEM CUT OUT.	'NORMAL SECTOR SWITCH' MAKES CONTACT AT ANGLE PRE-SET ON VERTICAL GYRO CASING	HORIZONTAL GYRO CONTINUES TO REPRESENT YAW/ROLL ON THE VERTICAL NEEDLE. VERTICAL GYRO REVERTS TO PITCH ON HORIZONTAL NEEDLE.		GYROS REQUIRE 30 SECS. TO RE-CAGE AND AIRCRAFT MUST BE STRAIGHT AND LEVEL TO AVOID DAMAGE TO GYRO STOPS.

FIG. 18-1 THE NORMAL TOSS ATTACK



SWITCH SEQUENCE	POWER ON	LABS. SIGHT	SELECT ALTERNATE	LABS. START		PRESS 'PICKLE'		RELEASE 'PICKLE'
LIGHT				ON →		OFF AT END OF TIMER RUN. IGNORE	ON	OFF
PILOTS TO NOTE					NO I.P. IS AVAILABLE. RUN IN VISUALLY ON TARGET	PULL UP	BOMB RELEASED AUTOMATICALLY AT PRE-SET	RECOVER AS NORMAL
TIMER						STARTS/STOPS (ONLY 2/10 SECS. IF SET TO MIN.)		
GYROS ETC.	← AS NORMAL			VERTICAL GYRO UNCAGES GIVING ROLL AND PITCH	→	GYRO CHANGEOVER GIVING YAW/ROLL AND 'G'	ALTERNATE SECTOR SWITCH MAKES CONTACT AT ANGLE PRE-SET ON VERTICAL GYRO CASING.	

FIG. 18-2 THE ALTERNATE ATTACK (OVER THE SHOULDER)

Missing pages were either CONFIDENTIAL or SECRET
and I burnt it when 899Sqn disbanded and our Sea Vixens
went to bone yards or Llanbedr as Radio Control targets,
back in the days of the Cold War and it all seemed so important
not to let on that such facts as that when it came to the crunch,
2”R/P were the weapon of choice in A/A against a Mig21!
Don’t believe me? Talk to me about the Island of Lesser Tunb
in the Persian Gulf, 1971

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(1) <u>Normal or Long Toss</u> (Fig. 18-1)

In this attack a suitable I.P. (Identification Point) is chosen from which a timed run is made to the pullup point where the manoeuvre is performed and the weapon released to destroy the target.

This is the more accurate form of attack giving greater immunity to AA fire and safer separation from the burst.

(2) <u>Alternate or Over the Shoulder</u> (Fig. 18-2)

Pullup is initiated at the target. The same manoeuvre is flown as for Normal, but the weapon is released at the unique angle near the vertical such that the distance the bomb travels back to the target equals the forward travel of the aircraft from pullup to release. It is used where no I.P. is available, or when a Normal run is aborted for some reason.

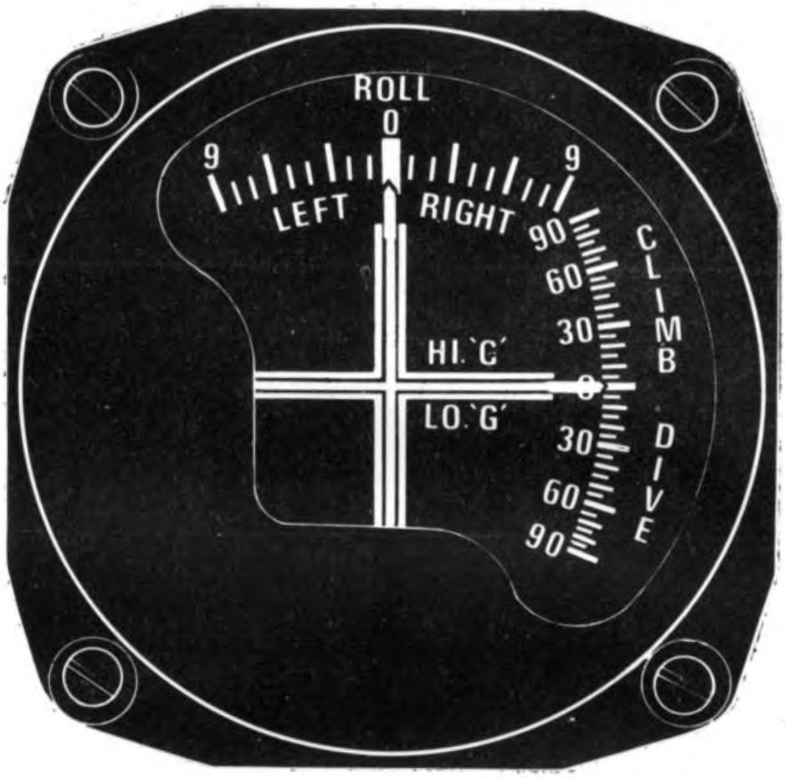


FIG. 18-3 INDICATOR

1803. Equipment

a. Indicator and Light (Fig. 18-3)

These are fitted above the pilots instrument panel, the light is separate from the indicator gauge, and is lit and extinguished to provide information to the pilot.

The indicator is a two-needle gauge, the vertical needle indicating roll, or yaw and roll, and the horizontal needle indicating pitch or G.

Indications during an attack are as follows:-

(1) Run in - roll and pitch, light on.
(2) Pull up - combined yaw/roll, and G, light goes off.
(3) Release - combined yaw/roll, and G, light on.
(4) After release - when the trigger is released yaw/roll and pitch, light out.

b. The Timer

This is fitted above the radar display - a knurled knob reads against a scale of 0.2 - 28 seconds in 0.2 seconds steps. The knob must be pulled out before rotating and should not be touched while the timer is running.

It is used to time, electrically, the run in from I.P. to Pullup point which is calculated before and set before or during flight. When the timer stops at the end of its run the indicator light is extinguished and gyro changeover takes place indicating G, by the pitch needle dropping, and yaw/roll on the gauge.

c. The Accelerometer

This is sited near the aircraft c of g., and indicates up to 5 G in the vertical plane of the aircraft.

At the pullup point the horizontal needle is deflected downwards and by application of G a signal is fed from the accelerometer so that when the correct 4 G, selected during calibration, is applied the needle is zeroed.

d. The Vertical Gyro

This is situated behind the observers seat, and has 360° freedom in pitch and $\pm 85^\circ$ in roll. It can be electrically caged, has a mercury switch erection system with an erection rate of 4°/min.

There are two sector switches preset before flight to provide weapon release at selected angles of climb.

The selections may be made for

Normal 0 - 135°
Alternate 85 - 135°

A wings-level switch can judge the aircraft roll attitude to within $\frac{3}{4}^{\circ}$ of arc.

The gyro takes 2 minutes to run up, and ten seconds to uncage. It must not be uncaged before the 2 minutes run up period is complete.

Recaging takes 30 seconds and must only be carried out in level flight.

The gyro provides.

