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WAR DEPARTMENT

AIR CORPS FIELD MANUAL

TACTICS AND TECHNIQUE OF AIR ATTACK

Transferred to Air Force

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FM 1-10

AIR CORPS FIELD MANUAL

TACTICS AND TECHNIQUE OF AIR ATTACK

Prepared under direction of the
Chief of the Air Corps

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BY ORDER OF THE SECRETARY OF WAR:

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Chief of Staff.

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The Adjutant General.

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[redacted]

AIR CORPS FIELD MANUAL

TACTICS AND TECHNIQUE OF AIR ATTACK

CHAPTER I

GENERAL

SECTION I

NATURE OF AIR ATTACK

■ 1. DEFINITION.—Air attack is the attack of objectives on the earth's surface by aircraft.

■ 2. SCOPE.—*a.* This manual contains in brief form the technical and tactical doctrines for the employment of the means provided in the Army Air Corps to accomplish air attack.

b. In applying the doctrines governing air attack set forth in this manual, they will be interpreted in the light of the Rules of Land Warfare and of the restrictions imposed by ratified treaties and other international agreements to which the United States is a signatory power.

■ 3. FUNCTIONS.—*a.* The successful prosecution of a war or military campaign requires the attack of objectives which are vital to the enemy. The purpose of air attack is to destroy or neutralize surface objectives, particularly those which cannot be reached effectively by other weapons. Destruction of a material objective is accomplished by breaking down the structure so that it must be abandoned, replaced, or extensively repaired before it can again be used by the enemy. Material objectives may be neutralized or rendered useless to the enemy by air attacks that do not completely break down or destroy their structures. Highways, railroads, or area targets are not readily susceptible to complete destruction but may be neutralized by the destruction of essential parts. Material objectives may be neutralized against immediate use if rendered only temporarily ineffective or useless. Personnel may be rendered ineffective by the neutralization of material objectives required for their effective employment. Hostile troops may be temporarily neutralized by air attacks for demoralization.

b. A major strategic function to be accomplished by air attack will be the destruction of enemy aviation facilities and of enemy aircraft at its bases, whether land or sea.

■ 4. DOCTRINE OF EMPLOYMENT.—*a*. A thorough understanding of the powers and limitations of aviation used to accomplish air attacks is essential to correct strategical and tactical employment. As a basis for sound employment, appropriate commanders must know the capabilities of their equipment and operating personnel and be familiar with the circumstances under which they must function.

b. Air attack extends the sphere of operations to include vital objectives within enemy territory, limited only by the radius of action of the air forces employed.

c. (1) Air attack by aviation in support of ground forces may generally be applied most effectively by blocking or delaying movements of reserves, disrupting lines of communication, or otherwise isolating the battlefield from enemy reinforcements and supplies.

(2) Air attack supports the operations of armored forces by neutralizing antitank guns; destroying tank traps or other tank menaces; attacking hostile mechanized forces seeking to engage friendly forces; and by attacking various hostile establishments in conjunction with armored forces.

SECTION II

OBJECTIVES FOR AIR ATTACK

■ 5. GENERAL.—*a*. Strategic objectives for air attack include elements of the enemy's armed forces, and facilities and establishments which support the operations of those forces and the enemy national structure.

b. Knowledge of the specific situation is essential to a determination of the relative importance of objectives for air attack. Each objective must be considered not only in the light of the information available or required for its attack, but also as to the probable immediate and ultimate contribution to the accomplishment of the national aim, to be secured by air attack.

c. Objectives for air attack in counter air force operations include—

(1) Air bases, including aircraft carriers and tenders.

(*a*) Aircraft.

(*b*) Munitions, fuel, and other essential supplies.

(*c*) Personnel.

(*d*) Landing areas.

(*e*) Installations and facilities, such as those for shelter, administration, storage, communication, and repair.

(2) Rail, water, and motor communication essential for the supply of aviation forces.

(3) Supply and repair depots.

d. Objectives for air attack in operations against ground forces include—

(1) Hostile aviation supporting their ground and base facilities.

(2) Logistical establishments.

(3) Communication essential for the movement of personnel and matériel.

(4) Equipment and supplies.

(5) Fortifications.

(6) Trucks, trailers, armored vehicles, and artillery.

(7) Troops, especially armored and motorized.

e. Objectives for air attack in operations against naval forces include—

(1) Armed naval vessels.

(2) Naval supply ships and transport.

(3) Naval bases.

f. Objectives for air attack in operations against joint ground and naval forces include troop transports, cargo and escort vessels, as well as shore weapons, troop concentrations, and installations.

g. Objectives for air attack in operations against war means include rail, water, and motor transportation systems; power plants, transmission lines, and other utilities; factories and processing plants, steel mills, oil refineries, and other similar establishments.

■ 6. SELECTION.—*a.* The essence of air attack lies in the selection of proper objectives. The basic characteristic of air forces—freedom of action—normally affords a wide choice in such selection.

b. Selection of objectives or system of objectives for an air offensive is a responsibility of the commander of the field forces. Designation of objectives to be attacked may be delegated to subordinate commanders who will be guided in their designations and priorities of attack by the general aim or plan of the higher commander.

c. A system of objectives against which an air offensive is to be directed is selected as result of a thorough estimate of the existing situation. Once selected, the system of objectives is adhered to in order to realize the cumulative effect derived by the destruction of individual components of the system.

■ 7. NATURE.—Air attacks may be directed against a wide variety of objectives ranging from the most massive material objects, such as fortifications, steel and reinforced concrete buildings, heavy bridges, and battleships, to such fragile objects as light matériel and personnel. The nature of the objective is the important factor in determining the most suitable type of fire to employ and the best method by which to effect the attack.

■ 8. CLASSIFICATION.—Bombardment objectives may be fixed, transient, or fleeting in character.

a. Fixed.—Permanent structures which are not normally subject to movement are classified as fixed objectives. This class of objectives includes permanent buildings, standard railway systems, the massive bridges of improved highway systems, factories, oil refineries, power plants, permanent docks, structures pertaining to canals or inland waterways, and all other permanent installations. Information of the location and nature of fixed objectives may be obtained during peacetime, and plans prepared for their attack during initial air operations.

b. Transient.—Structures and facilities that are of a temporary nature and subject to movement are classified as transient objectives. This classification includes temporary military installations, such as supply depots, ammunition dumps, ponton bridges, and various other objects which do not possess the power of motion. Information of such objectives must be collected during war. Transient objectives may be attacked either pursuant to orders or in accordance with indoctrination, depending upon their importance in specific situations.

c. *Fleeting.*—Objects which possess the power of motion are classified as fleeting objectives. Vehicles of all kinds, water craft, aircraft, troops, and equipment of all types are fleeting objectives. Time usually is an important factor in the attack of fleeting objectives. The extent to which indoctrination must be depended upon in conducting operations against fleeting objectives varies with the degree of their mobility. Formation commanders should be given the greatest possible freedom of action in the conduct of air attack against fleeting objectives.

■ 9. OBJECTIVE FOLDERS.—The Chief of the Air Corps is responsible for initiating objective folders (files of information) pertaining to fixed objectives in all probable theaters of operation. The folder will contain all obtainable information pertinent to the planning or execution of air attack of a given objective, together with a brief resumé of the tactical or strategical value to the enemy of such objective. Objective folders, pertaining to fixed objectives, which are developed after hostilities are begun will be prepared, distributed, and used in accordance with instructions of the commander of the field forces.

a. When operations in a given theater are imminent, the data assembled for a particular objective are forwarded to the wing or task force headquarters concerned. There they are studied and notation made of any further information needed. Information necessary for completion of a pertinent folder is then listed on the appropriate G–2 plan, along with essential elements of enemy information, and is so carried until the necessary information has been collected. Folders are retained in the files of the wing or task force until such time as the actual attack of specific objectives can be foreseen, when they are forwarded to the proper unit (group or squadron) for study and preparation of attack plan. Information affecting specific folders will be forwarded by higher headquarters to units charged with their custody. The latter are responsible for keeping folders up to date and will notify higher headquarters of all changes thereto made by them. The initiation, preparation, maintenance, and file of objective folders in a theater are intelligence functions.

b. It is desirable that the folder contain an analysis of the objective, the critical areas for attack, appropriate size of bombs, type of fuze and fuze setting, number of hits required for destruction or neutralization, and, when practicable, the nature and location of antiaircraft defenses. Pilots and bombardiers should be thoroughly familiar with the contents of pertinent objective folders prior to the performance of bombing missions. It is proper to refer in field orders to objective folders for detailed information of objectives.

c. For form and detailed statement of contents of objective folders, see FM 1–40.

SECTION III

MEANS FOR AIR ATTACK

■ 10. BOMBARDMENT AVIATION.—*a. Function.*—Tactical units of bombardment aviation may be equipped with either heavy, medium, or light type bombardment aircraft. All bombardment aircraft are designed and equipped for the attack of surface objectives. The performance of air attack is the primary tactical function of bombardment aviation.

b. Military characteristics.—Bombardment aviation is characterized by its ability to carry large loads of destructive agents to attack surface objectives.

(1) Light bombardment aviation constitutes the striking element of that combat aviation which is organized, trained, and equipped primarily to operate in direct support of ground forces. It is characterized by high speed, moderate size, maneuverability, provision for loads of various types of fire, and by provision for some defensive fire forward to cover low altitude attack approaches. The principal types of offensive fire carried are bombs and chemicals.

(2) Heavy and medium bombardment constitutes the offensive power of the aviation striking forces. They are characterized by high speeds, medium and long ranges, great load carrying capacity, large sizes, and provision of defensive fire against hostile fighter aviation. Their principal type of fire is the demolition bomb.

■ 11. ROLE OF BOMBARDMENT AVIATION.—Bombardment aviation is capable of attacking a wide variety of surface objectives at any point within the operating radius of the aircraft employed. Bombardment aircraft possess a relatively high degree of flexibility by reason of their great transposability of fuel and armament loads. The great variety of possible bombardment missions is such that no one model of aircraft is ideally suited to the accomplishment of all types of missions.

■ 12. ARMAMENT.—All bombardment aircraft carry both offensive and defensive armament. Their defensive armament is carried solely for their own protection against hostile aircraft in flight or against ground forces in the case of minimum altitude attacks.

■ 13. ROLE OF PURSUIT AVIATION IN AIR ATTACKS AGAINST GROUND OBJECTIVES.—While the normal role of pursuit aviation is intended for air fighting, it is capable of conducting air attack operations against ground personnel and light matériel targets that are vulnerable to its weapons. When so employed it conducts attacks against point targets by precision gunnery, bombing from a diving approach, or attacks area targets by minimum altitude bombing tactics while employing fixed forward machine gun fire to cover the approach to the target. For pursuit aviation in air attacks in support of ground forces see section VII, chapter 5, FM 1–15.

CHAPTER 2

BOMBARDMENT AVIATION

SECTION I

GENERAL

■ 14. ORGANIZATION.—The basic element of organization in bombardment aviation is the individual airplane and its combat crew. The flight is a tactical grouping or unit consisting, according to type, of three or more airplanes. The squadron consists of two or more flights; the group of two or more squadrons; and a wing of two or more groups.

■ 15. BASIC TACTICAL UNIT.—The squadron is the basic administrative and tactical unit. The group is the largest unit which can function as a single combat command under the direct control of an individual and is the normal unit of tactical employment of an air force. The group contains all of the elements essential for operation, maneuver, and combat. Squadron tactics fit into the group scheme of employment and also permit each squadron to function as a separate combat command under circumstances suited to such employment. When a mission requires that two or more groups operate in conjunction, each group functions as a separate combat command, one group conforming to the action of the other throughout the operation.

■ 16. CLASSIFICATION.—Bombardment aviation utilizes aircraft of different sizes and capabilities which include different offensive armament load and operating radius. Bombardment squadrons are classified, according to the kind of aircraft with which they are equipped, as heavy, medium, and light.

■ 17. EMPLOYMENT OF HEAVY AND MEDIUM BOMBARDMENT.—The striking forces of GHQ aviation consist of units of heavy and medium bombardment aviation. Such units are capable of destroying the most massive bombardment objectives. Heavy and medium bombardment aircraft can carry the heaviest types of bombardment munitions to great distances. Heavy bombers are long range aircraft. Medium bombers have intermediate ranges. Neither of these types is fully suited to the performance of minimum altitude attacks since neither is equipped to deliver all types of fire appropriate to such attacks.

■ 18. EMPLOYMENT OF LIGHT BOMBARDMENT.—In general, light bombardment aircraft are smaller, more maneuverable, and have a shorter operating radius than heavy and medium bombers. The striking units of support forces usually consist of light bombardment aviation. The aircraft of light bombardment units are designed and equipped to enable them to perform minimum altitude missions when required. They usually are not capable of carrying the largest size bombs.

SECTION II

OFFENSIVE ARMAMENT

■ 19. CLASSES.—The offensive armament of bombardment aviation is divided into the following classes:

a. Demolition bombs.
b. Fragmentation bombs.
c. Incendiary bombs.
d. Chemical bombs.
e. Chemicals for spraying.
f. Machine guns, and other larger caliber guns.
g. Torpedoes.

■ 20. DEMOLITION BOMBS.—The demolition bomb, designed for the destruction of material objectives, is the principal destructive agent of bombardment aviation. These bombs are made in a variety of sizes suitable for the destruction of various kinds of objectives. The standard sizes of demolition bombs at the present time are as follows:

DEMOLITION BOMBS

Size	Actual weight	Weight of explosive
Pounds	*Pounds*	*Pounds*
100	112	65
300	295	162
500	500	276
600*	600	322
1,000	971	556
1,100*	1,140	605
2,000	2,000	1,130

* Limited standard.

■ 21. BOMB FUZES.—Standard demolition bombs are fuzed with both nose and tail fuzes. Bomb fuzes are of two general types, instantaneous and delayed action. The instantaneous type explodes the bomb immediately upon impact. The delay fuze permits penetration of the objective by the bomb prior to detonation. The arming mechanism of the bomb rack permits the dropping of bombs either armed or "safe." Demolition bombs can be dropped "safe" in an emergency from altitudes below 4,000 feet without detonation upon impact even upon hard surfaces. Bombs dropped "safe" from very high altitudes will detonate upon impact on a solid surface.

