2. MODES OF ATTACK

2.1 General

In any attack it is desirable that the approach to the target should be carried out with the minimum risk of detection and that the aircraft, if detected, should itself present a poor target. The combination of low level approach and high speed helps to fulfil these requirements. The early stages of any long-range attack after marking the target, will be carried our below the radar horizon, where practicable.

The mode of attack and the type of weapon are selected by the pilot on the ATTACK SELECTOR and WEAPON SELECTOR switches. The ATTACK SELECTOR with eight positions and the WEAPON SELECTOR with 12, are engraved as follows:-

ATTACK SELECTOR	WEAPON SELECTOR
(1) LAYDOWN	(1) OFF
(2) LONG TOSS	(2) BOMBS A
(3) VARI TOSS	(3) BOMBS B
(4) MEDIUM TOSS	(4) ROCKETS
(5) DIVE TOSS	(5) SIDEWINDER
(6) AUTO D.S.L.	(6) BULLPUP or MARTEL
(7) MANUAL D.S.L.	(7) Spare
(8) MANUAL R.R.	(8) Spare
	(9) Spare
	(10) Spare
	(11) NUCLEAR

Attacks can be divided into four separate categories: nuclear bombs, conventional bombs, rockets, missiles. When a nuclear bomb attack is to be carried out either LONG TOSS or LAYDOWN is selected, depending on the type of nuclear bomb to be delivered. LONG TOSS is selected when delivering a non-retarded nuclear bomb and LAYDOWN for a retarded one. LAYDOWN is also used for retarded conventional bombs. All the other modes on the ATTACK SELECTOR, except MANUAL R.R. (radar ranging), are associated with conventional bomb attacks. The depressed sight line modes (AUTO D.S.L. with radar ranging and MANUAL D.S.L.) are also available for rocket attacks. MANUAL D.S.L. can also be selected for missile attacks although the main mode for either missile or rocket attacks is MANUAL R.R.

Practice attacks are possible in any of the above modes by switching the ATTACK SELECTOR switch to the appropriate mode and the WEAPON SELECTOR switch to OFF. The switching sequence and indications are the same as those for the chosen attack carried out under normal conditions except that weapons cannot be released.

2.2 Long Toss

Introduction

The Long Toss mode is the primary mode of attack and releases weapons 'standing off from

approximately 4.0 nm. The final manoeuvre involves a low level approach followed by a computed and programmed pull up, weapon release, and loop or similar recovery.

Search and target marking

The fire-control sub-system is switched on by the observer who also selects the required range and the search phase. Search and target marking can be carried out at ranges up to 200 nautical miles and normally at high altitude (up to 35000ft.). In the search phase the radar scanner automatically sweeps 50° either side of the fore and aft axis of the aircraft. The i.a.r. presents a p.p.i. sector scan (or B scan, depending on the range selected) in synchronism with this sweep. When the observer identifies the target echo, he places the target marker over the echo. The target marker takes the form of two arcuate lines forming a gap in a radial line. The position of the marker on the p.p.i. is controlled by the observer operating controls on the c.r.s. which provide along the across heading rates. These are resolved through aircraft heading *(\l>)* (compass bearing) to produce northing and easting rates as drive for the reset servos in each integrator and their outputs, distances-to-go north and east are now resolved into aircraft axes, as distances to go, along and across. These rectangular co-ordinates are resolved into polar co-ordinates, range (R) and bearing *(0).*

Note . . .

In ARI.5930 the symbol *"6"* refers to target bearing whereas in Strike Sight *"6"* refers to pitch.

The distance of the centre of the gap from the origin of the display represents the distance (R) of the marked position from the aircraft while the angular position (0) of radial line with respect to the dead ahead graticule line indicates the bearing of the marked position relative to aircraft heading.

The observer now switches in the ground speed input to the c.t.m. where it is resolved through drift angle (6) and compass bearing (i//) to give N and E which drive the integrators. They provide distances-to-go north and east. As previously described the final outputs of the c.t.m. are R and *0.* The target marker is controlled by the outputs of the servos so that it continually represents the marked position of the target relative to the aircraft whose position on the i.a.r. display remains stationary at the origin, regardless of aircraft movement. This is known as ground stabilization of the marker.