(1) Roll and pitch during run in.
(2) Release angle to bomb circuits.
(3) Pitch only after trigger is released.

e. Horizontal Gyro

It is sited next to the vertical gyro, but has no erection system or sector switches. It can be caged electrically and in addition mechanically. Time limitations for run-up electrical caging and uncaging are the same and apply simultaneously.

Gyro freedom is 360° in roll and ± 58° in yaw.

It provides roll/yaw information during pullup, since the vertical gyro cannot provide it as the aircraft rolls about the gyro spin axis during a vertical climb.

Normally the horizontal gyro is mechanically uncaged at the P.U.P. but two provisions are made to ensure that it uncages to the true vertical. If the aircraft is not within $\frac{3}{4}^{\circ}$ in roll of the true vertical as judged by the wings level switch in the vertical gyro a thermal delay of 4 seconds operates; if in this time the pilot rolls the aircraft wings level the gyro uncages as it passes the true vertical. If this does not occur within the 4 seconds then the gyro uncages to an incorrect "vertical".

If turbulent conditions are experienced during the run in to P.U.P. the pilot can select manual yaw/roll to anticipate the necessity of uncaging to the true vertical. Operation of the switch changes pitch indication to G, until the switch is released when it returns to pitch, and roll to roll/yaw as the aircraft flies through the true vertical.

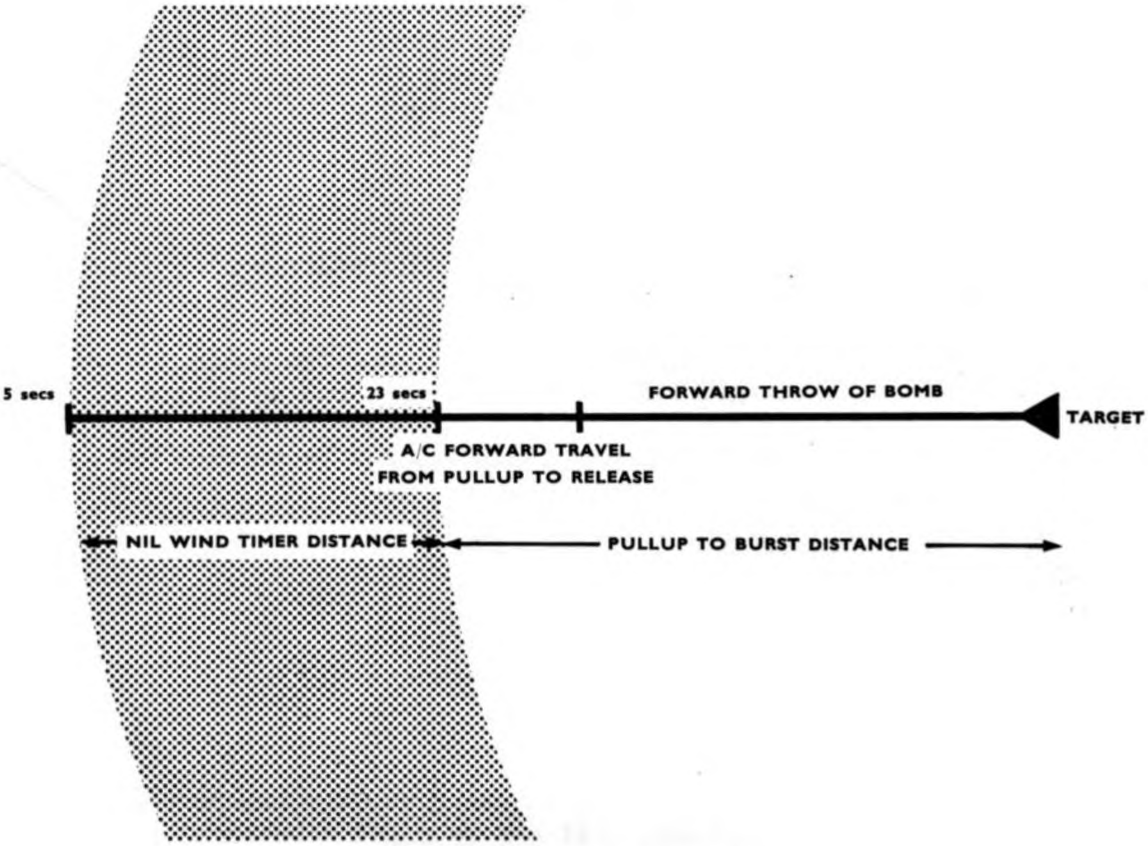
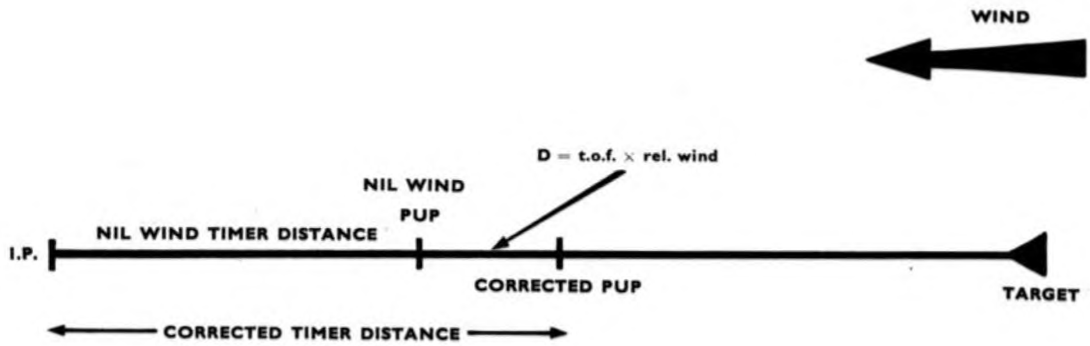


FIG. 18-4 I.P. SELECTION LIMITS



NOTE:

CORRECTED TIMER DISTANCE FLOWN AT GROUND-SPEED (T.A.S. ± HEAD/TAIL COMPONENT OF APPROACH WIND) GIVES CORRECTED TIMER SETTING (SECS).

FIG. 18-5 ALONG TRACK WIND

f. The Relay Box

This is fitted behind the pilot's seat and contains relays and potentiometers which enable the indicator needles to be zeroed during calibration.

g. The Calibration Box

It is sited with the relay box and contains the thermal delay for uncaging the horizontal gyro, circuitry and relays used during the manoeuvre, and adjustments to the sensitivities, ratios and calibration of the system.

1804. The Nil Wind Problem in Detail

The calculations are worked out from the target backwards. The forward throw of the bomb for all flight path release angles above the horizontal and the flight path of the aircraft from pullup to release are known so the pullup point to burst distance can be found.

The timer may be set from 0.2 to 28 seconds but to allow for any wind along track a nil wind timer setting between a maximum of 23 and a minimum of 5 seconds is selected. The distances covered at 540 knots T.A.S. for these times can be calculated, and when added to the pullup-to-burst distance form an annular area in which a suitable I.P. may be selected (Fig. 18-4). The Approach - run-in - Height and the Burst Height are selected with their interrelation affecting the forward throw and time of flight of the weapon, while the run-in height directly controls the release height above mean sea level.