■ 22. FRAGMENTATION BOMBS.—Fragmentation bombs are designed to break into fragments, each of which is effective against personnel or light matériel. This type of bomb has some demolition action in the immediate vicinity at the instant of explosion, but its effectiveness arises principally from the fragmentation action. Fragmentation bombs are of small size, weighing up to 30 pounds complete, depending upon the model of the bomb. Standard fragmentation bombs used by bombardment aviation are fitted with nose fuzes of the instantaneous type.

■ 23. TYPES OF FRAGMENTATION BOMBS.—There are two general types of fragmentation bombs, fin stabilized and parachute bombs. The fin stabilized type is similar to the demolition bomb in general conformation. Fin stabilized fragmentation bombs, in order to avoid damage to the airplane from which they are dropped and to minimize the loss in fragmentation effect occasioned by the angularity of the bomb axis at the instant of explosion, should be dropped from an altitude of 800 feet or more, depending upon the ground speed of the airplane. The parachute type bomb is fitted with a parachute in a light weight case in lieu of the fin assembly. The parachute quickly changes the attitude of the bomb so that its axis is substantially vertical as it approaches and strikes the ground. The parachute slows down both the forward motion and the descent of the bomb. These bombs may be released at a minimum altitude of 65 feet.

■ 24. INCENDIARY BOMBS.—Incendiary bombs are employed to set fire to buildings, grain fields, tented areas, dry wooded areas, and similar combustible matériel.

■ 25. CHEMICAL BOMBS.—Chemical bombs are employed for the placement of chemical agents within a specific area of limited extent. They are designed to be carried and released in the same manner as demolition or fragmentation bombs. A 30-pound chemical bomb is now standard, and one weighing about 100 pounds is under development. The cases of chemical bombs are of light weight, and an explosive charge is utilized to effect better distribution of the chemicals than would otherwise be attained.

■ 26. CHEMICAL SPRAY.—Chemical agents in liquid form are carried in special tanks and when released in flight form a chemical spray. When so released the liquid immediately forms a finely atomized cloud of droplets. The droplets of certain chemicals used for obscuring purposes hydrolize to form an opaque curtain or cloud of smoke. Other chemicals fall to the ground in small droplets eventually to vaporize or gasify and be dissipated in the air, or if sufficiently volatile to gasify before reaching the ground. Chemical spray provides a means of screening operations; blanketing hostile objectives; contaminating areas to deny their use to the enemy; causing enemy casualties; or of effecting delays and harassment of his forces.

■ 27. MACHINE GUNS.—Machine guns are mounted on bombardment aircraft primarily for defensive fire but may be used for offensive fire. Machine guns may be used offensively against small naval craft, troop formations, aircraft exposed on the surface, or similar light matériel.

■ 28. TORPEDOES.—The torpedo, normally used by the Navy, is not standard in the Army. The size and weight of torpedoes are within the capacity of heavy and medium bombers, and most models of such aircraft can be fitted to carry and launch torpedoes by means of suitable accessory equipment. The use of torpedoes is advantageous under conditions of low ceilings which prevent the effective use of large demolition bombs. Large size demolition bombs are effective in the attack of objectives against which torpedoes are used.

SECTION III

EFFECTIVENESS OF BOMBS

■ 29. GENERAL.—The most effective utilization of bombardment aviation necessitates a reasonably correct relationship between the munitions used and the nature of the objectives to be attacked. The actual destructive effect of any one bomb is subject to so many variable factors that it is impossible to lay down inflexible rules for the utilization of the various types. The data presented in this section are based upon the best available information of the effectiveness of bombs and are intended as a guide to responsible commanders in the selection and use of bombs.

■ 30. DEMOLITION BOMBS.—The explosive charge of demolition bombs normally is slightly more than half the total weight of the bomb. Maximum effectiveness is obtained only when the explosion of the bomb occurs either within or very close to the object to be destroyed. The radius of effectiveness of a demolition bomb dropped in water may be increased somewhat by the hydraulic ramming effect produced in the vicinity of the explosion. Accurate placement is essential to the most effective utilization of demolition bombs.

■ 31. SELECTION OF BOMBS.—A knowledge of the power and effect of bombs is essential to the proper selection of the specific type for any particular mission. It is important that the size of bomb used for the attack of an objective be appropriate to the requirements of the mission. An objective against which large bombs should be used normally cannot be destroyed by a larger number of smaller bombs of equivalent or even greater total weight. The bomb used should be large enough to produce the desired degree of destruction. On the other hand, it is wasteful to use bombs of substantially larger size than that appropriate for the destruction of the objective. When the extent of the objective is such that it must be hit at more than one point in order to obtain the requisite degree of destruction, the desired effect is best obtained by attacking the several vulnerable points separately, using bombs of an appropriate size.

■ 32. BOMB CRATERS.—*a.* The size of the crater produced by the explosion of a demolition bomb of a particular size depends upon the nature of the material upon which the bomb is dropped and also upon the depth of penetration prior to detonation. The depth of penetration is controlled by the striking velocity and the rapidity or delay in the functioning of the bomb fuze. The striking velocity depends principally upon the altitude and the velocity of the airplane from which released. The probable size of craters produced by demolition bombs dropped from 8,000 feet upon soil areas, such as rail centers or airdromes, can be judged from the results shown in table I.

TABLE I.—*Dimensions of demolition bomb craters in sandy loam soil*

Weight of bomb	Depth of crater	Diameter at surface	Material displaced
With instantaneous fuze			
Pounds	*Feet*	*Feet*	*Cubic yards*
100	2	9	4
300	3	13	10
600	5	17	17
1,100	6	20	28
2,000	7	22	47
With delay fuze			
100	5	20	30
300	7	27	70
600	10	37	170
1,100	13	45	320
2,000	17	50	600

b. The craters produced in harder materials may be considerably smaller. A 2,000-pound bomb dropped experimentally on solid granite from an altitude of 15,000 feet produced a crater 6¾ feet deep by 31 feet in diameter at the surface and displaced approximately 80 cubic yards of material. Similar data are not available for 500- and 1,000-pound demolition bombs.

■ 33. EFFECT ON REINFORCED CONCRETE.—Large demolition bombs are effective against massive reinforced concrete structures such as dams, piers, moles, and wharves. The blast effect of a bomb detonated in the water alongside a dam or reservoir wall is augmented by hydraulic pressure. The experimentally determined blast effect of demolition bombs exploded alongside reinforced concrete walls above the surface of the water is shown in table II. (See also table IV.)

TABLE II.—*Blast effect on reinforced concrete*

Demolition bomb	Thickness of wall	Diameter of hole blasted
Pounds	*Feet*	*Feet*
600	8.6	17.2
1,100	10.4	20.8
2,000	12.3	24.6

■ 34. EFFECT OF DEMOLITION BOMBS AGAINST PERSONNEL.—*a.* Demolition bombs are normally not as effective against personnel as an equivalent weight of fragmentation bombs. The effectiveness of individual demolition bombs decreases very rapidly with the distance from the point of explosion. The danger radius of blast effect is very limited. The energy of individual fragments decreases rapidly, and their dispersion at considerable distances renders them comparatively ineffective. The radius of casualty effect on personnel resulting from the blast of individual demolition bombs is indicated in table III.

b. The continuous detonation of large quantities of high explosive may produce a cumulative shock effect on personnel in the open with a consequent lessening of their combat efficiency, even though the individual detonations occur at such distances or under such conditions as to preclude direct injury from either the blast or the bomb fragments.

TABLE III.—*Casualty effect on personnel*

Size of bomb	Approximate maximum distance that blast will produce direct casualties
Pounds	*Feet*
100	40
300	55
600	75
1,100	90
2,000	110

■ 35. EFFECT OF DEMOLITION BOMBS AGAINST SPECIFIED OBJECTIVES.—Approximate results to be expected from the use of demolition bombs against various objectives have been determined experimentally. The results of those determinations are indicated in table IV to serve as a guide to bombardment commanders in the selection of demolition bombs appropriate to the attack of objectives of the nature specified in the table.

■ 36. INCENDIARY EFFECT OF DEMOLITION BOMBS.—Demolition bombs are effective incendiary agents against objectives containing materials which are readily ignited. The incendiary effect is marked in the case of structures reinforced with steel or iron members and containing inflammable material in the immediate vicinity of the explosion. Heavy timbers do not always ignite.

TABLE IV.—*Effect of demolition bombs against specified objectives*

Objective	Bomb	Fuze	Point to be attacked	Danger radius	Probable results from detonation of bombs within danger radius
	Pounds				
(1) Airplane	100 [1] 300	Instantaneous.	Distributed over area occupied by airplanes.	75 to 100 feet; 100 to 125 feet.	Blast and fragments should cause serious damage to structure.
(2) Ammunition dumps	100 [1] 300	do	Distributed over area occupied by dump.	Direct hits on piles of ammunition.	Blast should detonate piles of ammunition.
(3) Bridge, concrete, reinforced and supported wholly by piers.	[2] 1,000	Delay	Piers and approach spans of bridge.	15 feet	Displacement of piers and span, causing collapse of one or more spans.
(4) Bridge, concrete, reinforced, of massive construction supported by piers and/or suspended by cables.	2,000	do	Piers, cable anchorages, and tower supports at end of bridge.	15 feet	Displacement of piers and destruction of anchorages should cause collapse of the main span. Several hits may be required.
(5) Bridge, steel, railway, light construction.	600	do	Piers and approach spans.	15 feet	Hit alongside pier should undermine foundation, causing collapse of pier and span, and/or hit beneath or upon a span should cut girders, causing collapse of span.

(6) Bridge, steel, railway, heavy construction.	[2] 1,000	do	do	15 feet	Do.
(7) Buildings of steel, brick, and concrete construction; latest type of factories, warehouses, rail terminals; in fact all types of construction except skyscrapers.	100 [1] 300	do	Building itself	Building itself	Should penetrate floors before detonating; should destroy walls and floors and cause serious fires.
(8) Dams and spillways	2,000	do	Close to dam on water side.	15 feet	Should crack dam or cause hole in its side causing collapse of structure.
(9) Railway engines and cars.	100 [1] 300	Instantaneous	On or alongside target	10 feet	Direct hits should cause damage beyond repair. Near hits should disable target so that immediate repairs cannot be made.
(10) Railway tracks	100 [1] 300	do	If a single track, the track itself. If rail center, distribution over entire area desired.	7 feet; 9 feet	100-pound bomb should cut rails and tear up 20 feet of roadway. 300-pound bomb should cut rails and tear up 30 feet of roadway.

[1] When more 100-pound bombs can be carried than 300-pound bombs, it is preferable to use 100-pound bombs.
[2] Or 1,100.

TABLE IV.—*Effect of demolition bombs against specified objectives*—Continued

Objective	Bomb	Fuze	Point to be attacked	Danger radius	Probable results from detonation of bombs within danger radius
	Pounds				
(11) Railways, underground (subways).	500 (or 600).	Delay	On ground above	15 feet to either side	Should penetrate, and detonation should cave in roof or cause collapse of walls.
(12) Modern submarine, transport, supply vessel, destroyer.	300	do	Vessel itself (or in water alongside or astern).	20 feet	Should seriously damage or sink vessel.
(13) Aircraft carrier (except converted cruiser).	300	do	do	20 feet	A direct hit should destroy about half of flight deck; hit in water, serious underwater damage. Several hits may be necessary to destroy completely or sink vessel.
(14) Cruiser	[3, 4] 500	do	do	25 feet	A direct hit should cause serious damage to parts of structure, armament, or fire control equipment; hit in water, serious underwater damage. Several hits may be necessary to destroy completely or sink vessel.
	1,000	do	do	35 feet	

(15) Battleship	[3] 2,000	do	do	35–55 feet	Do.
Battle cruiser	[2] 1,000	do	do	35 feet	Do.
(16) Wharves, concrete	[4] 500	do	Wharf itself or close alongside.	25 feet	Cause collapse of wharf for 75–100 feet.

[3] Preferred loading.
[4] Or 600.

■ 37. Fragmentation Bomb Effects.—Fragmentation bombs are designed for maximum effect against personnel, animals, and light matériel objects, such as airplanes, small open boats, trucks, artillery tractors, and the equipment of mechanized forces. The fragments are relatively ineffective against railroad engines and cars. Upon explosion, the present standard fragmentation bomb produces about 800 to 1,200 fragments. Maximum effectiveness is attained when the axis of the bomb is approximately vertical at the instant of explosion. The standard fragmentation bomb, exploded with axis vertical, has been demonstrated to be an effective casualty producing agency up to 165 feet from the point of explosion. The maximum danger radius from fragments is approximately 500 yards. The blast effect of a fragmentation bomb at a distance of 1 foot is approximately the same as that of a 100-pound demolition bomb at a distance of 3 feet. Direct hits will cause severe damage to tanks, trucks, airplanes, locomotives, and railway cars. Railway tank cars because of their usually inflammable contents are particularly vulnerable to direct hits. Fin stabilized and parachute type fragmentation bombs are identical as to size, number of fragments, and explosive charge. Differences in casualty effect will result from variations in the attitude of the bomb with respect to the ground at the instant of detonation.

■ 38. Chemical Bombs.—The effectiveness of chemical bombs depends upon the kind of chemical employed, the type of fuze, and expelling charge, and may be materially affected by the existing atmospheric conditions. Chemical bombs, except incendiary types, normally are employed so as to affect enemy personnel and animals. By the use of bombs filled with liquid chemicals, a high concentration may be accurately applied to an objective. An effective means is thus provided for neutralization of enemy air bases and airdromes, antiaircraft artillery positions, and to delay the enemy by at least temporarily denying him the use of railroad yards, troop assembly points for motor, rail, or water transportation, communication and supply centers, bridges, bridge approaches, and other defiles. Depending upon the persistency of the chemical used and upon the atmospheric and terrain conditions, effective concentrations may persist for several days, and for considerably longer periods if conditions are especially favorable.

■ 39. TEAR GAS BOMBS.—Tear gas acts immediately but its effect is of a temporary nature. The tear gas bomb produces a high concentration within a limited area. Extremely low concentrations of tear gas are effective in producing lachrymation. Tear gas is used against targets where immediate, although temporary, disability of personnel is required, and in areas which may be used by our own troops as soon as the gas has been dissipated sufficiently. When a tear gas bomb bursts, the cloud formed may be expected to drift with the wind for a distance of several hundred yards in a sufficiently strong concentration to cause lachrymation. Troops exposed will be forced to use gas masks with consequent loss of operating efficiency.