The position of the target has been fixed by the c.t.m. and this makes it possible for the observer to switch the radar transmitter to standby and cage the scanner thereby greatly reducing the risk of detection. To further reduce detection risks, the aircraft can now dive below the radar horizon and begin a low level approach, with adequate target range and bearing information stored in the c.t.m.

Pilot's display

When the fire-control sub-system is switched on, the true airspeed scale and roll bar appear on the P.D.U. The presence of this scale indicates to the pilot that the system is switched

on as well as enabling him to estimate aircraft speed, especially in the later stages of an attack, without having to refer to his flight instruments. Once target information is available, i.e. when the target has been marked, the observer switches in the C. & R.C. and this produces the full P.D.U. display (fig.2) so that the pilot can use the information to steer the aircraft accurately towards the target. The desired course is the collision course so it is necessary to know where the target is and what allowances to make for wind and target speed. Target position information is provided by the target spot whose locus on the pilot's display is controlled by bearing information from the c.t.m. The target spot represents a point on the horizontal plane in the direction of the target and it is not affected by aircraft roll, its deflection inputs being roll-stabilized in ARI.5930. Allowances for wind and target speeds are made by deflecting the aiming mark from its central position in the display by an amount proportional to the cross components of wind and target speeds. The settings of wind speed and direction and target speed and course are made manually by the observer on the c.i. where they are resolved into north and east components of wind and target speed before being fed to the C. & R.C. There, they are resolved into

along and across heading components and the sum of the across heading components is roll resolved so that the resultant deflection of the aiming mark occurs in the aircraft horizontal plane. The pilot, in tracking the target spot with the deflected aiming mark flies on a track which is the required target-collision course.

C. & R.C. servos

Only the control aspect of the C. & R.C. has been considered so far. The computing, or release section, basically consists of the *6,* V, Y and X servos. The *6* servo is driven by the R.O.C. input from the A.D.C. together with vertical acceleration from the gyro unit to give better servo response. The V servo is driven by the ground speed input from ARI.5880 and the along-heading component of target speed so that V represents aircraft speed relative to the target. The Y servo represents aircraft height at the pull-out point with respect to the predetermined burst height of the weapon. The observer sets the burst height, between + 5000 ft and- 5000ft, on the HEIGHT ABOVE BURST control on the c.i. The X servo uses c.t.m. range information which, at ranges above 12 nautical miles, is supplied as being 12 nautical miles. The X servo therefore remains at its 12 nautical mile end stop and no range circle is displayed until the range falls below 12 nautical miles. No computation is done at this stage in the attack although a potentiometer on the V servo shaft positions the pull-out range indicator where its leading edge represents 29.5 seconds to collision for the actual speed of the aircraft.

Consider the aircraft beginning its low level approach at a speed between 500 and 615 knots. The pilot is tracking the target spot, positioned by c.t.m. and M.R.G. information. The computing servos have been positioned by their appropriate inputs. The speed scale indicates T.A.S. and the roll bar shows the aircraft attitude in roll, both of these indications being provided to save the pilot having to refer to his flight instruments during the attack.

Radar acquisition and lock-on

In a typical attack the situation continues until the aircraft is within 30 nautical miles of the target which is the range at which the radar can lock-on to the target. The observer

of ^{1}/i second to assist the pilot in tracking the target spot, while maintaining the roll bar horizontal.

Release

During pull-out, the computing servos are driven only by the accelerometers and their shaft positions represent the values of the appropriate parameters. When the release equation is satisfied, the aircraft speed and track, the H.A.B. point and the range to the target are such that the weapon released at the point will arrive over the target at the correct height. It should be noted that any deviation from an attack speed of 560 knots or from a pull-up rate of 7° per second will result in a change in the pull-out profile and in the solution of the release computation. Thus the attack speed should be 560 knots ± 10 per cent and the pull-up rate as nearly 7° per second as possible since any large discrepancy from the nominal may prevent a release being obtained.