Knowing the temperature and pressure at approach height, the IAS at which to fly (adjusted by P.E.C. and instrument error) to give 540 knots T.A.S. can be calculated.

1805. Wind Effect Normal Toss

a. The wind at release height is taken to be the wind affecting the bomb from P.U.P. to burst. It is divided into its along and across track components.

b. Similarly the wind at approach height is the wind affecting the aircraft from I.P. to P.U.P. and is split into its two components.

c. Along Track Wind (Fig. 18-5)

(1) Release

The along-track component of the release wind moves the bomb during the time of flight (although it's attached to the aircraft until release) from P.U.P. to burst, over or short by a distance.

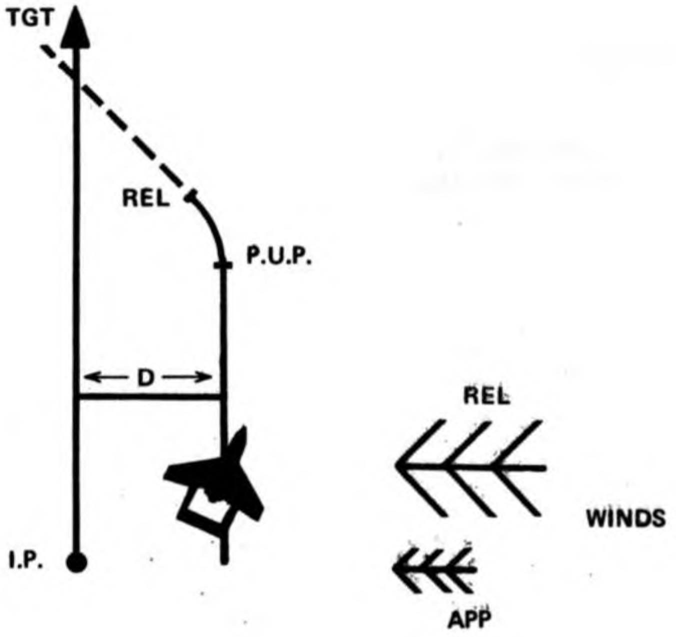
D = t.o.f. x release wind.

So by moving the P.U.P. that distance closer to the target for a headwind and further away for a tailwind, the bomb should hit the target.

(2) Approach

The along track component of the approach wind gives ground-speed from I.P. to P.U.P.

The distance I.P. to corrected P.U.P. flown at ground-speed gives the corrected timer setting to be applied.



D = DISTANCE BOMB TAKEN DOWNWIND DURING T.O.F. BY STRONGER RELEASE WIND

FIGURE 18–6. ACROSS-TRACK WIND

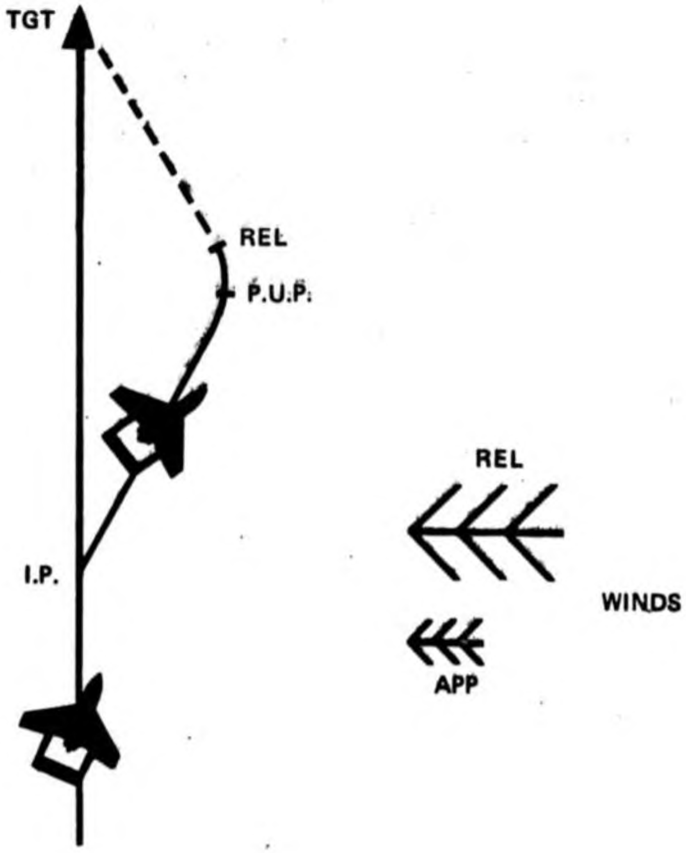


FIGURE 18–7. ACROSS-TRACK WIND–METHOD USED

d. Across Track Wind

There is no means of allowing for crosswind in the L.A.B.S. equipment, so a correction must be applied by aiming the aircraft.

(1) Taking the case where there is a crosswind component at release different from that on approach, to get the bomb to hit the target one needs to release the bomb by the amount upwind of the track IP to burst that the bomb will be taken downwind during its time of flight, with the aircraft track at release paralleling the IP to burst track (Fig. 18-6).

This proves to be an impossibility because

(a) The aircraft would have to pass the IP offset that distance - upwind of track, which nullifies the reason for an IP.

(b) During pullup the aircraft drifts downwind because of its reduced forward speed, so the track at release no longer parallels the IP to burst track, and one can not turn into wind during pullup to allow for this.

(2) The alternative is to approach the IP angled into the approach crosswind by the amount of pre-IP drift required to keep the aircraft on track from IP to P.U.P., and increase that drift angle at the IP to take the aircraft upwind of track heading such that at the PUP both the distance upwind of track and aircraft track at release conditions are satisfied (Fig. 18-7).

This method is in fact used.

(3) The calculations are as follows:-

Pre IP drift required $= 57.3 \left(\frac{C_A}{V}\right)$ degrees

where C_A = approach crosswind component from IP to P.U.P.
V = approach T.A.S.

Correction to Pre IP drift, to be applied at IP

$$= \frac{\dfrac{57.3 \times F_b \times C_r}{V_r \cos R} \pm F_b \times (\text{Pre IP drift})}{D}$$

Where:

F_b = forward throw of bomb

C_r = release crosswind component

V_r = release T.A.S.

R = flight path release angle

D = IP to target distance

More simply put:

$$\text{Correction} = \frac{\text{Throw}}{\text{IP to Tgt distance}} \times 57.3 \left(\frac{\text{Release crosswind}}{\text{Release TAS Cos R}} + \frac{\text{Approach Xwind}}{\text{Approach T.A.S.}} \right)$$

NOTE

For a 45° flight path release angle where the crosswind is the same on approach and at release, the correction to be applied to Pre IP drift is equal to the Pre IP drift. i.e. At IP double the drift to give required track.