SECTION IV

DEFENSIVE ARMAMENT

■ 40. GENERAL.—Bombardment aircraft are equipped with defensive armament for protection against the fire of hostile aircraft during flight. The defensive armament of bombardment aircraft is so placed as to cover all probable directions of approach by hostile fighter aircraft. Blind angles are eliminated from all directions which may favor approach of fighter aircraft and are reduced to a minimum in unfavorable directions of approach. High speed aircraft can be attacked most effectively from the rear. The machine gun is the standard defensive weapon of bombardment aviation.

■ 41. MACHINE GUNS.—Standard aircraft machine guns are of .30 and .50 caliber, guns of both calibers being used on bombardment aircraft. All bombardment aircraft have flexibly mounted machine guns for defense against aircraft in flight. Bombardment aircraft intended for use in support force missions have, in addition to the flexible guns, fixed type guns for the delivery of forward fire against ground weapons during the approach to the objective in minimum altitude attacks. Flexibly mounted machine guns can be fired in any direction within a wide field of fire.

Section V

ACCESSORY EQUIPMENT

■ 42. General.—*a*. Bombardment aviation requires accessory equipment in order to function. The expert manipulation of adequate and suitable accessory equipment is an important factor in the effectiveness of a bombardment force. Accurate placement of both offensive and defensive fire is essential to the efficient employment of the force.

b. Data pertaining to the construction, maintenance, and operation of accessory equipment are contained in pertinent technical orders and regulations.

■ 43. Bomb Sights.—The destructive power of aerial bombardment is controlled largely by the accuracy of bomb placement. A suitable sight is an essential item of bombardment accessory equipment. High altitude precision bombing requires a sight of great accuracy and capable of coping with several factors affecting the success of the mission.

■ 44. Bomb Racks.—Bomb racks may be either internal or external to the surface of the carrying aircraft. Bombs normally are carried internally. Bombs carried externally may seriously interfere with the performance of the aircraft, and external racks are used only when necessary. The racks provide a means of attaching bombs to the airplane in such a manner that they can be systematically released at will.

■ 45. Release Mechanisms.—The bomb release mechanism may be operated manually or electrically. Accurate timing is essential to precision bombing from high speed aircraft. When the airplane is flying at a ground speed of 300 feet per second (approximately 204 miles per hour) a delay of ¼ second in the release of the bomb after the proper time would cause an error of 75 feet on the ground. An arrangement is always provided whereby the bombardier may drop bombs, independently of the sight, singly, in train, and in salvo. Emergency releases are likewise provided whereby bombs may be released instantly in emergency.

■ 46. Chemical Spray Equipment.—The necessary equipment for spraying chemicals consists of chemical tanks and release mechanisms. Chemical tanks may be carried either internally or externally. The tanks may be specially mounted or they may be carried on the bomb racks. Chemical spraying equipment should be readily removable from the airplane when not required for use.

■ 47. ACCESSORIES FOR DEFENSIVE ARMAMENT.—The principal accessories for the operation of defensive armament in bombardment airplanes are sights, mounts, control mechanisms, and ammunition containers. Flexible gun mounts must permit rapid traversing of the gun and easy handling under all conditions of flight. Sights, control mechanisms, and munition containers are designed for use with particular types of guns.

■ 48. COMMUNICATION EQUIPMENT.—Bombardment aircraft are equipped with radio receiving and transmitting facilities. Long range radio equipment is provided for air to ground communication. Short range equipment is used for command communication. (See FM 1–45.)

■ 49. FLIGHT CONTROL MECHANISMS.—Flight control mechanisms are standard accessory equipment on bombardment aircraft. These mechanisms usually rely on gyroscopes for their stabilization and directional control.

■ 50. NAVIGATION EQUIPMENT.—The navigational equipment of bombardment aviation includes aperiodic compasses, drift indicators, and various other instruments required in dead reckoning and celestial navigation. (See FM 1–30.) Radio equipment also constitutes an important navigation accessory in situations where radio aids to navigation are available.

SECTION VI

FLIGHT FORMATIONS

■ 51. FORMATION FLYING.—The military airplane is a complete combat unit. Its capabilities are dependent upon its type and the character of its combat equipment. The offensive and defensive powers of even the largest and most powerful individual airplane are relatively limited. Hence the effective utilization of aircraft in warfare frequently requires that they be employed in suitable tactical formations rather than as single units. The organization of aviation forces into suitable tactical units facilitates the simultaneous employment of the aircraft in the accomplishment of an assigned mission.

■ 52. PURPOSE.—*a*. Bombardment units resort to flight formations only when there is a reason therefor. The principal purposes of formation flight are—

(1) The massing of defensive fire power for the security of the command against attack by hostile aircraft.

(2) The massing of offensive fire power to render more effective or immediate the destruction and/or demoralization of hostile installations or combat forces.

(3) To minimize losses during attacks upon strongly defended objectives, by delivering the maximum blow with a minimum exposure of the attacking force to the fire of defending weapons.

(4) To expedite movement of large units by air.

(5) To facilitate tactical control of aircraft in flight.

b. Bombardment units may be required at any time to utilize flight formations in the performance of their missions.

■ 53. UNITS.—*a*. The bombardment squadron formation consists of two to four flights of three or four airplanes each. In the air the squadron commander exercises control through flight leaders.

b. Group formations comprise two to four squadrons. The group commander, through the squadron leaders, exercises general control in the air over the actions of the aircraft of the group.

■ 54. SYSTEM OF ARRANGEMENT.—The arrangement of bombardment airplanes into a formation usually is based upon the strength, disposition, and employment of the tactical unit to which the aircraft pertain. It is preferable that all of the aircraft in any formation be comparable as to type and performance characteristics. The association of dissimilar types of aircraft in the same formation should be avoided.

■ 55. TYPES.—The flying of bombardment aircraft in formation limits their freedom of maneuver, the degree of the restriction being dependent upon the size and character of the formation. There are no prescribed types of bombardment formations which must be rigidly followed. The formations described in this manual have been used by tactical units and may be regarded as basic types. Each formation must meet the requirements of the specific situation presented. The basic types described herein must be regarded only as guides in the development of the proper formations to meet varying situations confronting tactical commanders in actual operations.

■ 56. SIZE.—*a.* The size of a bombardment formation depends upon the situation to be met and will be governed by the specific purpose for which it is formed. The number of airplanes that can be effectively controlled during flight in one compact formation by a single commander is definitely limited. When the number of airplanes required to perform a given tactical operation is greater than can be controlled in one compact formation, they are organized into two or more of visual signals.

b. In large formations the commander transmits his orders to subordinate commanders by means of radiophone and visual signals.

■ 57. TACTICAL REQUIREMENTS.—*a.* In the arrangement of a bombardment formation to meet the requirements of any particular situation it is important that sound tactical principles be observed so that the formation may efficiently accomplish its assigned mission with minimum losses.

b. Bombardment formations should possess a sufficient degree of flexibility so they may be changed as necessary during flight to meet a new situation. Formations must also be so adjustable that the loss of one or more airplanes will not jeopardize the security of the command or prevent the accomplishment of the assigned mission.

c. Simplicity of arrangement, signals, maneuver, and control are essential. It should be possible for each pilot to maintain his assigned position by guiding on only one airplane.

d. Formations should have sufficient maneuverability to enable them readily to accomplish their mission under the complete control of the commander.

■ 58. FORMATION ASSEMBLY.—The principal occasions for effecting the assembly of bombardment aircraft in flight formations are immediately after take-off preparatory to the conduct of a tactical mission; and the reassembly of the formation after the delivery of an assault by subordinate units or after the formation has been disrupted as the result of attack by hostile forces. The initial assembly usually occurs in the vicinity of home airdromes and will normally be completed before enemy fighters are encountered. Rally, after an assault, takes place in the vicinity of the objective and may have to be performed after enemy fighter aviation has engaged the bombardment in air fighting. (Rally point is the position in space at which the components of a formation reunite after an assault.) Prearranged points of group assembly in enemy territory may be necessary when unfavorable weather necessitates navigation through such weather by smaller units or even by individual aircraft.

■ 59. Assembly From One Airdrome.—In all cases of initial assembly a definite time of assembly is prescribed, and in all cases of assembly or of rally the formation, place, and altitude at which units are to assemble are specified in orders. When the formation is to consist of one squadron or less, and the entire unit is based on one airdrome, it may be conveniently assembled in the prescribed formation at the designated altitude above the airdrome. This method is particularly applicable at night or under conditions of adverse weather. Under favorable conditions the formation may be assembled en route, in which case the leader will fly at reduced speed until succeeding airplanes join the formation. If two or more squadrons are based on the same airdrome, assembly may similarly be over the airdrome or en route shortly after take-off.

■ 60. Assembly From Two or More Airdromes.—When the formation is to include aircraft based on two or more airdromes, a place of assembly is designated in the order directing the mission. A place of assembly should be some easily recognized terrain feature in friendly territory approximately on the route to the objective.

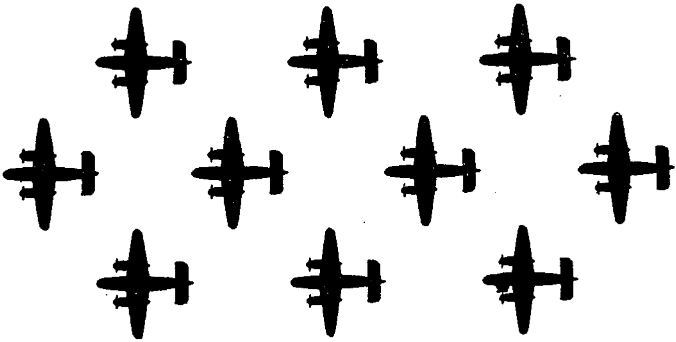
■ 61. Rally.—*a*. Formations which have been disrupted for any reason will rally as rapidly as conditions permit at a point and altitude designated by the leader, and in the formation most suited to existing conditions. The rally point selected by the leader should be beyond the range of the weapons of opposing ground forces.

b. Formations which have been separated into assault elements will be reassembled as soon as practicable en route to a rally point designated in the order for the mission. This order prescribes the formation for the rally and the altitude, which should be lower than the assault altitude of the lowest assault unit.

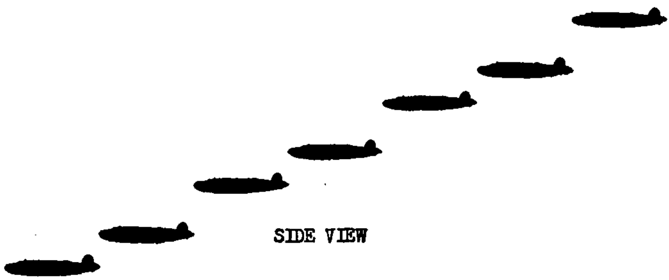
■ 62. TYPES OF SQUADRON FORMATIONS—The possible types of squadron formations are many. Two different types, the javelin formation and the stagger formation, both of which have been found to possess merit as offensive and defensive formations, are illustrative of squadron formations.

■ 63. SQUADRON JAVELIN FORMATION.—The javelin formation (fig. 1) is composed of two or more three-plane elements in close column. The second and succeeding elements may be either stepped-up or stepped-down. Certain defensive advantages accrue to each method and a change from one to the other can be quickly made. This formation affords one of the heaviest concentrations of defensive fire possible to present with the number of airplanes involved. While this formation offers a maximum degree of compactness, it is also very maneuverable and easily controlled. Any sector of approach may be covered by at least three gunners. In the stepped-down formation all rear gunners may fire in the upper rear hemisphere. The lower rear hemisphere is protected by cross fire. This formation is extremely narrow and makes a simultaneous close-in attack from the rear very difficult. The last element may be composed of four airplanes instead of three, as shown in figure 1.

■ 64. SQUADRON STAGGER FORMATION.—The stagger formation (fig. 2) consists of three flights of three airplanes each and is designed to afford the maximum degree of maneuverability in a squadron formation. In this formation, B and C flights normally take position to the right and left of the leading flight (as shown in fig. 2), one being stepped-up and the other stepped-down in such a manner as to permit freedom of lateral movement across the flight path of the formation. The lateral freedom of all flights and of individual airplanes contributes to the maneuverability of the formation as a whole, and facilitates the presentation of a strong defensive fire against flank attacks by merely shifting the formation so as to uncover all of the top and side guns of the formation.



PLAN VIEW



SIDE VIEW

FIGURE 1.—Squadron javelin formation.

This type of formation is very flexible, and the positions and distances may be varied greatly from those shown in the figure. The freedom of maneuver of each flight and of each airplane within the flight on its own horizontal plane renders this formation readily adjustable to quickly changing conditions with great speed and effectiveness. These lateral movements may be used to confuse the enemy and minimize the effect of his fire.

■ 65. TYPES OF GROUP FORMATIONS.—A group formation will consist of two or more squadron formations, and the arrangement may be varied according to the requirements of different situations. Two types of group defensive formations which have been found satisfactory are the wedge formation and the group stagger formation.

■ 66. WEDGE FORMATION.—The wedge formation is composed of squadrons in javelin formation, arranged as diagrammed in figure 3. The second and third squadron formations are echeloned above and to the right and left of the leading squadron. A fourth squadron, if present, may take position to the rear and above the leading squadron and with its leader approximately opposite the leaders of the second flights of the flank squadrons. The position of the fourth squadron is not fixed, because it is a responsibility of the commander of that squadron to maneuver his formation so as to provide the maximum support possible for the other squadrons of the group. The wedge formation is sufficiently flexible to permit the shifting of squadrons for defense against all types of attack by hostile aircraft. This type of formation is easily controlled.

■ 67. GROUP STAGGER FORMATION.—In the group stagger formation (fig. 4), squadrons are arranged in a manner similar to that of the flights in a squadron stagger formation. In this type of formation the group is staggered in altitude and in depth to such an extent that the squadrons have freedom of lateral movement to the same extent as have the flights in each squadron stagger formation. The differences in altitude of the lowest and highest flights in a homogeneous group formation of thirty airplanes may be varied from 600 to 1,600 feet. This is probably the most flexible group formation yet developed, the whole group being able to secure any degree of change in direction with the maneuverability of one flight of three airplanes.

