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PART 4: SECTION 2

CHAPTER 1

GENERAL AIMING PROBLEMS

Introduction

1. The aim of this chapter is to outline general problems of launching and directing conventional missiles from the aircraft to the target.

Bomb Aiming

2. While on its carrier in the aircraft the bomb has the same velocity relative to the target as the aircraft, but as soon as it is released the pull of gravity gives it an accelerating velocity earthward. Air resistance decreases the bomb's forward velocity as well as its vertical acceleration until a certain velocity is reached, and this is measured in terms of "terminal velocity" or "ballistic index". For a given height of release, the vertical velocity establishes a time of fall from the aircraft to the ground. This time, applied to the forward velocity of the bomb, establishes the distance it will travel relative to the target during its fall. In addition, the wind forces acting on the bomb during its travel will displace it from the original path imparted to it by the aircraft. The amount of displacement depends on the wind speed and direction and the time of fall. If the target is moving, there are three velocities which must be resolved into distances to determine the point in space at which the bomb must be released. These are :—

- (a) The bomb's horizontal travel during flight.
- (b) The horizontal displacement of the bomb by wind speed and direction.
- (c) The movement of the target.

Rocket and Fixed-Gun Aiming

3. Rockets or fixed-gun missiles are launched along the flight path of the aircraft, their speed building up from that of the aircraft to one many times greater, depending on the forces exerted by the propellant.

4. As for all missiles, the problem is again to relate the movement of the missiles to that of the target, so that both arrive at a common point simultaneously. Whereas height is the prime factor in aiming calculations for the bomb, range is the prime factor in aiming rockets and machine-gun bullets. For a given range, the time of flight of the projectile can be calculated.

This time interval establishes the *trajectory of the projectile*, in association with the forces acting upon it (gravity and air resistance). In attacks on ground targets, the time interval determines the allowance to be made for wind speed and direction.

5. The time interval also establishes the distance the target will move from the moment of firing until target and projectile meet. This distance, when related to the flight path of the projectile at the given range, is interpreted as an angle between the line of sight to the target and the line of departure of the missile. This is known as the *angle of deflection*. Target velocity and range are, therefore, the two variable factors affecting the calculation of the angle of deflection.

6. The attitude of the aircraft, relative to its flight path or the horizontal, during aim and release varies with airspeed. If the airspeed during an attack is known, the angular difference between the lines of departure and the ultimate trajectory of the missile can be calculated and allowed for. In some sights, allowance for these angular variations is incorporated, e.g. the gyro-gunsight (G.G.S.), which automatically computes and compensates any change of attitude of the gun platform.

Free-Gun Aiming

7. Airspeed is a much bigger factor in the problem of free-gun aiming. With the fixed gun, the aircraft's speed is imparted to the projectile very nearly along the line of flight, and thus has little effect on the angle of deflection.

8. The free gun, however, can project its missile in any direction relative to the aircraft's line of flight and, consequently, the inertia forces set up within the projectile by aircraft speed may act at varying angles to its trajectory. In the case of a gun fired at right angles to the aircraft's line of flight, the projectile has, in addition to its own forward velocity, a sideways motion. The resultant produces a trajectory which is at an angle to the axis of the gun and which will vary according to the relationship of this axis to the aircraft's line of flight. This angle must be allowed for in the angle of deflection.

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Methods of Simplifying the Aiming Problem

9. Individual aiming problems depend on several variables, each of which can only be approximated. Differences between the approximations and the actual values become apparent in the flight of the missile after release and, except when using guided missiles, cannot be corrected after the missile has been launched. However, these aiming errors can be partially or completely compensated:—

- (a) By increasing the destructive radius of the missile.
- (b) By creating missile patterns.
- (c) By increasing missile velocity and the rate of launching.
- (d) By selecting the most advantageous direction of attack.

10. **Destructive Radius.** The lethal radius of blast or shock can be improved by increasing the explosive charge of the missile. Where destruction is desired by case fragmentation a proximity fuse assures dispersion of the fragments near the target. These and similar methods of ensuring that the missile detonates in the right place help to overcome small inaccuracies of aim.

11. Missile Patterns.

(a) If the lethal radius of the individual missile is insufficient to produce the lethal density required, a greater area of destruction can be created by using more missiles and directing each towards a separate portion of the target area so as to make each missile's lethal radius adjoin that of the next, until the overall pattern envelopes the entire target.

(b) If a combination of two or more machine-guns is used in an aircraft, a harmonization pattern is devised. By adjusting the gun barrels, the bullet groups from each gun will form this pattern at a predetermined range. The whole process results in a bullet pattern of a size which allows for small aiming errors, yet dense enough to prove lethal.

(c) While a similar pattern can be devised for rockets, an additional compensation for aiming inaccuracies is achieved by launching the individual rockets in rapid succession, or in "ripples". This technique compensates for slight errors in target movement by providing a stream of missiles, which either moves across

the target area, or into which the target moves. This stream can only be effective if the leading missiles arrive at the estimated point of intersection before the target. If the target arrives first, all missiles will pass behind it and be wasted.

(d) When bombs are dropped successively, or in "sticks", the time interval between releases determines the time interval between successive bombs on the target area. As each bomb has a horizontal velocity approximately equal to that of the launching aircraft, the time interval between bomb releases is therefore resolved as a distance interval between explosions. Thus the distance between the first and last bombs in the stick compensates for those aiming errors which would cause a single bomb to overshoot or undershoot the target.

(e) By releasing a number of missiles simultaneously, or in "salvo", the same general effects of the ripple or stick are achieved through the slight inconsistencies of performance of each missile. However, the distance interval between explosions or hits is smaller, and concentration is achieved over a smaller area. Another application of the salvo method is achieved by launching a number of missiles of poor ballistic qualities in a container of good ballistic qualities. Accuracy of aim is increased by the container, which ejects its contents at a relatively low altitude, whence the scattering of the missiles is concentrated in the target area.

12. Missile Velocity and Rate of Delivery.

(a) The greater the missile's velocity the less is its time of travel to the target. Consequently the forces acting on the missile after release have less time to influence its flight path, and the distances travelled by the target and launching aircraft are correspondingly less. When high-velocity missiles are used the angle of deflection is greatly reduced, and can therefore be estimated more accurately when the sighting system depends to some extent on the human eye. For the above reasons, the higher the missile's velocity the greater is its accuracy.

(b) An increase in the rate of delivery decreases the distance between successive missiles, thus creating a denser stream through which the target is less likely to pass between one missile and the next.

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13. The Direction of Attack.

(a) The direction of attack on a target directly affects the angle of deflection and the number of missiles with which it is possible to hit the target.

(b) With a moving target, an angle of deflection is required to ensure that missile and target meet at a common point. This angle varies with the relative paths of target and weapon, and is least when these coincide. Thus an attack from ahead or astern along the path of the target offers the best conditions for

the simplest of aiming problems—the zero-deflection aim.

(c) With a stationary target no angle of deflection is involved; consequently the best direction of attack is that permitting the greatest number of missiles to strike the target, *i.e.* the direction of attack to which the largest target dimension is exposed.

(d) Another important factor, though not directly related to the aiming problem, is the selection of a direction of attack that exposes the attacking aircraft to the least enemy opposition.

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