1806. Alternate Manoeuvre

a. The release height for this attack is naturally much higher than for Normal, and the release height wind is again taken to be the wind affecting the aircraft and bomb from P.U.P. to burst.

b. Upwind Aiming Distance

The time from P.U.P. to burst is known. During this time the release wind is moving the aircraft and bomb downwind by a distance proportional to the wind speed. If the P.U.P. is moved this distance upwind of the target, the bomb will hit the target no matter what the aircraft's direction of attack is. However if the aircraft overflies the target making good a track the same as the release wind direction, the timer may be used to provide an accurate P.U.P. by setting the time taken to cover the upwind aiming distance at the approach ground speed.

c. Buffet Boundary

In some conditions of aircraft weight, and temperature and pressure at the release height the aircraft may be flying beyond the buffet boundary before it reaches the release point. It is believed that this will have little effect on the accuracy of delivery, although some marked trim changes may be experienced when releasing the heavier store.

1807. Radar IP

Against radar discreet targets such as ships, the use of a radar IP is possible. Although not as accurate as a visual IP, results using this method of attack for a Normal toss are likely to be more accurate than those from an Alternate manoeuvre, and a stand-off capability is maintained.

1808. Errors in LABS

The greatest source of potential error is inaccuracies in forecast winds at release and approach heights, the probable inaccuracy increasing with base to target range. Errors listed are for average conditions with a mean P.U.P. to burst time of 45 seconds, and timer setting of 12 seconds.

1809. Errors in L.A.B.S. (Normal Toss)

ERROR SOURCE	EFFECT	AMOUNT AND REASON
a. Release wind		
(1) Along track component	Over/Short	75ft. per knot.
(2) Across track component	Left/Right	in order of 75ft. per knot.
b. Approach wind		
(1) Along track component	Over/Short	100 ft. per knot.
(2) Across track component	Left/Right	variable but in order of 70ft per knot.
c. Error at IP due to (1) Navigation (2) Pilot reaction in pressing trigger	Variable	Error at target is directly related to error at IP e.g. Pilot presses trigger 100ft late 100ft to right of IP to tgt track - bomb falls 100' over, 100' right of target.
d. Approach height	Over/Short	In order of 150ft per 100' error. If high bomb over because (1) Bomb trajectory is higher. (2) At calculated IAS, TAS is higher.
	possible Left/Right	Crosswind component will most probably vary with height, giving incorrect drift angle.
e. Approach speed	Over/Short	100ft per knot.
f. Incorrect PUP due to error in timer setting or pilot reaction.	Over/Short	900 ft per second.
g. Rate of application of G.	Over/Short	If 4G applied in more than 2 secs, bomb over.
h. G held	Over/Short	Low G - bomb over.
i. Release angle due to incorrect setting or aircraft incidence.	Over/Short	Very small errors occur at 45° release angle.
j. Roll angle	Left/Right	Approx. 450 ft per 1° bank angle at release.
k. Yaw angle	Left/Right	Approx. 400 ft per 1° yaw angle at release.
l. Heading	Left/Right	Variable depending on where error is applied, but a major source of line errors.

1810. Errors in L.A.B.S. (Alternate)

The effect of errors incurred during an alternate manoeuvre apply in a similar sense, but by a varying amount because of the high release angle and long weapon time of flight. An understanding of para 1809 will provide sufficient information for a comparison with the alternate manoeuvre to be made.

1811. Switches

a. LABS/Normal

A rotary switch situated on port shelf supplies power to the system, starts gyros and "converts" armament circuits to LABS.

b. LABS/Start

Situated on port shelf outboard of LABS/Normal switch. Uncages vertical gyro; information then available from LABS gauge.

c. LABS/Laydown Switch

Where fitted, it is on the port shelf near the LABS start switch. Used to release retarded bomb when timer runs out. So must be to LABS.

d. Normal/Alternative Switch

On panel ALL in front of Pilot, Normal Toss or Alternate manoeuvre may be selected.

e. Manual Yaw/Roll

On panel ALL in front of Pilot. Its use already explained.

f. LABS Gauge and Light

On panel ALL. A proposal has been made to move the Red Top Indicator down to the Radio Altimeter position, which may have been carried out in some aircraft.

g. Trigger

Sometimes known as "Pickle Button" in LABS. Pressed at IP to start timer and must then be held pressed to achieve weapon release.

h. Armament Switches

Correct switches to release weapon must be selected in the usual manner.

1812. Flying the LABS Manoeuvre

a. Pre-Flight Planning

Accurate pre-flight planning allied to a thorough knowledge of L.A.B.S. is vital to the success of a sortie. Time spent on the problem on the ground is never wasted in the air, and should be considered in terms of hours rather than minutes. If you haven't got it sorted out by the time you strap in you'll never hack it in the air.

b. The Approach

A suitable Pre-IP should have been selected for navigation purposes, at which LABS is selected on the LABS/Normal switch, far enough from the IP to allow the gyros the 2 minutes required to run-up. Armament switches should be made and all LABS selections completed.

Approach height and speed should be achieved and accurately maintained, and drift applied to hold the aircraft on track. The LABS START switch should be made in straight and level unaccelerated flight shortly before reaching the I.P.

c. The I.P.

The Pickle Button is pressed and held the moment the aircraft passes the IP, and correction to drift applied immediately. Accurate height, speed and heading are of paramount importance at this stage, while the timer runs.

d. The P.U.P.

At the PUP the timer runs out, the horizontal needle on the LABS gauge drops and the Indicator light extinguishes simultaneously, at which the pilot applies 4 G linearly and steadily to zero the horizontal needle, keeping the vertical needle, which now indicates yaw/roll, zeroed at the same time. Power is left at the setting applied on the approach.

e. Release

At the flight path angle above the horizontal preset on the release angle sector switch on the vertical gyro, the weapon is released, shown by the indicator light illuminating. After this occurs the pilot releases the pickle button, which reverts the horizontal needle back to pitch indication, and completes his escape.

f. The Escape

The half-hoop is completed by reference either to the LABS gauge or the Attitude Indicator or a combination, and the aircraft rolled out in a shallow dive with full power applied to gain maximum separation from the burst.

Subsequently, the pilot recages the gyros by selecting LABS START OFF in straight and level unaccelerated flight. 20 seconds later the LABS NORMAL switch is selected back to NORMAL and armament switches returned to SAFE, unless subsequent attacks are to be made.