■ 68. NEED FOR DEFENSIVE FORMATIONS.—Defensive formations are necessary whenever bombardment units are employed dur-

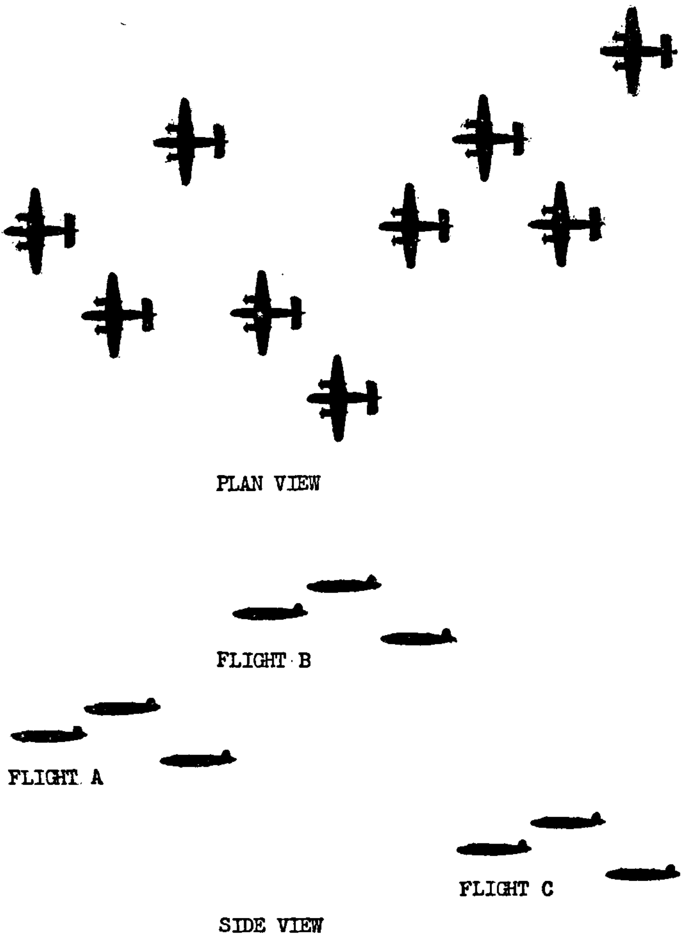


FIGURE 2.—Squadron stagger formation.

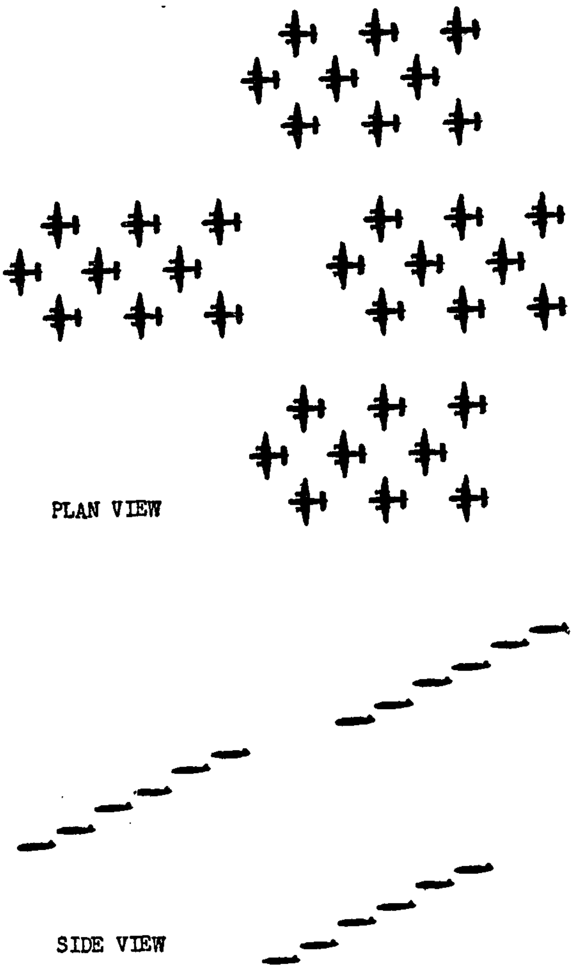


FIGURE 3.—Group wedge formation.

ing daylight within range of enemy weapons. Such protection is necessary in order to insure the completion of tactical missions in enemy territory and to minimize losses which may result from active opposition.

■ 69. GENERAL REQUIREMENTS OF DEFENSIVE FORMATIONS.—*a*. Defensive formations are so constituted as to facilitate concentration of their own defensive fire, particularly against short range fire from hostile aircraft. Such formations are sufficiently flexible to permit rapid changes in position and increases or decreases in the intervals and distances between airplanes, flights, and squadrons in the formation to meet any form of hostile attack.

b. The commander of a large formation rarely pilots the leading airplane. The commander who controls a formation and supervises its navigation, defense, and method of attacking the objective should be relieved of the duties of piloting when practicable. He is responsible for the tactics employed and for the air discipline of his command, and must be in a position from which he can best observe the conduct of the mission and can most efficiently perform his command duties.

■ 70. DEFENSE AGAINST HOSTILE AIRCRAFT.—*a*. Individual airplanes and elements in defensive formations must be so arranged as to facilitate the maximum concentration of defensive fire in that direction which is most favorable to approach of the enemy aircraft in launching attacks against the formation. It is desirable that such formations be capable of delivering simultaneous gun fire superior to that which can be brought to bear by the enemy at any one time. Defensive formations should have sufficient maneuverability to enable them to minimize their vulnerability to time-fuzed bombs and long-range aircraft machine gun or cannon fire.

b. The delivery of effective defensive fire from bombardment aircraft in flight requires coordination of the fires of the several defensive guns; proper location of guns and training of gunners to cover all sectors and avenues of approach of attackers; formation flexibility to permit concentration of fire of the defensive guns against the attackers on any avenue of approach; excellence of performance of the defensive guns; and a high degree of skill on the part of the gunners.

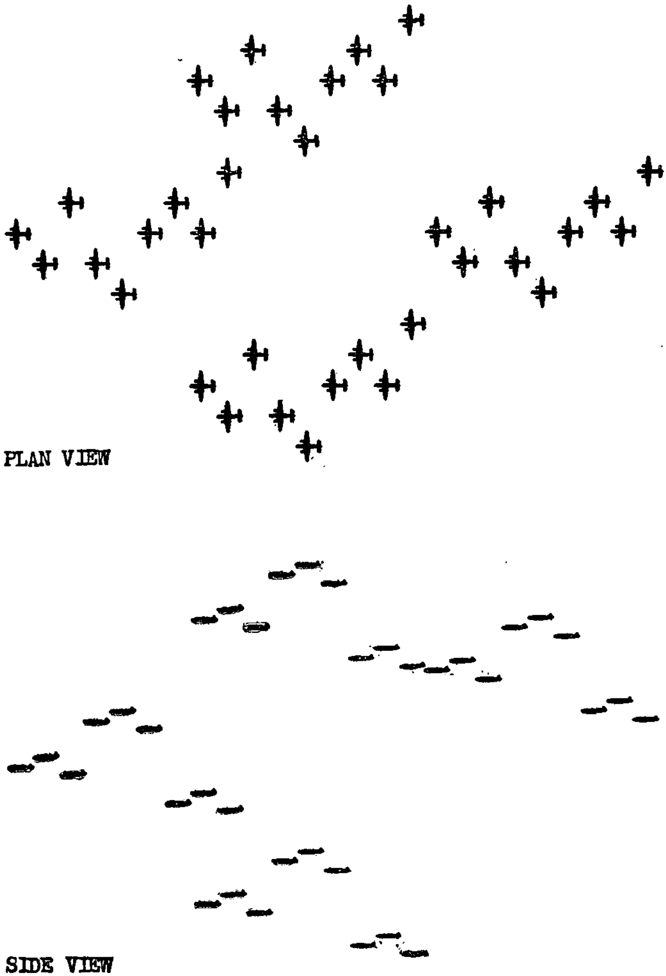


FIGURE 4.—Group stagger formation.

c. Simplicity and compactness are secured in a defensive formation when each pilot is able to maintain his assigned position by guiding on only one adjacent airplane. In such a formation, pilots may readily maintain their positions, and the degree of compactness attainable is limited only by the skill and training of the individual pilots. A simple compact formation may be readily controlled by the leader, who is assured that his commands will be quickly relayed to all airplanes in the formation. Efficient control requires also that the formation be capable of maneuver. A formation having great lateral width cannot be turned on a short radius without a lateral shift of elements because of the resultant distance differential between airplanes on the outside and on the inside of the turn. For efficient control and maneuverability, defensive formations should be as narrow laterally as is consistent with other requirements.

d. When a group formation is composed of two or more squadron formations, each squadron is charged with a definite responsibility in the conduct of organized defensive fire. Whatever the size of the defensive formation, its elements are arranged within themselves and with respect to each other to provide the best opportunity for supporting fire.

■ 71. DEFENSE AGAINST GROUND WEAPONS.—*a*. When it is necessary to conduct air operations during daylight in an area defended by antiaircraft weapons, it is essential that the disposition of the aircraft and the tactics employed while in the danger zone be such as to minimize the effectiveness of the fire of the defending weapons. Localities which are strongly defended by antiaircraft artillery are likely also to be protected by defensive air units. A compact formation, well suited for defense against hostile aircraft, does not afford adequate security against antiaircraft artillery fire. Air commanders conducting attacks against objectives defended by both antiaircraft artillery and aircraft must so adjust their formations as to provide the most effective defense under the actual conditions encountered during the conduct of tactical missions.

b. Formations specifically arranged for defense against antiaircraft artillery fire must permit sufficient maneuver of airplanes in all directions so that no single airplane is forced to fly to the point in space at which the antiaircraft fire control instruments predict it will arrive at the end of a predicting interval.

c. The formation must be so arranged that no single antiaircraft artillery battery round will disable more than one airplane.

d. Within the considerations of spacing required to prevent injury to more than one airplane by a single battery round, the formation should be as compact as possible to facilitate rapid transit of the danger area and to prevent, insofar as possible, aircraft being successively taken under fire by the same artillery units.

e. The formation must be able to take advantage of weather conditions that interfere with discovery and continuous observation from the ground.

f. The formation must be quickly convertible into formations suitable for air attack or for defense against hostile aircraft.

■ 72. CONVERTIBILITY OF DEFENSIVE FORMATIONS.—Formations suitable for defense against hostile aircraft may, by increasing the intervals and distances between airplanes, be adjusted to the requirements for defense against antiaircraft fire. Stagger formations, because of their great flexibility and variation in altitude between the highest and lowest flights, may be used to advantage in situations wherein a disposition suitable for defense against antiaircraft artillery fire may suddenly be required.

■ 73. OFFENSIVE FORMATIONS.—*a.* The character of the objective and the manner in which the attack is to be accomplished will influence the plan of the formation. The nature and strength of the ground and air defense forces also may influence the type of the offensive formation. Some modification of the best offensive formation plan may at times be justified in the interest of security. The value of or necessity for greater security must be balanced against any loss in effectiveness which may result from a change of plan or formation to secure it.

b. All bombardment echelons must be imbued with the offensive spirit that carries through to success the mission assigned. Losses can be anticipated and even though severe should, when unavoidable, be accepted in those cases in which the blow to the enemy justifies the aircraft loss incurred. Higher authorities may require destruction of objectives at all costs, in which case the commander in the air can accept no alternate that does not offer excellent promise of accomplishment of the mission. Even here, however, cases will arise in which questions of security must be weighed to prevent enemy action from so depleting the force prior to its arrival at the bomb release line that the success of the attack is placed in jeopardy.

c. A detailed study of each specific objective is required to determine the best formation from which it may be attacked. The conformation of the objective will determine, in general, the appropriate form and dimensions of offensive formation to be employed. The nature of some areas does not permit division into a series of point targets for individual airplane attack. Some targets will require uniform coverage over their entire area, especially if chemical agents are employed.

■ 74. FORMATION ATTACKS.—*a.* The javelin, wedge, and stagger formations are suited to attacks at all altitudes except those too low to permit minimum formation depth.

(1) Both point and area targets may be successfully bombed from javelin formation, either stepped-up or stepped-down, the intervals and distances between airplanes being adjusted to meet the requirements of each specific situation.

(2) The wedge formation is well suited to the attack of area objectives that require the fire power of more than one squadron to produce the desired effect.

(3) The group stagger formation, while especially well suited as a defensive formation, is highly adaptable for use in formation attacks of point targets. If the attack is conducted against an objective defended by antiaircraft artillery, all squadrons, flights, and even individual airplanes, which are at greatly increased intervals while within range of the antiaircraft guns, maneuver so as to present the poorest possible target consistent with the accomplishment of the mission. The squadrons approach the objective at different altitudes,

and the airplanes of each squadron converge on their assigned targets in three plane elements, each at a different altitude.

b. Attack from stagger formation is characterized by an apparent complexity but actually is easy of accomplishment, and the formation is so flexible as to afford maximum freedom of maneuver to each airplane in it. The group stagger formation brings a mass attack against the objective in a minimum of time, keeps the group in a good defensive formation to resist attack by hostile aircraft, and presents a confusing target to both air and ground defensive forces.

■ 75. MINIMUM ALTITUDE ATTACKS.—Air attacks may be launched from aircraft in offensive formation at either high or low altitudes depending upon the nature of the objective, the weapons used, weather conditions, and the character of antiaircraft defense employed by the enemy. Flexibility and maneuverability are of great importance at extremely low altitudes, and the most satisfactory arrangement under such conditions is to divide the formation into elements of three airplanes each. The elements fly in V-formation with intervals and distances as dictated by the requirements of the mission. Elements guide upon the leader and fly either in column or in echelon and at approximately the same altitude. When elements fly at different altitudes, the leading element flies at the lowest altitude. The intervals and distances between elements are varied to meet the needs of any particular situation. This type of formation has the requisite flexibility for minimum altitude missions and can readily be closed for defense against the fire of hostile aircraft. The size of the formation is determined by the offensive fire power required for the accomplishment of the mission.

■ 76. MINIMUM ALTITUDE FORMATIONS.—A typical formation of nine airplanes in an arrangement suitable for minimum altitude air attack is shown in figure 5. In this arrangement of flights, all may fly at the same altitude while delivering the attack, or the second and third flights of the formation may fly slightly higher than the leading one.