Solution of the release equation is detected in the release triggers of the C. & R.C. and a signal passed to the aircraft armament system to release the weapon in a forward toss at approximately 30° to the horizontal. The release signal also lights the RELEASE indicator lamp on the pilot's port console, and removes the target spot, aiming mark and upper event from the pilot's display, leaving the speed scale, air speed pointer and the roll bar. The lower event mark is removed one second after release provided the release lines are cleared.

If the attack is not accepted within *a Vi* second of the pull-out point being passed, the C. & R.C. will lock-out, i.e. it will:-

(1) I nhibit the triggers.
(2) Open circuit the release lines.
(3) Occult part of the pilot's display.

A REJECT button enables the pilot to cancel the attack at any time. Operation of the REJECT button resets the C. & R.C. and so permits a further attack to be carried out. The observer's switching of the COMP. switch to OUT and back to IN again on the c.i. has the same effect as operating the REJECT button. Thus, both the pilot and the observer have a means of rejecting an attack.

The weapon system recorder (W.S.R.) presents to a camera an identical display to that presented in the P.D.U. In all modes, switching the main switch on at the c.r.s. starts the camera motor running and switching the COMP. switch on the c.i. to IN starts the camera taking at slow speed while operating the ACCEPT switch changes the camera to the fast taking speed. The camera stops taking at release in the computed release modes and reverts to the slow taking speed in the other modes when the REJECT button is operated.

It should be noted that is is necessary to have range information up to the pull-out point, whether from the c.t.m. or from radar. Steering signals, i.e. positioning of the target spot by information from either the c.t.m. + M.R.G. or from radar are important at long range or in conditions of bad visibility at short range. However, where the target itself is visible to the pilot, he should steer to the target rather than use the target spot.

(3) The scale of the range circle is altered from 12 nautical miles full scale to 4 nautical miles full scale. The X-servo still drives down from 12 nautical miles, as in Long Toss, but the range circle only starts to wind down from the 4 nautical miles range. Associated with this aspect of the display is the bombs position of the pull-out range indicator which is set at 8 seconds to go, instead of 26.85 seconds. By setting the DIVE TOSS PULL UP (D.T.P.U.) switch on the c.i. to "8" or "11", the pull-up point can be initiated at either 8 seconds or 11 seconds (which corresponds to the 3-second warning point).

To maintain the accuracy of the ground speed output, the aircraft pitch must be maintained within —7° to +13°. In a dive toss attack, a 30° climb and a 30° dive are quite likely and when such manoeuvres are imminent, the observer operates a switch on ARI.5880. Operation of this switch substitutes an output of T.A.S. + wind memory for the normal output of ground speed. It may also be necessary for the observer to operate this switch prior to diving below the radar horizon in Long Toss attacks if there is any likelihood of the dive angle exceeding 30°. This is primarily for the benefit of the c.t.m. which receives the ground speed input from ARI.5880 and at this stage of an attack the role of the c.t.m. is more important than that of the V servo.

In a Dive Toss attack, the observer sets the wind and target controls on the c.i., as in a Long Toss attack. The aiming mark is deflected in elevation by an incidence term derived from the V servo to compensate for the change of the aircraft angle of attack with speed. During the climb, the target spot receives azimuth and elevation deflection signals from pick-offs on the locked-on scanner and will be deflected on the display by these inputs.