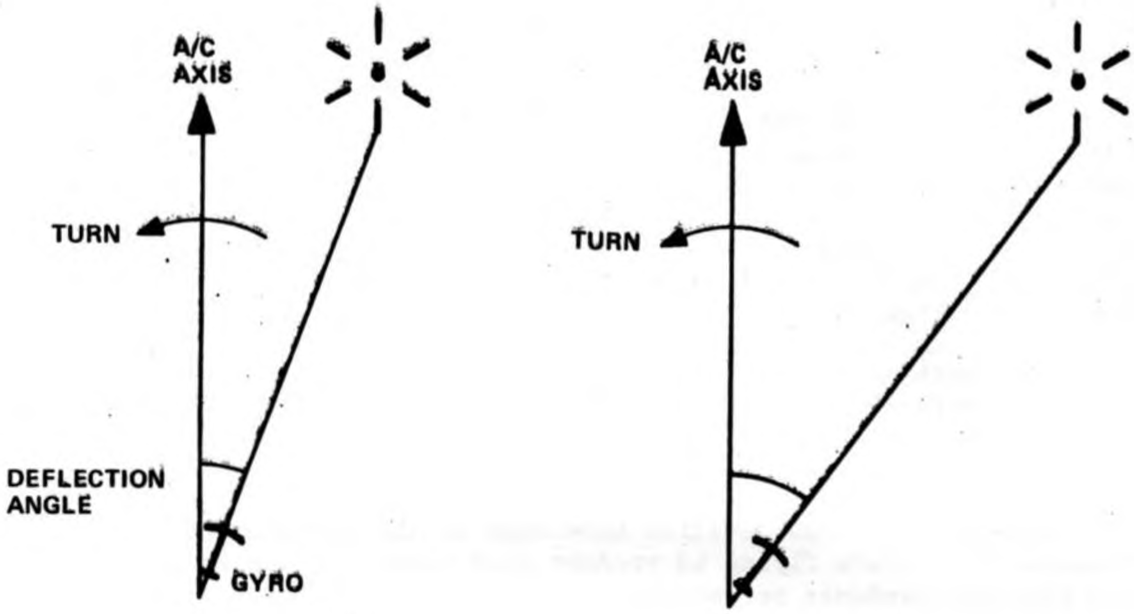
g. Aborting

(1) If for any reason the pilot does not wish to release the weapon after he has pulled up he must release the pickle button before the aircraft attitude reaches the preset release angle. The horizontal needle will continue to read G, and reference must be made to the attitude indicator for safe completion of the manoeuvre.

(2) If the pilot decides to abort a normal toss attack for some reason, such as missing the IP, he can still carry out an alternate attack, by selecting alternative on the Normal/Alternative switch. Pullup is initiated over the target or at the upwind aiming distance pullup point, by pressing the pickle button, which causes the horizontal needle to drop indicating G, and he then zeroes it as normal. The indicator light remains lit until any timer setting applied has run out, although this does not affect the manoeuvre in any way. Both needles are kept zeroed, for much longer in this attack, as before and the other sequencies are as for normal.

h. Summary

Both manoeuvres require detailed knowledge of the system, and a high standard of accurate flying to produce good results. As in all armament, practice produces perfection.



SLOW RATE OF TURN OR
SMALL SENSITIVITY

FAST RATE OF TURN OR
LARGE SENSITIVITY

FIGURE 19–1. GYRO LAG

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and I burnt it when 899Sqn disbanded and our Sea Vixens
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Missing pages were either CONFIDENTIAL or SECRET
and I burnt it when 899Sqn disbanded and our Sea Vixens
went to bone yards or Llanbedr as Radio Control targets,
back in the days of the Cold War and it all seemed so important
not to let on that such facts as that when it came to the crunch,
2”R/P were the weapon of choice in A/A against a Mig21!
Don’t believe me? Talk to me about the Island of Lesser Tunb
in the Persian Gulf, 1971

CHAPTER 19

METHODS OF GROUND ATTACK FOREIGN TO THE SEA VIXEN

1901. Gyro Sighting

A gyro can be used to compute the deflection required for target movement and wind effect. This deflection angle or lag depends on aircraft rate of turn and gyro sensitivity, the larger sensitivity producing greater lag due to decreased magnetic restraint (Fig. 19-1).

By selecting a sensitivity suitable to the type of attack the gyro can also compensate to a large extent for errors in dive angle release speed and slant range.

The disadvantages of gyro-sighting are that steady tracking is required during the dive, which precludes jinking to confuse AA fire, and the accuracy of the computed deflection improves with longer tracking times, so snap attacks or attacks with low cloud base are out. For long weapon times of flight a large sensitivity is required, which makes tracking extremely difficult, and limits its practical use to rocket attacks only.

1902. Buccaneer Modes

a. Auto DSL (Depressed Sight Line)

A depressed sight line is used to track the target, and when in the ensuing bunt the G has reached between 0.5 and 0.4 G, depending on the store and depression angle selected, the dive bombing equation is solved and the bomb is automatically released. In Depressed Sight Line bombing, the pilot solves the same equation by achieving the correct dive angle speed and height of release. The G required is measured by a sensitive accelerometer.

Correction for wind effect or target movement is fed manually into the sight, offsetting the aiming point the required amount for a 15° dive.

Better accuracy, greater flexibility of attack conditions, capability of accurate stick bombing, increased stand-off capability and reduction in height of cloudbase required are claimed for this system.

A minimum of 4 seconds steady target tracking is required, accurate release speed and dive angle becoming unimportant, but normally kept somewhere between 5 and 25° and 450-550 knots.

b. Long and Medium Toss

These modes of attack are used to give a stand-off bombing capability. From a low level approach the weapon system computes and displays to the pilot the correct pullup point, rate of pullup and point where automatic weapon release occurs, based on time to go to target. Release range for long toss approximately $3\frac{1}{2}$ miles, and medium toss $2\frac{1}{2}$ miles.

c. Dive Toss

From a dive attack the correct pullup point is computed and displayed, and the weapon is released automatically shortly after pullup. The use of this mode is in abeyance.

d. Locked on D.S.L.

Slant range from the target is measured by radar during the dive to give weapon release. Because of this, accurate results are possible.

1903. Stick Bombing

A stick is two or more bombs released from an aircraft so that they reach the target along the line of attack separated by a pre-determined horizontal distance.

There is a greater chance of hitting all but pin-point targets with a stick of bombs than with the same bombs aimed and dropped singly, particularly in the case where the target possesses a long dimension e.g. ship, bridge.

The optimum direction of attack varies between about 30° and at right angles to the longest dimension.

Optimum spacing between bombs depends on a number of factors, but is basically about twice the weapons lethal radius for small targets, and equal to the effective width of a larger symmetrical target.

1904. Strafing

The gun is a very accurate weapon, having a high muzzle velocity. The punch packed by each round is comparatively small but this is compensated for by the high rate of fire.

Effective range is in the 500 to 1,000 yard region, and sighting is simple because there is little gravity drop, it is not a flight-path weapon and with the high muzzle-velocity compared with aircraft speed, the weapon goes where the aircraft is pointing.

CHAPTER 20

NIGHT ATTACKS

2001. Requirement for Illumination

There are two main reasons for illuminating a target at night.

a. Visual Identification

Depending on circumstances this may be necessary for

(1) Initial classification by a probe.

(2) Identification of the target to be attacked in the absence of strike direction, or intelligence or other sources.

If the target is small, such as an F.P.B., identifying aircraft may have to close to a range of about 1 mile, nullifying the advantages gained by a stand-off delivery of the illuminant.

b. Visual Attack

An illuminated target may be attacked using the normal weapon sighting methods. Without illumination recourse has to be made to radar and a blind attack.

There are numerous other occasions when illumination may be required such as support of ground troops, helicopter assault etc., and for these the same principles apply.

2002. Lepus

a. Introduction

The Lepus flare provides illumination of 4 million candlepower for 3 minutes falling at a rate of approx. 24 feet per second. 4 can be carried on the Light Stores Pylons.

Lepus may be released from level flight or a toss manoeuvre, and start its flight as a free-falling clean bomb.