■ 77. NIGHT FORMATIONS.—The tactical principles applicable to the conduct of bombardment missions in flight formation are basically the same, whether the operations are performed during daylight or at night. The differences in operating technique appropriate to the conduct of bombardment operations in flight formations, during daylight and at night, are essentially those necessary to compensate for the reduction in visibility occasioned by night flying conditions. This reduction in visibility renders undesirable the use of stagger and stepped-down formations. The squadron javelin, the group

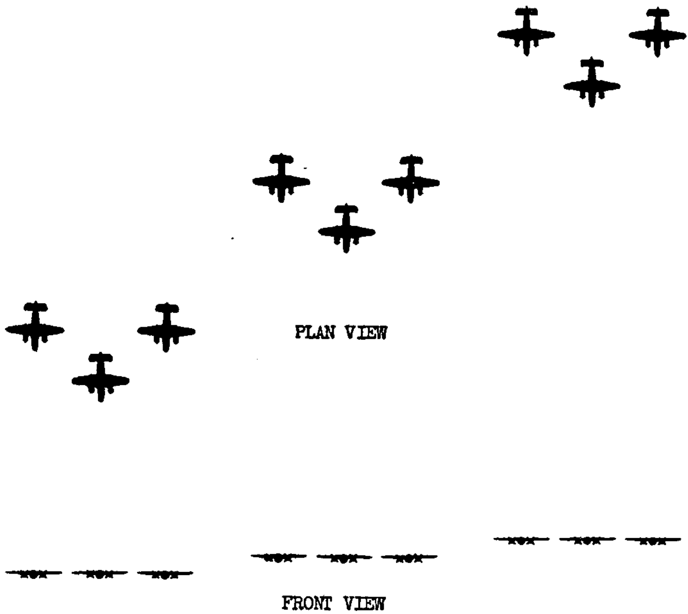


FIGURE 5.—Minimum altitude formation.

javelin (column of squadrons in javelin), and the route column, all stepped-up, are particularly adaptable to night flight in formation.

■ 78. FACTORS AFFECTING NIGHT FORMATIONS.—*a*. The visibility during night operations is subject to such wide variations that no precise rule can be stated for determining the degree of departure from daylight technique in the conduct of night flying formations under all conditions.

b. Decreased visibility incident to night operations renders the massing of defensive fire, against attack by hostile aircraft, of little if any practicable value.

c. Formations, even at antiaircraft intervals, are not normally used in night attacks against defended objectives.

d. The maintenance of compact formations, either defensive or offensive, for long periods of time is very fatiguing to piloting personnel. The fatigue of piloting personnel, incident to formation flying, is much greater at night than during daylight operations.

■ 79. ROUTE FORMATIONS.—Close defensive formations are required only during attacks by hostile aircraft or when such assaults are imminent. Offensive formations are necessary only during the bombing assault. In the conduct of bombardment missions there will be long periods during both the advance and the return when there is no necessity for the maintenance of a compact defensive formation. During such periods the formation will be flown with sufficient intervals between airplanes to relieve the pilots.

■ 80. GENERAL REQUIREMENTS.—*a.* Route formations are habitually used by tactical units during active operations whenever compact defensive or offensive formations are not required. Route formations are employed during the routine movement of aircraft by air in formation.

b. Route formations must be capable of quick and simple conversion either to defensive or offensive formations. Rear elements are habitually stepped-up in order to facilitate closing upon the leading airplane when necessary.

c. Route formations must not present a profitable target to antiaircraft artillery.

■ 81. CONVERTIBILITY OF ROUTE FORMATIONS.—In general, route formations are assumed by spreading out defensive or offensive formations without materially altering their original conformation. Individual aircraft and elements take convenient intervals and distances to facilitate route travel without undue fatigue.

■ 82. TYPES OF ROUTE FORMATIONS.—Typical route formations are shown in figures 6 and 7. The group route column is actually a column of squadrons in javelin up at increased intervals and distances. Similarly the dispersed column corresponds to the group wedge.

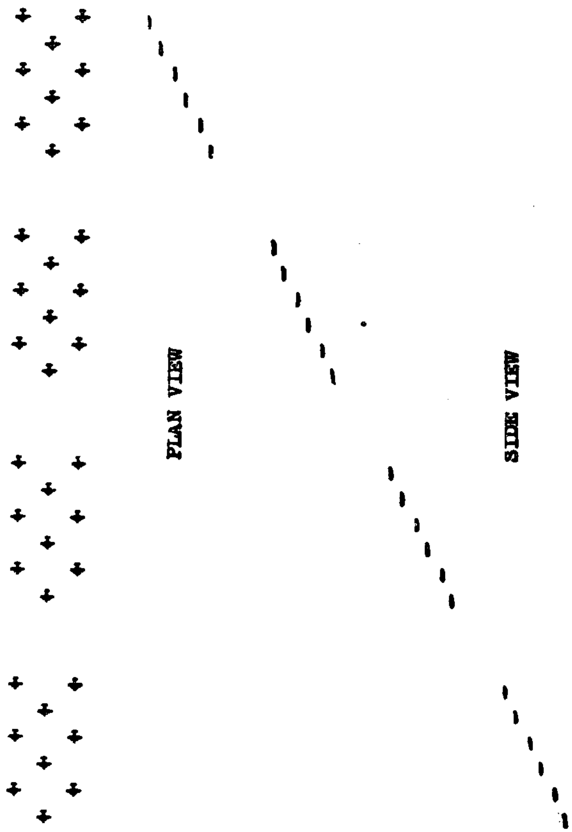


FIGURE 6.—Group route column formation.

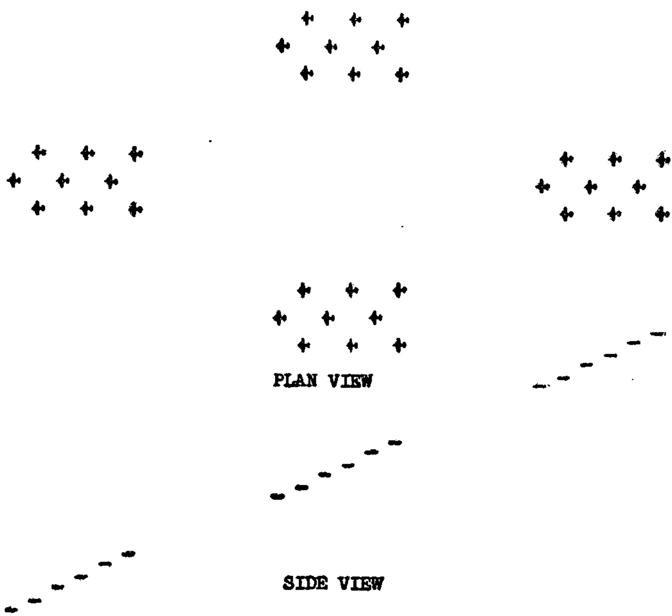


FIGURE 7.—Group dispersed column formation.

CHAPTER 3

TACTICS OF AIR ATTACK

SECTION I

ADVANCE AND RETURN

■ 83. GENERAL.—*a.* A bombardment mission normally consists of three separate phases—the advance, the assault, and the return. The advance phase ends when the attacking force is assembled in the air at the initial point, where the assault phase begins. The return phase begins at the rally point and ends with the return of the aircraft to their respective airdromes. (An initial point is a position in space at which the component units of a formation take up the disposition required for the execution of the assigned assault task.)

b. Secrecy and security are of paramount importance during the advance and return phases when the tactics are essentially defensive, as distinguished from the offensive tactics requisite to success in the assault phase. Security is important at all times during the mission, and secrecy is especially important during the advance, when it is desirable to avoid detection by the enemy and possible attack by hostile aircraft. Surprise is an important factor in the success of air attacks, particularly when directed against fleeting objectives.

c. It is desirable that the advance and return phases are as brief as possible, consistent with the requisite security measures. However, the routes followed during both the advance and the return may have to be circuitous in order to avoid passing over or near the stations of active elements of the hostile antiaircraft defense. During the advance, it is particularly important to avoid, when practicable, known or probable locations of observation stations pertaining to the enemy's aircraft warning service. As a matter of policy, bombardment units also avoid flight over areas defended by friendly antiaircraft artillery, but utilize to the maximum the protection afforded by friendly fighters in general or local defense.

■ 84. Unopposed Operations.—*a*. Situations in which the enemy offers no active resistance allow the most effective and economical employment of the bombardment force. Bombardment attacks, when made at night or during periods of very poor visibility, may be unopposed during the advance and return phases of the operation.

b. When the attacking force is not likely to encounter any active opposition, air attacks by individual airplanes afford greater ability to overcome adverse weather conditions; have greater effective ranges, greater maneuverability, and speed; are simple and permit maximum freedom in the exercise of individual initiative in coping with unforeseen difficulties. Individual airplane attacks may be employed to advantage in either day or night operations against undefended objectives, except when formation pattern bombing is required. Airplanes operating singly are able to attain maximum accuracy of offensive fire, thereby affording the most effective results from the munitions expended.

c. Even though active opposition may not be expected, the tactics of the advance and return should be such as to keep the force prepared to employ its defensive fire power quickly, and to guard against surprise.

■ 85. Penetration of Antiaircraft Defenses.—Air attack operations are conducted against objectives which are vital to the enemy. The enemy will dispose the active elements of his antiaircraft defense forces in the manner best suited to the defense of those installations or facilities which are most vital to his military operations and which are vulnerable to air attack. On any specific mission against a vital objective, the penetration of hostile antiaircraft defenses may be necessary. Hostile antiaircraft defenses may be encountered at other points as well as in the vicinity of the objective. Knowledge of the nature, location, and strength of the defending forces, also of the probable weather conditions and the manner in which such conditions may affect both attacking and defending forces, is essential to the penetration of hostile antiaircraft defenses with a minimum of losses. The bombardment force may resort to evasion; may employ massed defensive fire; may be supported by light bombardment and/or fighter aviation; and also may take advantage of the security afforded by concurrent air operations.

■ 86. Evasion.—*a.* The power of evasion is an important factor in avoiding contact with active elements of the hostile antiaircraft defense forces. Routes and the time of the operation are selected with a view to avoiding detection. Areas in which enemy defensive aviation is active, also localities defended by antiaircraft artillery, and places at which there may be ground observation stations are avoided during the advance and the return.

b. Darkness, cloud formations, poor visibility, circuitous routes, speed, altitude, changes of altitude, camouflage, and inaudibility resultant from use of glides are factors which may be utilized to advantage to evade the hostile antiaircraft defense forces. Flight at high altitudes may be effective in evading detection by ground observation stations. Operations at minimum altitudes over uneven terrain may effectively mask antiaircraft artillery weapons. Reduced audibility in flight materially assists in obtaining surprise, either by preventing or by delaying discovery.

■ 87. Massed Defensive Fire.—Tactical formations which facilitate the massing of the defensive fire of the bombardment command are used when contact with enemy fighter aviation cannot be avoided. In penetrating the air element of the hostile antiaircraft defense, the elements of the combat command are so disposed as to facilitate the rapid massing of its defensive fire power when within the zone of action of the hostile air fighting force.

■ 88. Speed and Maneuvers.—*a.* High speed and maneuver are employed to lessen the effectiveness of the fire of antiaircraft guns. These methods are most effective at high altitudes when the time of flight of the projectile necessitates the use of firing data based upon a predicted position considerably in advance of the actual position of the aircraft when the gun is fired.

b. Single airplanes when not engaged in the actual bomb sighting operation resort to high speed and maneuver when taken under fire by antiaircraft guns. They change their altitude and their direction in such a manner as to make prediction difficult. Changes should be made at intervals shorter than the time of flight of the projectile, whenever practicable.

c. When taken under fire by antiaircraft guns, formations assume a spacing between airplanes greater than the effective zone of one antiaircraft artillery battery round and sufficient to permit maneuver of individual airplanes in the formation. When there are more airplanes than artillery directors, a portion of the airplanes may be able to complete the attack without receiving enemy fire. During daylight hours a formation spaced as stated above provides greater security than does a succession of individual airplanes. This is because the command is exposed to the antiaircraft gun fire for a shorter period of time.

■ 89. LIGHT BOMBARDMENT AND FIGHTER SUPPORT.—Friendly light bombardment and fighter aviation may be employed in direct support of the attacking force in situations and phases which render such action practicable. Such support usually must be provided for in the plans of the next higher commander. Interceptor and support force fighter aviation and light bombardment aircraft, because of their limited radius of action, are not ordinarily employed in the direct support of long-range bombardment missions. Escort fighter aviation having long-range aircraft normally will be utilized if available when the direct support of bombardment units is required. Fighter support is especially important when strong opposition has to be overcome and the defensive fire power of the bombardment force is inadequate.

■ 90. INDIRECT SUPPORT.—Bombardment operations may be afforded indirect support by concurrent attacks which may draw hostile fighter aviation to other areas. It is important that information of all contemplated air activities in the theater of operations be available, in order that bombardment operations may be so timed as to take advantage of the indirect support afforded by concurrent operations which may attract a portion of the hostile air fighting force.

■ 91. SEARCH OPERATIONS.—When the accomplishment of air attack involves search operations for the purpose of locating the objective before launching the attack, the search constitutes a part of the advance phase of the operation. The tactics employed during search operations are based upon the active opposition likely to be encountered. Search operations may be conducted over sea areas, where active opposition by carrier-based aviation is to be expected. The technique of search is outlined in FM 1–20.

SECTION II

ASSAULT

■ 92. ASSAULT DOCTRINE.—*a.* The assault phase of bombardment operations begins at the initial point and ends with the rally of the command for the return flight. The initial point is selected with a view to facilitating the effective conduct of the assault. The initial point always should be beyond the range of the antiaircraft guns employed to defend the objective and, if feasible, beyond the probable audibility range of the antiaircraft artillery intelligence service observers.

b. The security of the attacking aircraft always influences the tactics of the assault. The successful accomplishment of the mission is of paramount importance during the assault phase; but whenever, in the planning of the assault phase, there is conflict between security measures and maximum offensive effort, the commander must make a tactical decision with both considerations in view.

c. When the required degree of destruction of the bombardment objective can be accomplished at one blow, the bombardment force dispatched on the mission should be of sufficient size to accomplish the mission in one assault, thereby minimizing the time during which the bombardment command is exposed to enemy fire.

d. When the accomplishment of the mission requires more than one blow, the successive assaults should be so timed that the enemy cannot employ all of his defending fighters to oppose each attacking wave in turn.