When adequate height has been gained, and the range is satisfactory the pilot puts the aircraft into a dive by placing the aiming mark over the target spot. With the aircraft on the dive path the pilot accepts the attack by operating the ACCEPT switch momentarily while at a range greater than that corresponding to 3 seconds to pull-out, as indicated by the position of the range circle relative to the pull-out range indicator on the pilot's display. At the range corresponding to 3 seconds to pull-out, the display normally shows the upper and lower event marks. However, if the attack is accepted after the 3 seconds to pull-out point, only the lower event mark appears as the ACCEPT switch is pressed. As the range approaches pull-out the pilot operates and holds the ACCEPT switch until the attack is completed. Pull out in this case is too short to allow the pilot to track the target spot in elevation, so he pulls out at the best rate he can achieve. Computation is similar to that for Long Toss but using a different equation. After a short-pull-up period the weapons are released automatically in a forward toss. Ballistic plugs and the bomb distributor are used in this form of attacks as in Medium Toss attacks. Fine adjustments of the bomb strike point may be made by prior setting of the A.M. DEPRESSION control on the c.i.

2.5 Visual attack with radar ranging

Bombing attacks are normally carried out visually. The major differences from the blind Dive Toss attack are due to the absence of information from locked-on radar, and the fact that the approach will have to be either visual or, if the observer can correctly position the target marker, by the pilot tracking the target spot which is controlled by c.t.m. + M.R.G. outputs. The approach configuration is identical until R.R. (radar ranging) is selected by the observer on the c.i. Selecting the R.R. role has the following effects:—

(1) The X servo is set to a range of 2Vi nautical miles and the pilot's display indicated accordingly.

(2) The target spot is removed and the roll bar is positioned about the aiming mark and deflects with it.

(3) The deflection signals from the aiming mark gyro pick-offs which control the aiming mark are also fed out to ARI.5930 where they are roll-resolved and used to control the scanner so that it now points in the same direction as the aiming mark. The radar set is not producing range information at this stage.

Once R.R. is selected, without the target spot the pilot has to fly the aircraft visually to the dive path. In superimposing the aiming mark over the target the pilot flies the aircraft down the dive path with the scanner pointing directly at the target. The pilot accepts the attack by operating the ACCEPT switch momentarily and this brings up the lower event mark, applies a long (0.63 second) sensitivity to the aiming mark and also applies a R.R. START signal to ARI.5930. Immediately, a radar lock signal should appear. This signal connects the range rate output of the radar to the X servo replacing the fixed input (2^1/z nautical miles) and driving the X servo to integrate R. The computation of £ (or 8) is now

possible and the 3-second warning and pull-out triggers will operate at the appropriate times. The pull-out point is signalled, as usual, by the partial disappearance and caging of the display but, since there is no target spot to follow, the pilot immediately pulls the aircraft up, maintaining the roll bar level. The release equation is as for the blind attack and release occurs on its solution, provided the ACCEPT switch has again been operated, as in the blind attack.

2.6 Manual radar ranging

This mode is the same as the Dive Toss mode for a visual attack with the R.R., up to and including the accept point but with the A.M. DEPRESSION control on the c.i. set to 3° maximum. After accept there is no 3-second warning, pull-out or automatic release. This is due to the triggers being inhibited by the selection of MANUAL R.R. on the ATTACK SELECTOR switch and ROCKETS on the WEAPON SELECTOR switch. The pilot releases the weapon by the FIRING TRIGGER which passes a signal to the armament system to release the weapon.

If the target is suitable the Manual R.R. mode may be used in a missile attack as it provides a range circle and an aiming mark. The WEAPON SELECTOR switch is set to SIDEWINDER, BULLPUP or MARTEL and the A.M. DEPRESSION control is set to 0°.

2.7 Manual Depressed Sight Line

Release is manual in these modes because there is no computation for either release or pull-out. Either bombs or rockets can be delivered and, apart from initial weapon selection and the amount of depression set in, the procedure is the same for both. The required aiming mark depression is set on the c.i., the value being dependent upon whether bombs or rockets are used and upon the airspeed, aircraft height and release range from the target. To carry out a bombs attack, the WEAPON SELECTOR switch is set to BOMBS A or

BOMBS B and the ATTACK SELECTOR switch to MANUAL D.S.L. The A.M. DEPRESSION control on the c.i. is normally set to more than 3° but less than 10°. Irrespective of whether the WEAPON SELECTOR switch is set to a BOMBS mode or to ROCKETS, the X servo runs down to zero with appropriate effect on the range circle and the pull-out range indicator. In addition, the target spot is removed and the roll bar is tied to the aiming mark. Selection of MANUAL D.S.L. inhibits all trigger operations in the C. & R.C. The roll (0) servo operates to orientate the roll bar and, with wind and target settings on the c.i. at zero, the aiming mark is central on the pilot's display.