It has a timer which may be preset on the ground from 6 to 56 seconds in 5 second steps.

A safety device permits the timer to start 2 seconds after release.

When the timer runs out the tail of the bomb is jettisoned.

0.2 secs later a small drogue is deployed.
3.3 secs later the main parachute opens.
1 sec later the nose cone is jettisoned.
0.1 secs later the flare ignites.

So the time from release to ignition is 6.6 seconds plus the timer setting on the flare.

b. Choice of Attack Method

The Lepus flare offers great flexibility as an illuminant, both in method of attack and degree of illumination.

It may be delivered from level flight or by a toss manoeuvre using a wide variety of approach speeds and heights, with different times and intensity of illumination being available. These are found in the Lepus Tables (P.A.53C).

Their selection will depend on a number of factors, among them the target to be attacked, its defence capability, the state of aircrew training, and weather.

In a level flight delivery, the aircraft armament circuits are used, while in a toss manoeuvre the LABS equipment is brought in as well. It is possible to carry out a modified toss manoeuvre without using the LABS equipment by releasing in a selected angle of climb at a known height, speed and range from the target; from the limited statistical evidence available, this method offers a number of advantages with little probable degradation in accuracy of delivery.

c. Selection of Ignition Height

The intensity of illumination of a target varies inversely as the square of the distance of the flare from it. (i.e. 4 times brighter when the flare is at 1000 ft than it was when the flare was at 2000 ft).

For two minutes of illumination a minimum ignition height of 2,700 is required.

So when planning an attack the two factors of time and intensity of illumination have to be considered.

d. Allowance for Wind and Target Movement

D = W x t.o.f.

This distance (D) the wind moves the flare during its time of flight and burning has to be allowed for by correcting the release point. Since the airborne time of the flare is long, the corrections can be large - in the region of a mile for a 20 knot wind.

e. Reliability

The weapon has proved to be very reliable, but operationally it is likely that a minimum of two would be released to illuminate a target.

f. Illumination

It is generally considered that one Lepus flare provides greater illumination than four Glow-worm, with a whiter light. The longer illumination time is also advantageous.

g. Practice Target Safety

For practice attacks the Lepus safety-trace should be strictly observed. The target will naturally be somewhat vulnerable, particularly from the tail section, which tumbles after release and follows an unpredictable flight path, and may be expected to fall in the target area.

The centre section, the flare, may be expected to fall downwind of the target and the nose section beyond the target on the line of attack.

h. Switches

On the Ground

Accelerometer 4G
Gyro Release Angle .... 42.3 degs.
Flare Fuse Setting .... 21 secs.
Lepus/Glo .... Off

LABS Switches

LABS/Normal .... LABS (-2 mins)
LABS/Laydown .... LABS
Normal/Alternate .... Normal
LABS Timer .... 5.4 secs (nil wind)
LABS Start .... On (by make switches)
Trim .... 505 kts.

Armament

L.P.S.
Lepus Pylons .... On
2" Pylons .... Off
H.P.S. .... Off
Fusing .... Nose On
A.M.S. .... Bombs

After Attack

LABS/Start .... Off (S & L for 30 secs)

2003. Glow-Worm

a. Introduction

The glow-worm head of a 3" rocket provides 1 million candle power for 70 seconds, falling at a rate of 30 feet per second. 16 seconds after the rocket is fired the ballistic cap is blown off and 2 seconds later the flare and parachute are ejected and the flare ignited.

8 can be carried, on the Light Stores Pylons.

FIG. 19-2 GLOWSTRIKE RUN-IN FORMATION

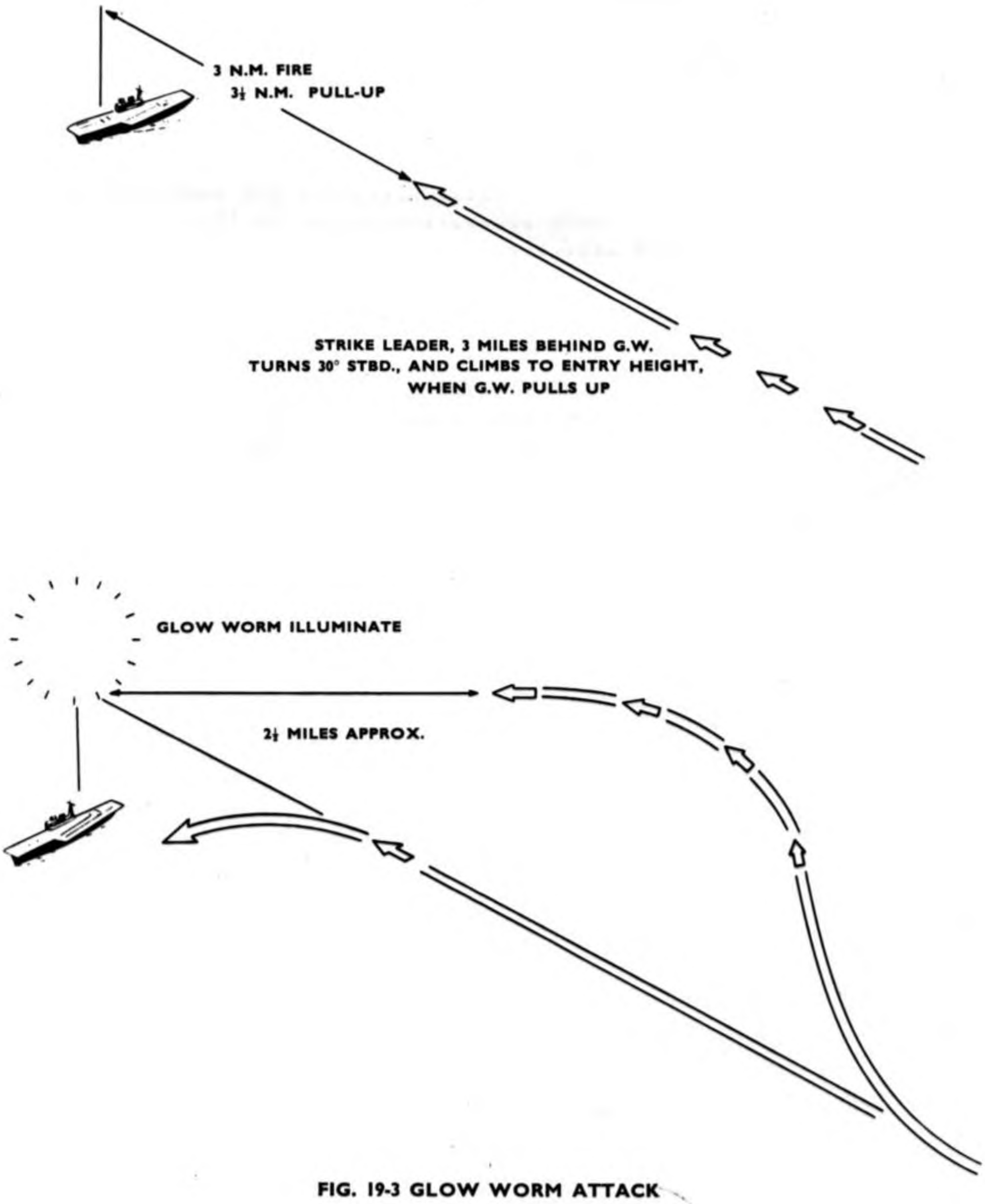


FIG. 19-3 GLOW WORM ATTACK

b. Night Anti-Ship Strike

The Lead aircraft carries glow-worm to illuminate the target, and is followed at 3 miles by the strike leader, the remainder at 1 mile intervals, carrying suitable armament (Fig. 19-2).