■ 93. ENEMY OPPOSITION.—Important objectives which are vital to the enemy may be strongly defended both by fighting aircraft and by antiaircraft artillery. Barrage balloons may be encountered in the vicinity of important objectives. When balloons are encountered, preliminary operations by supporting aviation may be necessary to destroy the obstructions before undertaking the air attack of the ground objective. The enemy may not be able to provide local antiaircraft defense for all objects which may constitute profitable targets for the attacking force; hence, the assault phase may be unopposed. Unless it is known that no opposition will be met in the vicinity of the objective, the operations plan should include provisions for appropriate action should opposition be encountered.

■ 94. ASSAULT VARIATIONS.—*a.* Bombardment forces exert their power by air attack operations. Assaults may be delivered at high or low altitudes, during daylight or at night by means of area or precision bombing; and may be opposed or unopposed by the enemy. It is, therefore, manifestly impossible to lay down any system of set rules to be implicitly followed in all situations.

b. For convenience of presentation, tactics of the assault are treated in this chapter under the categories of high altitude and minimum altitude operations. High and minimum altitude operations are distinguished not so much by the actual height at which the assault is made as by the difference in the character of the operation, particularly with reference to delivery of fire and by the manner of effecting surprise and of obtaining security against the fire of hostile weapons wherever located. Operations which normally are conducted at altitudes of 5,000 feet or more above the ground may, by reason of weather condition or other factors, actually be performed at a comparatively short distance above the ground (1,000 to 3,000 feet in some cases); however, the operation is tactically a high altitude operation though the actual altitude may be relatively low. Altitude, considered as a separate factor, affords security at both extremely high and at extremely low levels. Only those missions which usually are performed at minimum altitudes, or which employ forward protective fire as a security measure, are treated as minimum altitude operations.

SECTION III

HIGH ALTITUDE BOMBING

■ 95. GENERAL.—*a*. (1) Bombing attacks involving the performance of precise sighting operations are treated herein as high altitude bombing. Such operations may be conducted within one or more of the following altitude brackets:

	Feet
Low	2,000 to 5,000
Low medium	5,000 to 9,000
Medium	9,000 to 13,500
High	13,500 to 18,000
Maximum	18,000 to service ceiling

(2) From an offensive point of view the best altitude from which to launch an attack is the one which is most favorable to the obtaining of the greatest accuracy of offensive fire. The altitude may be modified by considerations of security or weather. High altitude bombing operations may be conducted either by day or at night, the decision being influenced primarily by the effectiveness of enemy opposition. Undefended objectives can be most effectively attacked during daylight. Strong enemy opposition may necessitate night operations against important objectives in order to minimize losses.

b. When air attacks are made against objectives having an organized antiaircraft artillery defense, the proper force should be employed to accomplish the purpose of the air offensive in one mission, if this force is available. In conducting the attack, security is gained by attacking simultaneously with as many aircraft as can conveniently and expeditiously do so. Where conditions indicate the necessity for attack by waves, the time interval between waves should be reduced to a minimum. The time of passage of each wave through the defended zone is also held to a minimum.

■ 96. DIRECTION OF APPROACH.—*a*. The nature of the target should be carefully considered. Objectives which are compact and approximately square or circular in shape may be attacked equally well from any direction. Elongated targets may be attacked either across or along their long axis when range and deflection probable errors are equal and bombs are individually sighted. When range and deflection probable errors are not equal, the direction of approach for independently sighted bombs, other conditions being favorable, should be such that the greatest probable error is in the direction of the long axis of the target. An elongated maneuvering target may have to be attacked as found, regardless of the direction of approach with respect to the axis of the objective.

b. Visibility is an important factor in precision bombing. The direction of approach should afford best visibility for the bombing teams and poorest for opposing antiaircraft forces. Approaching from the direction of bright sunlight, moonlight, or protecting clouds may provide definite advantages to the attacker.

c. Upwind approaches are most favorable for bombing accuracy because of the lower ground speed, but the bomb release point is thereby brought closer to the target and the exposure of the aircraft to antiaircraft artillery fire somewhat prolonged. Antiaircraft artillery fire usually is more accurate against slow than fast moving aircraft. The advantages of reducing exposure to antiaircraft gunfire must be considered in comparison with the decrease in bombing accuracy resulting from the greater ground speed incident to a downwind approach.

■ 97. ALTITUDE.—Altitude affects the accuracy of precision bombing. In general, bombing accuracy is best at relatively low altitudes but the loss in accuracy is not necessarily directly proportional to the altitude. The altitude at which best accuracy has been attained by individual teams or bombardment units should be used whenever practicable. Bombing teams should be trained to do accurate work at the lowest altitude at which they may be forced to bomb because of ceiling limitations imposed by clouds. The accuracy of antiaircraft artillery fire varies with the altitude of the aircraft fired upon and is, in general, best at medium altitudes and poorest at fairly low or extremely high altitudes. The optimum bombing altitude in any situation can be ascertained only after careful consideration of bombing accuracy as against antiaircraft fire effectiveness and the consequent probable losses of aircraft.

■ 98. SIGHTING OPERATION IN FORMATION BOMBING.—*a*. Formation bombing has the disadvantage of sacrificing to some extent the accuracy obtainable in separately sighted single releases. The formation leader is responsible for directional accuracy, and the bombing team of the leading airplane should exercise extreme care to minimize the directional error. The deflection errors of bombs dropped from other aircraft in the formation are affected by the precision with which these aircraft are controlled in maintaining their position in the formation. Bomb sight controlled timing of the release of the bombs dropped from each airplane in the formation is essential to the minimizing of range errors and to assuring compactness of the pattern.

b. Release upon signal or when the bombs are seen to leave the leading airplane involves an uncontrolled delay which may result in large range errors at high ground speeds and also subjects all bombs to any initial range error made by the leading bombardier. Each airplane in a bombing formation must have a trained bombing team. Since it cannot be foreseen what aircraft may become casualties, the success of the mission must not be jeopardized by placing full responsibility for the entire sighting operation upon the bombing team of the leading airplane. It is necessary that every bombardier and every bombing team be fully trained in the performance of the complete sighting operation and capable of taking the lead whenever the need for such action arises.

■ 99. DAYLIGHT OPERATIONS.—Good visibility is an important factor in securing the most effective results in high altitude bombing attacks. Such operations normally are conducted during daylight unless other factors render night operations more desirable or necessary. All kinds and classes of objectives can be effectively attacked during daylight. The methods employed in the attack of area targets in daylight frequently differ from those best suited to the attack of point targets.

■ 100. DAYLIGHT ATTACK OF AREA TARGETS.—*a.* Area bombing is employed against targets which cover a considerable space with no single vulnerable point, the destruction of which insures the destruction of the objective. Area bombing is also employed when the general location of the objectives is known but their exact placement cannot be determined with sufficient accuracy to permit them to be used as aiming points. Precision sighting is necessary in bombing an area in order to insure the correct placement of the bomb pattern. Area bombing against defended objectives normally is conducted in formation. When the size and shape of the target area are such that the conformation of a single formation can be adjusted to produce a bomb pattern covering the entire area, all of the attacking aircraft may operate in a single formation as one combat command.

b. The attack of an extensive area requiring a large attacking force may be accomplished by dividing the force into suitable separate combat commands and assigning each attacking unit a definite subarea against which it is to operate. If the objective is defended, all units of the attacking force should assault it as nearly simultaneously as possible. The direction of approach should be such as to minimize the number of guns which can be brought to bear upon the attacking force, and also to make the exposure to antiaircraft gunfire as brief as possible. In the attack of area targets, bombs usually are released in train.

■ 101. DAYLIGHT ATTACK ON POINT TARGETS.—*a.* Objectives consisting of point targets requiring the accurate placement of bombs, individually or in a closely spaced train, are attacked by precision bombing methods. Point targets may, depending upon their size and nature of construction, be attacked by aircraft operating either singly or in formation. When formation attacks are made against point targets, the assault formation usually must be compact in order to secure a suitably concentrated bomb pattern. When the target is undefended, the assault tactics are based solely upon the requirements for the most effective employment of the attacking force. Individual airplane attacks are the most effective against undefended point targets because the attack can be repeated by dropping bombs singly until the desired result is attained. Avoidance of contact with active elements of the hostile antiaircraft defense force may be practicable during the advance and up to initiation of the bombing approach by employing evasion tactics, but evasive maneuvering is not feasible during the bombing approach. (Bombing approach is the brief period of flight of the bombing airplane or formation during the actual sighting operation and immediately preceding bomb release.)

b. Effective results are of paramount importance. However, when the target is defended, the assault tactics may, within limits prescribed by higher authority, be modified so as to minimize the effectiveness of the enemy's opposition. High altitude daylight bombing attacks in the presence of defending antiaircraft artillery, aircraft opposition being either weak or absent, may be effected by simultaneous convergence upon the target, either by individual airplanes or by flights, thus permitting individual sighting for release of each bomb or train of bombs. When the simultaneous convergence method of attack (either by individual airplanes or by flights) is employed, it is desirable that the initial point be as close to the objective as practicable without being within the horizontal range of the defending antiaircraft artillery. When the attacking aircraft are exposed to antiaircraft gunfire for a considerable period, they should maneuver individually when not in the bombing approach in order to lessen the effectiveness of the fire.

■ 102. NIGHT OPERATIONS.—*a.* (1) High altitude bombing operations can be conducted at night whenever the conditions are such that the target can be seen and the necessary sighting operations performed. Artificial illumination of the target frequently is necessary at night. Initial illumination usually is provided by observation or reconnaissance aircraft as an auxiliary supporting operation. Darkness imposes limitations upon both the attacking force and hostile antiaircraft defense forces because of the decreased visibility. Direct illumination of the attacking aircraft normally is required for the proper direction of the fire of antiaircraft guns. Aircraft when directly illuminated and not in their bombing approaches may resort to high speed and to changes in altitude and direction in order to lessen the effectiveness of the antiaircraft artillery fire. Under favorable conditions, searchlights provide a considerable amount of general illumination by reason of diffused rays not forming an integral part of the focused beam.

(2) Aircraft flying at high altitude cannot be seen from the ground unless directly illuminated. However, nearby aircraft not in the beam of a searchlight are sufficiently illuminated to make them visible to other aircraft which are only a short distance away. Hostile fighting aircraft can take advantage of the illumination provided by searchlights and can, by proper maneuver, fire upon the attacking force without themselves being illuminated long enough to enable the defending gunners to retaliate upon equal terms. However, fighter aircraft cannot effectively attack unless their targets are within the limits of an illuminating beam.

(3) High altitude night attacks, whether against defended or undefended objectives, normally are accomplished by individual airplane attacks. Attacking aircraft by approaching the objective at night in a glide from high altitude may be able to introduce an element of surprise and thereby delay detection and minimize the time of exposure to hostile antiaircraft fire. In some situations, it may be possible to employ gliding during both the approach and the retirement.

b. (1) Area targets which are of practically uniform vulnerability throughout can be attacked at night from high altitude when the illumination is sufficient to facilitate definite identification of the area, even though details within the area may not be distinguishable. When the size and shape of the area to be attacked are such that full coverage can be obtained by a formation bombing pattern, attack in formation is effective and expedites completion of the mission, but for defensive reasons is normally inadvisable against defended targets. Individual bombing is relatively more accurate and should be employed when feasible.

(2) During night attacks by individual airplanes, bombs may be released in salvo, in train, or singly, depending upon the requirements of the situation. Undefended targets are attacked in the manner best suited to the accomplishment of the desired results and with the minimum expenditure of

bombs. Individual airplane attacks normally are employed in high altitude night operations against point or area targets.

■ 103. ILLUMINATION OF TARGETS.—A plan of illumination should provide that—

a. The entire coordination and/or success of the maneuver should not depend upon the performance of any individual airplane or flight, or upon a complex scheme of coordination between flight units.

b. The objective should be illuminated before the assault aircraft are so committed to their attack as to be beyond the control of unit commanders. This may, in some cases, involve illumination of the objective prior to departure of the assault units from their initial points, notification of the discovery of the target being furnished the assault units by pyrotechnic and/or radio signal.

c. Illumination should be maintained until the attack is completed.

■ 104. FLIGHT METHOD.—*a.* This method of attack can be employed by any size of bombardment force from a single flight up to and including a group. It is essentially a night method of attack but can be used in daylight in the absence of pursuit opposition or with the protection of friendly pursuit. It is illustrated in figure 8.

b. (1) In this method the assault unit is led to an initial point beyond the range of defending antiaircraft artillery and the range of its sound locators, provided the hostile antiaircraft intelligence service is localized to a matter of 20 to 25 miles around the objective. At the initial point the assault unit circles, and flights of three aircraft detach themselves successively and advance in the assault. The interval between assaulting aircraft is normally prescribed in orders. The customary interval is 10 seconds, but variation from this amount may be necessary to meet local requirements.

(2) An alternate method to achieve the flight spacing may be employed. In this method, flights take the prescribed interval during the advance shortly before arrival at the initial point. They, therefore, arrive at the initial point at the proper interval for the initiation of their assaults, thus eliminating necessity for circling at the initial point.

c. (1) The altitudes of attack and withdrawal are prescribed in orders for each airplane of all flights. The flight normally departs from the initial point at the assault elevation of the leading airplane. The leading airplane of the flight proceeds directly toward the objective at its attacking altitude; the numbers two and three airplanes swing to the right and left, respectively, executing shallow dives to their prescribed assault altitudes which usually are 2,000 and 4,000 feet respectively, below that of the leading airplane. At the proper time the numbers two and three airplanes change their course so as to converge upon the objective within an arc of from 30° to 50°. The points at which the numbers two and three airplanes change course to converge upon the objective may be determined by an estimated time of arrival, or may be prominent landmarks readily distinguished at night where such landmarks are conveniently available.