Selecting this mode applies the depression set by the observer on the c.i. to the aiming mark. This downward deflection is roll-stabilized on the 0 servo in the C. & R.C. and therefore occurs in the true vertical. The pilot, by keeping the depressed aiming mark superimposed on the target, flies the aircraft in the bunt and he can release the weapon at any point on this path by operating the FIRING TRIGGER. Release of the weapon has no effect on the display since no triggers are operated in the C. & R.C. The pilot observes the RELEASE indicator lamp, which lights on release, and pulls away as desired.

The Manual D.S.L. mode is also used in missile attacks as it provides an aiming mark to define the aircraft sight line. In this case, the WEAPON SELECTOR switch is set to SIDEWINDER, BULLPUP or MARTEL and the A.M. DEPRESSION control on the c.i. is set to 0°.

2.8 Auto Depressed Sight Line (with acceleration [g] release)

The Auto D.S.L. with g release mode is used to deliver conventional bombs, and requires vertical acceleration together with a pseudo V term to compute the release point. This pseudo V term is supplied by the c.i. via the HEIGHT ABOVE BURST control. The setting of the H.A.B. control provides fine adjustment of the bomb release point and correction of the overall system bias. The A.M. DEPRESSION control on the c.i. is normally set between 3° and 10° depending on the attack entry height, speed and type of weapon. The pilot's display shows all the symbols except the target spot. Before the attack is accepted the range servo in the C. & R.C. remains at $2^1/z$ nautical miles, the waiting range, as in the Dive Toss R.R. mode. After accept, the range servo is connected to the output of the vertical accelerometer in the gyro unit. Vertical acceleration is shown on the "range" circle which now represents 0.3g at minimum to 1.0g at maximum.

In this mode the pilot tracks the target with the depressed aiming mark and on accepting the attack, the lower event mark appears. As the vertical acceleration decreases towards 0.45g the pilot presses, and holds, the ACCEPT switch while still tracking the target with the aiming mark. When the vertical acceleration reaches 0.45g, the weapon is released automatically. The pilot's display indicates release by the pull-out and release sequences of display symbols, similar to the Long Toss display, appearing in rapid succession.

2.9 Auto Depressed Sight Line with radar ranging

For the firing of air-to-surface rockets or the delivery of bombs an alternative automatic release is available by selecting R.R. on the radar role switch on the c.i. This release mode is normally preferred to Auto D.S.L. (g release) which is less accurate and so is reserved for

use should the radar ranging fail. The ATTACK SELECTOR switch is set to AUTO D.S.L. and the WEAPON SELECTOR switch to ROCKETS or BOMBS A or BOMBS B. In this attack the range servo in the C. & R.C. remains connected to the radar ranging output. The target is tracked with the depressed aiming mark and the H.A.B. control used as in Auto D.S.L. Release occurs at a specific range to the target. The attack sequence and display are similar to those in the Auto D.S.L. mode except that the display circle represents 4 nautical miles as in the Dive Toss mode.

2.10 Laydown

In the Laydown mode all the trigger circuits are inhibited so that no release or pull-out computations can occur on selection of LAYDOWN on the ATTACK SELECTOR switch and either NUCLEAR or BOMBS A or BOMBS B on the WEAPON SELECTOR switch. A signal from the pre-release timer to the armament system initiates release. This signal is produced when the timer runs to the end of the preset delay, which is determined from charts giving relationships between aircraft height and speed, angle of depression and type of weapon.