Unless the target and its position are unmistakable, strike direction by Gannet aircraft or other means is advantageous during the initial approach to the target. By a minimum range of 10 n.m. Glow-leader should have achieved approach height and speed, acquired the target on radar, gone Judy, and made switches for the attack. Dependent on the tactical situation, approach height is normally 500 ft and speed 450 knots. Target movement is assessed together with wind velocity, and a heading assumed to fire the glow-worm so that they ignite 500 yards to the left of the target.

Pullup is initiated at $3\frac{1}{2}$ n.m., a 15° climb established, and glow-worm fired at 3 n.m., both "pull up" and "fire" being called on R.T. Glow-leader then clears to port and if carrying strike armament in addition to glow-worm, sets up for his attack (Fig. 19-3).

Strike leader has been following Glow-leader at 3 miles, and at the pullup call or $6\frac{1}{2}$ n.m. turns 30° starboard and commences a climb, aiming to achieve the dive entry conditions for a 20° dive of 4000 ft on a 2 mile radius from the target at entry speed, shortly after the glow-worm ignite.

Subsequent aircraft turn 30° starboard at 8 second intervals to follow strike leader's flight path, and adjust their entry point on the correct radius circle from the target to obtain optimum sighting. All aircraft call on dive entry and when clear.

c. Safety and Wrinkles

(1) General

A thorough and fully understood briefing before the sortie invariably leads to good results.

A maximum armament switch selection consistent with safety and cross-checked between crew members, early in the sortie preferably at height, saves possible embarrassment or danger.

When descending from altitude to commence target approach, double check altimeters and target QFE set, and take precautions against canopy and windscreen misting.

Beware of the disorientating effect of changing armament switches, particularly at low level or in a turn.

FLY INSTRUMENTS, SWITCH ON.

(2) Glow-Worm Aircraft

Accurate flying on the approach to the target is most important. Variations are greatly magnified by the time they reach "Tail-end Charlie" whose fuel consumption can be increased dramatically by correcting for them. Heading changes should be called if Emcon policy permits. Normally a lot of minor heading adjustments can be expected in the final stages of the approach. Accurate speed and height should be maintained while making these. At pullup, the nose should be lifted to the 15° climb angle, and checked there. There is a natural tendency to pull and overshoot the desired climb without checking, in which case the glow-worm will ignite high and short.

The interval between pulling up and firing is short.

(3) Strike Aircraft

Avoid the tendency to throttle pump on the run-in. Allow for your distance astern of the next ahead on turns; delay, and let him come across before starting yours.

When turning out and pulling up to achieve dive entry conditions make it immediate and positive otherwise you will end up too close to the target, and steep. Look left 40-45° for glow ignition, and adjust position on entry circle to give optimum target sighting. Know the position of the next ahead. Normal divisional attack safety rules apply.

It is extremely difficult to recognise dive angles by night, and at the top of the dive the Attitude Indicator should be checked for steepness of dive.

BEWARE TARGET FIXATION

Get the sight in the correct release point of aim at the right speed by the release height, fire, and pullout recovering on instruments.

Search for the next ahead and the other aircraft and rejoin as briefed.

2004. Switches

Lepus/Glo .... Off
LABS/Normal .... Normal
L.P.S.
   Glo Pylons .... On
   2" Pylons .... Off
Firing Rate .... Slow
A.M.S. .... RB
Trim .... 450 kts.

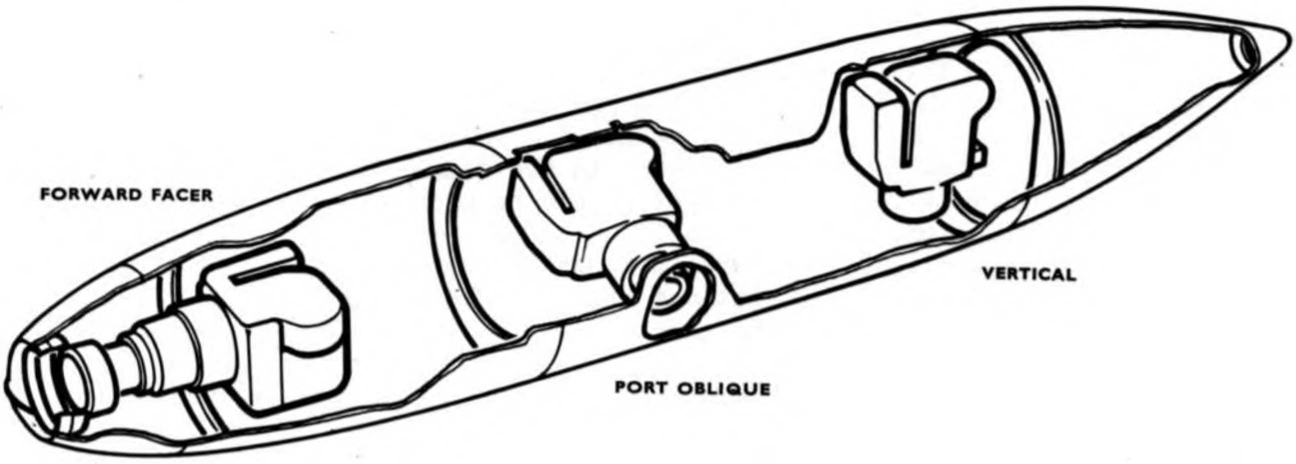
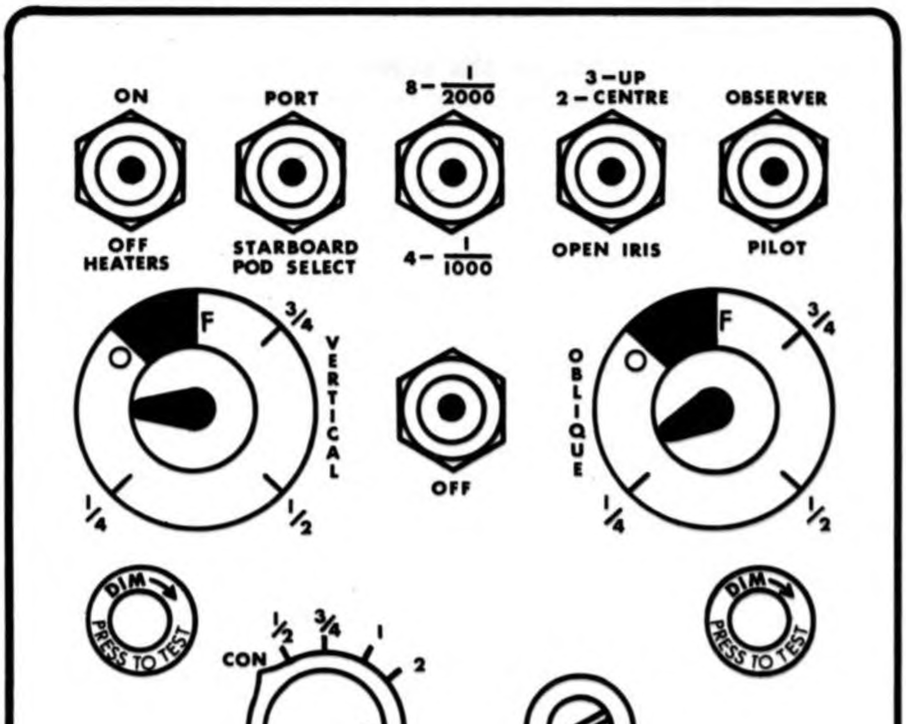