(2) Immediately after releasing their bombs the assaulting aircraft turn approximately 180° and withdraw at a prescribed altitude, usually 1,000 feet lower than its assault altitude. This withdrawal is made approximately on the line of the advance. The number two airplane normally turns to right and numbers one and three to the left. Altitudes are prescribed so as to avoid interference and to confuse the defending artillery directors; for example, the leading airplane may attack at 12,000 feet and withdraw at 11,000 feet; number two attacking at 10,000 feet and withdrawing at 9,000 feet; and number three attacking at 8,000 feet and withdrawing at 7,000 feet. During daylight the altitude intervals may be smaller than are required for safety in night attacks. The assault procedure is repeated by each successive assaulting flight.

d. This method of attack renders difficult the detection and illumination of individual aircraft. When 10-second intervals are used, the number of aircraft within range of the antiaircraft artillery usually will exceed the number of firing batteries. By this method the bombardier of each airplane performs an independent sighting operation.

■ 105. SQUADRON METHOD.—*a.* (1) The squadron method of attack is designed primarily for use at night but may be employed in daytime in the absence of effective pursuit opposition, and when weather or cloud conditions favor it. In this method of attack each squadron is assigned a separate initial point to which it proceeds from the group initial point. The squadron aircraft proceed individually to assault their objectives at the altitude and intervals prescribed in group orders.

(2) The interval between successive squadron aircraft is usually 10 seconds but may be greater for special situations. The assault technique is similar to that employed in the flight method. Airplanes, one from each squadron, attack simultaneously and then return to their respective squadron initial point. Restricting the sector of advance for a four squadron group to 45° favors the creation of a confusion of sound.

b. Circling the initial point prolongs the time of the bombardment force over enemy territory, and care must be exercised to prevent circling formations from being illuminated and fired upon by surprise. The squadron method of attack is illustrated in figure 9.

■ 106. BASE ALTITUDE METHOD.—*a*. In the base altitude method one initial point is used and the squadrons of the group arrive thereat successively at 1 to 2 minute intervals. The order for the attack specifies a base altitude, which is the lowest altitude from which bombs are released during the mission. Each squadron upon arrival at the initial point, separates into assault units which may be either individual airplanes or flights. The leading assault unit dives and proceeds directly toward the objective and bombs from the base altitude. The other units form an echelon, each to the right of its immediate predecessor, and bomb successively from a slightly different direction and at successively higher altitude intervals of 500 feet.

b. When a base altitude of 10,000 feet is prescribed, the leading assault unit bombs at that altitude, the second unit at 10,500 feet, the third unit at 11,000 feet, and so on. Each squadron arrives at the initial point at or above the highest altitude from which it will release bombs. This method provides for release of bombs singly, in salvo, or in train by separate sighting operations in each airplane and is suited to daylight attacks against objectives defended by antiaircraft artillery. Some coordination of defensive fire against hostile pursuit is obtained when the assault unit consists of a flight.

■ 107. GLIDE METHOD.—The various methods of attack may be modified so that assault units approach the bomb release line in a glide instead of in horizontal or diving flight. A glide approach reduces the sound made by the aircraft, thereby lessening the likelihood of discovery particularly at night, and also introduces a range change factor which may adversely affect the accuracy of the antiaircraft artillery fire.

SECTION IV

MINIMUM ALTITUDE BOMBING

■ 108. GENERAL.—*a*. The advance and return phases of minimum altitude air attack operations usually are flown at altitudes which facilitate accurate navigation and afford a considerable degree of security from the fire of ground machine guns and of antiaircraft guns. Assaults which bring the attacking aircraft within range of machine guns, small cannon, and small arms on the ground should be performed at an altitude which is a compromise between the desire for most effective offensive fire and security from ground weapons. Practically any type of small bore light weapon may be used in defense of an objective against low altitude air attacks, and for that reason there always is likelihood of encountering hostile fire during such operations.

b. Minimum altitude assaults may be delivered either in daylight or during the hours of darkness. The attack of objectives which are undefended or only lightly defended can best be accomplished during daylight. When strong opposition is anticipated, it is desirable to take advantage of the security afforded by darkness.

c. When minimum altitude attacks are performed in support of high altitude operations, proper coordination is essential to the maximum effectiveness of the combined operation. Coordination in supporting air attacks normally is effected by adherence to a time schedule, rather than by assembly with the force which attacks at high altitude.

■ 109. Daylight Operations.—*a*. Minimum altitude bombing operations normally are conducted during daylight unless night operations are required. During daylight the aircraft engaged in minimum altitude attacks usually operate in formation. They may operate singly for short periods in the vicinity of the objective when the mission requires or permits individual airplane attacks. Aircraft employed in minimum altitude assaults during daylight habitually employ forward protective fire while within range of ground weapons of the forces defending the objective. Operation at minimum altitude, particularly over irregular terrain, affords security to the attacking force because of the masking of the fire of ground weapons and by limiting the time of exposure to any particular weapon. Defensive formations are employed for protection against hostile fighting aircraft which, because of the low altitude, can attack only from the upper hemisphere.

b. Surprise is sought whenever possible. It is gained by taking advantage of speed and of the defilade provided at minimum altitudes by irregular terrain. The operations of two or more attacking units assaulting the same objective are so coordinated as to secure the maximum possible surprise.

c. When the objective is strongly defended, the attack is accomplished by a single assault in suitable offensive formation. In such cases, the main attack may, when practicable, be preceded by a preliminary operation for the purpose of laying smoke to interfere with the hostile antiaircraft defense force and to afford cover for the main attacking force.

■ 110. Area Targets.—Minimum altitude daylight attacks against area targets normally are accomplished in formation. The whole attacking force may assault the objective in a single formation or, when such a maneuver is not suited to the particular situation, the attacking force may be divided into small units, each of which is assigned a specific portion of the area against which to operate. In covering large areas, general destruction and demoralization are of greater importance than accurate fire against particular points within the area. The direction of approach is selected with due consideration of the concealment afforded by irregularities in the terrain, position of the sun, nature of the target, and enemy defensive measures. The direction and velocity of the wind are important factors affecting the utilization of chemical agents in connection with the assault.

■ 111. LINEAR TARGETS.—Linear targets, such as marching columns and motor or railway trains, are attacked either by individual airplanes or small formations in column, formations being used when the width of a single airplane attack is insufficient to attain the desired result. The attacking units approach obliquely, turn, and fly over the objective only during the actual delivery of offensive fire.

■ 112. POINT TARGETS.—The type of sighting equipment and nature of fire used usually determine the minimum altitude at which precision bombing can be accomplished. Minimum altitude attacks against point targets are effected by individual airplanes, unless the size and nature of the target are such as to require the employment of a formation attack. When a number of separate point targets are located within a relatively limited area, the attacking force may fly in formation to the critical area. The individual aircraft then operate singly only during the short interval required for assaulting their respective assigned targets. Smoke may be employed in conjunction with the attack of point targets during daylight, but care must be exercised in order not to obscure the targets themselves in such a manner as to interfere with the effectiveness of the attack.

■ 113. NIGHT OPERATIONS.—*a.* Darkness definitely limits the effectiveness with which low altitude attacks can be accomplished but at the same time interferes with the employment of the active elements of the hostile antiaircraft defense forces. Night attacks at minimum altitude are effected by airplanes operating singly, unless the size and nature of the target are such that formation attacks are required in order to attain the desired results.

b. Enemy activities conducted at night to utilize the security normally afforded by darkness may result in many targets suitable for minimum altitude air attacks being available only during the hours of darkness. Night attacks are resorted to when time is pressing, when effective results can be obtained against objectives not available during daylight, or when the defenses are so strong as to prohibit the assault being launched during daylight without incurring excessive losses.

c. Assaults launched at dawn enable the attacking force to utilize the security afforded by darkness during the advance phase of the operation and may gain a considerable element of surprise. Opportunities for the effective launching of minimum altitude attacks at dusk may occur when enemy preparation for night movement is in process. Darkness is utilized for the return phase of the operation after an assault at dusk. This may prevent hostile aircraft from tracking the attacking force to its airdromes. Darkness is the principal security factor for aircraft engaged in minimum altitude assaults at night.

■ 114. Illumination of Targets.—Since it is essential that the attacking force be able to see the target, artificial illumination frequently is required during night operations. At night, initial illumination of the target may be provided by observation or reconnaissance units operating in support of minimum altitude bombing. When successive assault waves are used at night, the successive individual airplane attacks can be so timed that each airplane after completing its assault can climb to a suitable altitude and drop a flare to illuminate the target for the succeeding airplane.

■ 115. Coordination of Night Attacks.—When an area target is attacked at night by means of coordinated assaults by two or more separate attacking forces operating at minimum altitude, each unit force is assigned a definite zone in which to operate. Coordination of the attack as a whole is obtained by having the unit forces operate in accordance with a time schedule. When minimum altitude assaults are launched at night in support of high altitude operations, coordination is obtained by means of a time schedule which must be accurately followed by both supported and supporting forces in order to secure the most effective results.

■ 116. Neutralization of Antiaircraft Artillery at Night.—Minimum altitude night attacks in support of high altitude operations normally are directed against the searchlights of the opposing antiaircraft artillery. In rendering such support it is necessary to destroy or neutralize only those searchlights which serve gun batteries so located as to be able to deliver effective fire into the sector of approach of the high altitude attacking force.

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CHAPTER 4

AIR ATTACK PLANNING AND OPERATIONS

SECTION I

PLANS AND PLANNING

■ 117. GENERAL.—This chapter includes a discussion of technique applicable to the successful accomplishment of the assault phase of the bombardment mission. The technique of air attack must be suited to the conditions under which the mission is performed in order to insure the most effective utilization of the force employed and to minimize the losses resulting from enemy opposition. The method best suited for use in any particular situation can be determined only after consideration of the factors affecting the success of the mission.

■ 118. PLANS.—Plans for bombardment operations can be formulated only after due consideration of all probable and possible contingencies which may arise during the conduct of the mission. By such planning the possibility of encountering unforeseen circumstances is reduced to a minimum. Thorough understanding of the plan of the combat commander by all elements of the command is important to the successful accomplishment of bombardment missions. It is desirable that plans of operations are given in requisite detail for all phases not covered by indoctrination; also that they are as simple as the situation permits.

■ 119. ALTERNATIVE PLANS.—*a*. Plans should be prepared for attacks against alternate objectives when targets cannot be attacked in the order of priority established in combat orders. A commander may be unable to operate against objectives in the order of their assigned priority because of adverse weather or other conditions which would expose his command to unjustifiable risks not foreseen by the higher commander. In such a case, the combat commander is justified in the attack of objectives of a lower priority. These will normally be secondary objectives which, because of their being undefended or lightly defended, require no complex scheme of maneuver for their attack.

b. When a combat commander while proceeding on another mission unexpectedly gains contact with a fleeting objective not covered by instructions, he must use his initiative and judgment in deciding the proper course of action. In reaching a decision, he must consider the nature and importance of his mission, security of his command, importance of the fleeting objective, the likelihood of its destruction by other forces, and adequacy of the fire that he is able to deliver.

■ 120. INFORMATION REQUIRED.—The effectiveness of the operations plan is largely dependent upon the completeness and accuracy of the information available. Information pertinent to the planning of bombardment operations may be considered under three categories: information of the objectives; information of the enemy activities; and information of pertinent weather conditions.

■ 121. INFORMATION OF OBJECTIVES.—Much information of fixed objectives will be obtainable initially from pertinent objective folders which normally are made available to the commander charged with the preparation of plans for air attack missions. Information of transient objectives will be accumulated and filed in objective folders after the commencement of active operations. In many situations the available information of fleeting objectives will not be sufficient for the preparation of complete plans for their attack. In such situations, indoctrination and training must be depended upon to exploit favorable opportunities for effective operations against the fleeting objectives.

■ 122. ASSIGNMENT OF OBJECTIVES.—Objectives for air attack are assigned in combat orders. Orders assigning objectives in the order of their importance will establish an operating priority. Whenever possible, a sufficient number of objectives should be assigned to each unit to permit the selection of alternate targets in the event that unforeseen conditions prevent the attack of objectives in the order established in the operating priority. Fleeting objectives when given precedence over other assigned objectives should be designated in relative order of importance.

■ 123. Initiative.—The bombardment commander, by selecting a time of attack and altitude which are least favorable to the defender, can gain an initial advantage. The defender cannot be equally strong on all points; hence, a wise selection of bombardment objectives, in conjunction with the most advantageous times and altitudes at which to deliver the assault, is an important factor in the successful penetration of antiaircraft defenses. However, once hostile pursuit effects interception, the initiative passes. The action of the enemy will determine the time to engage and withdraw as well as the direction and number of assaults.

■ 124. Nature of Targets.—A target is the space within which fire must be placed to accomplish the desired result. The objective and the target are one and the same when the entire objective is vulnerable and direct hits are required. The target may be larger than the objective if hits nearby are effective, smaller if hits are effective only on certain parts of the objective. An airdrome is an example of an area target; a bridge, that of a point target.

■ 125. Information of Enemy.—It is important that all possible information be available of the location, strength, and composition of such enemy forces as may affect the conduct of the mission. Knowledge of the performance characteristics of hostile fighting aircraft and of the enemy's air fighting tactics is an important factor of information. The objectives of bombardment attacks frequently will be located deep in enemy territory, and all hostile forces which may be encountered, whether en route or in the vicinity of the objective, must be considered when plans for the attack are prepared. In planning a bombardment attack, every effort must be made to avoid exposing the command to unnecessary risk of hostile interference.

■ 126. INFLUENCE OF WEATHER CONDITIONS.—*a*. Weather conditions should be regarded not only as possible obstacles to be overcome in the conduct of a mission or of an air offensive, but also as a varying situation the most favorable aspects of which should be selected to render the maximum assistance to the attacking force. From this point of view there are three general uses of weather advices:

(1) When an air offensive is being planned, summaries of climatic conditions in the theater of operations should be consulted by the planning agency to ascertain the probable weather in which operations will have to be conducted, and to plan, in general, the method of operation which will utilize to a maximum the favorable aspects of such weather conditions. At this phase of the planning, expected weather conditions will influence the choice of aircraft employed, location of operating bases, frequency of contemplated missions, and other general factors.

(2) Higher commanders will require forecasts of weather conditions over definite areas and routes for periods up to 36 or 48 hours in advance of the issuance of orders for specific missions.