In this mode the aircraft enters in level flight at a predetermined height and speed with the A.M. DEPRESSION control on the c.i. set to between 0° and 10°. The pilot's display shows T.A.S. and the depressed aiming mark with roll bar. The pilot flies the aircraft straight and level towards the target so that the aiming mark passes through the target. When the aiming mark and target coincide, the pilot presses the ACCEPT switch starting the pre-release timer. At the end of the preset time interval the weapon is released automatically, the release being indicated by the lighting of the RELEASE indicator lamp and occulting the aiming mark and the lower event marker.

2.11VariToss

Selection of VARI TOSS on the ATTACK SELECTOR switch and BOMBS A or BOMBS B on the WEAPON SELECTOR switch inhibit the release triggers. As in the Laydown mode, release in the Vari Toss mode occurs when the pre-release timer runs down through the preset delay. In this mode, however, the timer is started at pull-out and release takes place during the pull-up phase.

In this case the aircraft flies straight and level at a predetermined height and speed. The pilot's display shows T.A.S., the aiming mark and target spot, roll bar, pull-out range indicator and the range to the target from 12 nautical miles inwards. Range information is supplies either from locked-on radar or from the c.t.m. The pilot tracks the target spot with the aiming mark. However, when range information is not available the pilot may visually identify the target and then track it with the aiming mark. At a suitable range the pilot presses the ACCEPT switch so that the display indicates pull-out (as in the Long Toss mode) and simultaneously starts the pre-release timer. The aircraft is pulled up by tracking the target spot with the aiming mark, achieving a rate of 7° per second. The weapon is released automatically in a forward toss when the timer completes its run-down the release being shows on the RELEASE indicator lamp and the removal of the aiming mark and the event markers.

3. OFFSET AND IDENTIFICATION POINT FACILITIES

All the locked-on radar attacks so far considered have dealt with a target which produced a radar echo at long range and preferably could be locked-on to at short range. Such attacks are also feasible where the target is not echo-producing, provided that there is a suitable landmark nearby from which the range and bearing of the target is known. The c.tm. provides for two alternatives, offset attack or identification point (I.P.) attack.

Offset attack

An offset attack can be carried out where a landmark within about 10 nautical miles of the target produces a recognisable radar echo. The observer presets the known range and bearing on the c.i. and then marks the landmark with the target marker on the i.a.r. Selecting O + D (offsets + Doppler) on the c.i. moves the marker from the echo position by an amount equal to the range and bearing set in, i.e. to the position of the true target. The target marker is ground stabilized in this position and the situation is now exactly as if the target marker has been placed over the target echo initially and then ground stabilized. The attack is carried out as for Long Toss but using c.t.m. information up to the pull-out point.

Identification point attack

In the case where neither the target nor a suitably positioned landmark provides a recognisable radar echo, use may be made of the I.P. facility. The range and bearing of the target from the landmark are set on the c.i. by the observer who then selects I.P. Only the bearing aspect of ground stabilization is present on I.P. and the marker is positioned on the p.p.i. at the preset range and bearing from the origin. The marked position will only truly represent the target position at the instant the aircraft is over the landmark so that the ACCEPT switch is pressed to switch in full ground stabilization when the aircraft is directly over the landmark. The marker then continues to represent the target fully and the attack proceeds on c.t.m. information right up to the pull-out point.

4. SUMMARY OF CHARACTERISTICS

Long range Search and strike radar for H.S.A. Buccaneer

Principal modes:— (i) Normal

search and track
off sets and IP

(ii) Radar ranging

(iii) Terrain warning (not released)

X-band two plane monopulse

185 kW peak power

4.0° azimuth and 3.0° elevation beamwidths

Search Scan ± 50°

Acquisition scan ± 10°

Track out to 30 n.m.

2 jusec pulse width

316 p.p.s. p.r.f.

Scanner stabilised ± 90° to starboard ± 200° to port in roll

± 30° in elevation

Scanner Tilt control + 10° to - 30° Range scales of

0-30 nm, 0—60 nm and 0—180 nm

80—240 nm with 60 nm expand brackets

Weight 235 Ib main unit MTBF 25 hours (in service operating hours)