FIG. 21-1 PHOTOGRAPHIC POD

FIG. 21-2 CAMERA CONTROL PANEL



CHAPTER 21

AERIAL PHOTOGRAPHY

2101. Introduction

Aerial photography can be successfully accomplished in the Sea Vixen by use of the Photographic Pod (Mod.5137) in which 3 cameras can be carried.

2102. The Photographic Pod (Fig. 21-1)

The Photographic Pod is similar in basic construction to the Bullpup control pod, comprising a centre section with hinged nose and tail section.

The Pod is modified to carry a Port Oblique and Vertically mounted Type F95 camera in the centre section and a forward facing F95 in the nose section.

In normal usage the pod is attached to the Starboard Outer light store pylon - this is to allow a completely free field of view for each camera. However in the missile assessment role, the pod is fitted to the port outer light stores pylon - in this case only the forward facing camera is used, the field of view of the Oblique camera being obstructed by the Port Drop Tank. The Vertical Camera should be fitted as ballast.

2103. Controls (Fig. 21-2)

In addition to the Phot Pod, a camera control panel is fitted to the Observers Port Shoulder Guard in place of the blanking plate or tanker panel. The following controls are mounted on the panel for the remote operation of the cameras.

a. Master Heater Switch ON/OFF

The purpose of the heaters is to ensure that the windows in the pod through which the cameras "look" do not get misted up. (Ram Air is supplied to the heater from vents in the nose cone of the pod and then distributed through a pipeline with an open end facing forward in front of the Window Casting).

b. POD Selector Switch - Port or Starboard.

c. Camera Shutter Speed

There are 2 speeds, $\frac{1}{2000}$ sec or 8 frames per second

$\frac{1}{1000}$ sec or 4 frames per second

d. Aperture Control

A three position switch with pre set apertures which can be adjusted or re-set in the workshops beforehand as necessary. e.g. depending on climatic conditions. ONLY APPLIES TO FORWARD FACER - OTHER TWO CAMERAS ARE FITTED WITH AUTOMATIC IRIS.

e. Observer/Pilot Switch

If this switch is made to "Observer" with the HEATERS ON then which ever camera has been selected will operate. However with "Pilot" selected the camera will only operate when the appropriate button on the pilots control column is pressed.

f. Camera Selector Switch VERTICAL/OFF/OBLIQUE

g. Remote Film Indicator

One for each camera indicating how much film has been used or is left.

h. Press to test Indicator Lamp for each camera.

i. Intervalometer with five intervals available from Continuous to Two Seconds.

2104. Camera Configurations

Although three cameras can be fitted to the pod, only two can be used in the air because the control panel is only capable of operating two. Therefore the normal configurations are VERTICAL + OBLIQUE or VERTICAL + FORWARD FACER. But it is often more advantageous to have OBLIQUE and FORWARD FACER together - in this case adjustments are made so that the appropriate electric circuits for the Vertical camera become the OBLIQUE camera circuits, and the OBLIQUE ones become those of the FORWARD FACER. In this case notification has to be made on the Observers control panel.

2105. Lens

Both the Oblique and the Vertical cameras are limited to using the 4" lens because of space in the pod. However the forward facer can use either a 4" or 12" lens - but in either case the first few frames will be distorted because it takes 2-3 seconds for the forward "windows" to open - this is worse in the case of the 4" lens because of its larger field of view.

FIELD OF VIEW - 4" LENS - APPROX 40°
12" LENS - APPROX $14\text{-}17^{\circ}$

2106. Film

Normally black and white film is used in the Vertical and Oblique cameras but for the Bullpup assessment role - Colour may be used.

The normal film running time is (500 frames) 1 minute 40 secs., at 8 frames/second or twice that at 4 frames/second. With normal operation of ground runs, air bursts and clearing bursts it can be reckoned that film available for actual photography will be 1 minute at 8 frames/sec and 2 minutes at 4 frames/sec.

2107. Airborne Procedures

Before the aircraft is manned the Phot. Rating and Electricians will have carried out a ground run. So no need to switch on heaters until airborne. (Making sure that camera Vert. or Oblique is to OFF).

When safely airborne each camera can be selected in turn and a very brief air burst carried out, just enough to ensure that the camera is running and the amber light flickers.

On completion of filming, a clearing burst must be carried out to ensure that there is no risk of exposure of the important parts of film when the camera is taken out of the pod for developing.

2108. Sighting

This has always been a problem with the Vixen as there is no direct method of lining up the target with points on the aircraft - this is especially true of the Vertical camera, because the pod is out on the starboard wing and therefore the pilot has to displace himself slightly to Port and not fly directly over the target.

In the case of the oblique camera the problem is that the camera is on the starboard side of the pilot taking pictures out to Port therefore he must displace himself to starboard approximately 300 yards at a height of about 300'.

By trial and error it has been found that good results are obtained by drawing a line approximately one flat hand's width from the bottom of the Port side of the Canopy and aligning this with the IFR Probe through the target. Start the camera as the tip of the probe comes up to the target and stop as the root of the probe passes through the target.

A good way of sighting with the forward facer is by using the bottom diamond of the PAS picture in the R/P mode - with throttle gated - to get optimum results this way, the depression of the camera in the pod may be adjusted a degree or so as necessary.

It is to be expected that all pictures taken by the Oblique camera will have a small line in the top right corner of the frame - this is the UHF aerial of the aircraft which gets in the way, but is unavoidable and does not detract from the quality of the pictures very much.

2109. Processing

In operational conditions, contact prints can be ready for the P.I. within 12-14 mins. from Land on - this time can be shortened where the P.I. is content to only use the negatives on the Light Box - very often this is the case - he then selects the appropriate negatives for immediate printing on the fast ILFORD PRINTER.

2110. Aircraft Role Change

Under optimum conditions, to put an aircraft in the Phot. Role from another role will take about 3 hours. This does not include the fitting of the pod and the camera functionals which might take up to a further hour. However once an aircraft is in the Role the fitting of the pod etc., will often take only about 40 minutes. Camera loading and testing can be achieved in under 10 minutes under ideal conditions.