(3) Shorter range forecasts should be made available for subordinate commanders. Detailed plans for the missions should be prepared in accordance with expected weather conditions. Furthermore, the air leaders should be so thoroughly conversant not only with expected weather developments, but also with the possible variations therefrom that may occur, that plans may be intelligently modified in the air, in order to utilize to the maximum the assistance available from the weather situations existent during the period of conduct of the mission. Details of the commander's plan, influenced by weather conditions, include the determination of the force required for the mission, time of attack or assembly, routes and formation to be flown, method, altitude, and axis of attack, need for a rally, and selection of secondary objectives.

b. Even with the most careful consideration of the influence of weather conditions on the conduct of the attack, completely unanticipated weather situations may arise, necessitating changes in the manner of performance of the mission. Through indoctrination and training of all echelons, tactical units must be prepared to take appropriate action in unpredictable situations.

■ 127. COMMUNICATION.—The manner and effectiveness of tactical control of the combat command depend to a considerable extent upon the nature and reliability of the means of communication employed. Adequate means of communication are essential in operations involving tactical control during the conduct of a bombardment mission, and this factor must be carefully considered when plans are formulated. The use of radio, particularly when deep in enemy territory, may disclose the position of the combat command; hence the employment of this means of communication should be held to a minimum when there is danger of facilitating interception by hostile aircraft.

■ 128. ATTACKING FORCE.—The plan of operations must not call for the accomplishments of results which are beyond the capabilities of the force available. The size of the force required to accomplish a particular mission depends upon the requirements of the mission, skill and training of available tactical units, and nature and effectiveness of hostile antiaircraft defense measures. The size of the force to be employed is left to the judgment of the combat commander whenever practicable.

■ 129. CONCURRENT AIR OPERATIONS.—Team play and coordination are essential to the attainment of maximum results in the conduct of bombardment operations. It is important that all of the air activities in the air theater of operations be so coordinated that the bombardment operations, as a whole, properly fit into the general plan of employment for the aviation forces. The best results cannot be expected from an uncoordinated aggregate of unrelated assaults, even though each such assault may have gained a measure of success in its own locality. When several important objectives or groups of objectives are to be attacked, a considerable degree of security for the attacking forces may be gained by having separate air attack operations conducted concurrently. Security from the hostile air fighting forces is obtained by this simultaneous employment, because it is impossible for the defender to engage the attacker simultaneously at every point with his full strength.

■ 130. COORDINATION OF SUPPORT.—*a.* (1) The supported unit is the basis for the establishment of coordination in bombardment operations. The details necessary for securing coordination of the supporting operations should, whenever practicable, be left to the commander of the supported force. When coordinating details are prescribed by higher authority, the nature of such details is determined primarily by the ability of the supported force to meet the requirements thus imposed. Higher authority may make provision for coordination of the support by the following methods:

(*a*) Attachment of supporting units.

(*b*) Designation of supporting units and their general missions; prescribing necessary measures for coordination; or directing the supported command to prescribe the additional details required.

(*c*) Organization of task forces for a series of coordinated missions.

(2) The time of attack is not designated by higher authority for the purpose of securing coordination, unless no other means of effecting coordination is practicable.

b. The commander of the supported force normally issues necessary instructions to such supporting units as are attached to his command. The instructions include such details of the plan of action as are necessary to secure coordinated support and are issued in time to permit proper planning by the supporting units. The commander avoids committing himself to an inflexible plan of action unless such a course is definitely warranted by the situation.

c. When a time of attack is specified for the purpose of effecting coordination of the support, the time usually is selected by the commander of the supported force either before take-off or as soon as possible during the advance to the initial point. The time of attack should be selected as early as practicable, but not before it becomes apparent that the announced time is practicable.

d. When the operation involves a supporting attack and the time of attack is to be determined after take-off, the support force assembles with and guides on the supported force, keeping within such distance as will assure the continuous maintenance of signal communication. When the time of attack has been signaled, the supporting force takes such action as is required to protect the attacking force during the assault. When the time of attack is announced before take-off and assembly with the supported force is not practicable or desirable, the commander of the supporting force selects his routes and conducts the mission in a manner that will insure the protection of the supported force during the assault.

e. When the advance only is made during darkness, the supporting force assembles with the supported force at dawn, when practicable, in order to insure coordination at the objective. When the attack is made during darkness, the time of attack must be announced before take-off, unless conditions permit maintenance of signal communication, accurate navigation, and fixation of position during the advance. When required, coordination of supporting operations at night usually can be effected by both supported and supporting forces working by a predetermined time schedule.

f. The attacking force furnishes such auxiliary support of its own operations as is consistent with the effective utilization of the force. When auxiliary support is furnished for guidance during the advance or for illumination of the objective, the commander of the supported force prescribes all details that are essential for coordination.

SECTION II

BOMBING PROBABILITIES

■ 131. GENERAL.—The bombardment commander, in order to utilize his force most effectively, requires information which will enable him to estimate the minimum force required for the accomplishment of any particular bombardment task. The accuracy of aerial bombing is affected by a great many factors, the more important of which must be taken into account in the solution of problems in bombing probabilities. Bombing probabilities are not susceptible of exact mathematical determination. Tables are available, however, whereby a bombardment commander may, by the application of his knowledge of the performance of his particular organization, estimate the requirements for the successful accomplishment of bombardment missions. Such tables, together with type problems illustrating their use, are included in this section.

■ 132. HITS REQUIRED.—After selection of the proper size of bomb to use against a particular objective, it is necessary to determine the number of hits required to produce the desired degree of destruction. The information furnished in the objective folder should be adequate for this purpose. A large proportion of individual bombardment objectives may be destroyed if hit by one properly selected size of bomb. Objectives including numerous structures or elements may sometimes be appropriately divided and so assigned that if each element is hit by one bomb of proper size its destruction will be complete. Certain structures or facilities may require a number of hits, all of which must be sighted at a single aiming point or target. Still others will require a uniform pattern of hits over a given area. These factors must be considered in the planning to determine the number of effectively placed bombs required to complete the mission with the required degree of assurance of success.

■ 133. SIZE OF FORCE.—It is necessary to determine the size of the force which must be employed on the mission to assure a reasonable chance of obtaining the required number of hits under the prevailing conditions. Economy of force dictates the dispatch of the smallest practicable number of airplanes. On the other hand, the chance of successfully accomplishing the assigned mission increases with the size of the force dispatched, and this consideration indicates the dispatch of ample force. The effect of antiaircraft opposition, obviously, will not be accurately predictable at the beginning of any war nor at the beginning of any missions. Any factor applied to allow for action of the enemy should be applied after a careful estimate of the strength required at the bomb release line based upon the characteristics of the target and upon the established record of probable errors of the units which are to do the bombing. These are tangible factors and when properly deduced should be employed to the fullest extent. The invariable use of his entire force by a commander, whatever the mission assigned, in order to be most certain of success is normally unsound.

■ 134. SKILL OF PERSONNEL.—The skill of bombardment personnel can best be ascertained from the recorded results attained by them in bombing practice. It is important that bombardment commanders, particularly squadron and group commanders, have accurate records of the results attained by their bombing teams under various conditions of practice simulating, as nearly as practicable, the conditions expected to be encountered during war. Such records provide the best means of estimating the accuracy factor to be applied in the determination of bombing probabilities.

■ 135. BOMBING ERRORS.—*a*. Errors in bombing as used for measuring results and for making predictions of future results are defined as the distances by which bombs (or the mean point of impact of patterns of bombs) miss the center of the target at which they are aimed. The range error is measured parallel to the direction of the bombing approach; the deflection error, perpendicular to the direction of approach; and the circular error is measured on a radial straight line connecting the point of impact with the center of the target.

b. Errors in bombing result from many causes, some determinate, many indeterminate in extent. Some errors are systematic in nature, others accidental. For purposes of study to improve bombing accuracy, the extent and sources of systematic errors are sought in order to remove their several causes, whether said causes are defects of instruments, equipment, data, technique, training, or other source of inaccuracy.

■ 136. AVERAGE ERRORS.—*a*. Tables of average errors are the foundation upon which predictions can be calculated for the success of operations under similar conditions. The process which is involved in the determination of the probabilities of success, or of a certain percentage degree of success of a given mission, except for the tables of average errors (and aside from antiaircraft opposition), is mathematically sound.

b. The smaller the average error of a given individual bombardier, bombing team, or organization, the greater will be the chance of success on a bombing mission similar in nature to the type on which that small average error was attained. Average errors are of little value unless the number of releases which enter into those averages is relatively large and each is properly evaluated. All results of the droppings of bombs cannot be grouped into one single set of figures to form a single average. Experience has shown the necessity of separate averages of errors for bombing at the several different altitudes used by bombardment aviation. It has been found, therefore, to be a necessary step in the proper training of individuals, bombing teams, and organizations to maintain tables of average errors for each such individual, bombing team, or unit for various bombing altitudes.

c. The results of each practice, after analysis, should be added to the cumulative result of previous similar practices. Analysis of each practice is necessary in order that errors may be properly evaluated in accordance with conditions. It is appropriate in the establishment of averages of this type to discard or eliminate from the summation a proportion of the earlier data accumulated. This may occur because earlier data have become inconsistent with the results obtained after more thorough or advanced training, or those attained by the use of more modern or accurate equipment. This can probably best be done on an annual training year basis and should be done only as prescribed from time to time.

d. An organization commander should be able at any time to make a relatively correct estimate of the results of bombardment missions of a given type to be expected by any bombing team, or element of his organization, through calculations based upon properly maintained tables of average errors for all conditions for which such predictions may be necessary.

■ 137. PROBABLE ERRORS IN BOMBING.—Probable errors as used in connection with probabilities of hits in bombing are those errors which are as apt to be exceeded as not. Probable error has a simple arithmetic relation to the average error obtained under a given set of conditions by a given individual. The relationship gives an approximate value of probable error that is close to the correct value if the average error used is based upon a reasonable number (50 or more) of releases made under the given set of conditions.

■ 138. RELATIONSHIP OF PROBABLE ERRORS TO AVERAGE ERROR.—*a.* Having the recorded average errors of his command, the commander can prepare a table of probable errors for his unit by the application of the following mathematical relationship between probable errors and average errors:

Range probable error (Rep)	=0.845 times the arithmetic mean range error (0.845 Rea).
Deflection probable error (Dep)	=0.845 times the arithmetic mean deflection error (0.845 Dea).
Circular probable error (Cep)	=0.939 times the arithmetic means circular error (0.939 Cea).

$$\text{Cep}=1.746\sqrt{\text{Rep x Dep}}$$

b. The probable errors shown in table V are representative of results actually attained in the dropping of a large number of bombs. These values are included for convenience in solving illustrative problems and are not necessarily representative of either present or expected future bombing results.

c. Probable errors for use in planning bombardment missions should be computed from results actually obtained by the bombing team or unit in question under comparable conditions of bombing. No single table of probable errors is suitable for use under all possible conditions of bombing.

■ 139. VULNERABILITY FACTORS.—*a.* The probable errors of individual teams or bombardment units are best expressed in feet and are measured from the center of the target. The likelihood of hitting a particular target depends upon the probable error and the size of the target. Thus, if the range dimension of a target is equal to twice the probable error in range, and the range error of the point of impact of a given bomb does not exceed its probable error either short or over, then a hit, as far as range is concerned, is obtained within the vulnerable limits of either the near or far half of the target. The same reasoning applies to a hit, as far as deflection is concerned.

b. (1) Figure 10 shows the relation of target dimensions to probable errors and the physical meaning and application of the term "probability factor."

(2) The target is represented by the rectangle ABCD, any part of which is vulnerable. BC is the vulnerable dimension in the range direction, and AB is the vulnerable dimension in the deflection direction. Hence BF is one half the vulnerable range dimension, ½ RDT; and EB is one half the vulnerable deflection dimension of the target, ½ DDT, BF and EB are the allowable errors, the errors to either side of the aiming point which cannot be exceeded without missing the target.

TABLE V.—*Probable errors*

Altitude	Range probable error (Rep)	Deflection probable error (Dep)	Circular probable error (Cep)
Feet	*Feet*	*Feet*	*Feet*
1,000	47	36	72
2,000	47	44	78
3,000	48	50	86
4,000	49	58	96
5,000	52	66	105
6,000	55	75	116
7,000	60	83	129
8,000	65	91	142
9,000	71	100	157
10,000	80	109	173
11,000	88	119	189
12,000	96	130	207
13,000	107	141	225
14,000	118	153	245
15,000	130	168	266
16,000	142	182	287
17,000	155	198	311
18,000	170	215	336
19,000	186	233	362
20,000	201	250	392

(3) The values NT and SN are, respectively, the range (Rep) and deflection (Dep) probable errors. The strip between MN and PO, if extended to infinity both to right and left, would contain one half of the bombs dropped. The strip

between MP and NO if similarly extended would also contain one half of the bombs dropped.

(4) If BF and NT are equal, that is to say if one half the range dimension (½ RDT) of the target equals the probable error, any bomb dropped has a 50-50 chance of hitting the target insofar as range is concerned. It is obvious that if the value of BF is greater than that of NT there is a greater than 50 percent degree of certainty of hits as far as range is concerned. Since BF and NT are seldom equal it is necessary to provide a means of evaluating the chance of hitting the target for any ratio of those values. The ratio of those values is called the vulnerability factor for range. Similarly the ratio EB to SN is the vulnerability factor for deflection.

c. (1) Thus the vulnerability factor in range equals one half the range dimension of the target divided by the probable error in range:

$$\text{Vulnerability factor in range} = \frac{\frac{1}{2}\ \text{RDT}}{\text{Rep}}$$

in which RDT represents the range dimension of the vulnerable part of the target.

(2) The vulnerability factor in deflection equals one half the deflection dimension of the target divided by the probable error in deflection:

$$\text{Vulnerability factor in deflection} = \frac{\frac{1}{2}\ \text{DDT}}{\text{Rep}}$$

in which DDT represents the deflection dimension of the vulnerable part of the target.

d. Similarly, the vulnerability factor for circular targets equals the radius of the vulnerable part of the target divided by the circular (or radial) probable error:

$$\text{Circular Vulnerability factor} = \frac{\text{RCT}}{\text{Cep}}$$

in which RCT represents the radius of the vulnerable portion of the circular target.

■ 140. Probabilities of Hits.—Corresponding to each deflection or range vulnerability factor there is a percentage of chance of a hit insofar as that direction is concerned. When using rectangular errors, separate probabilities must be found for a hit with respect to range and for a hit with respect to deflection. The product of those two values gives the probability of the concurrences of the two events—thus, of a hit on the target. When using circular errors and circular targets, a single value—which is the probability of a hit on the target—may be ascertained from the single ratio, the circular vulnerability factor.

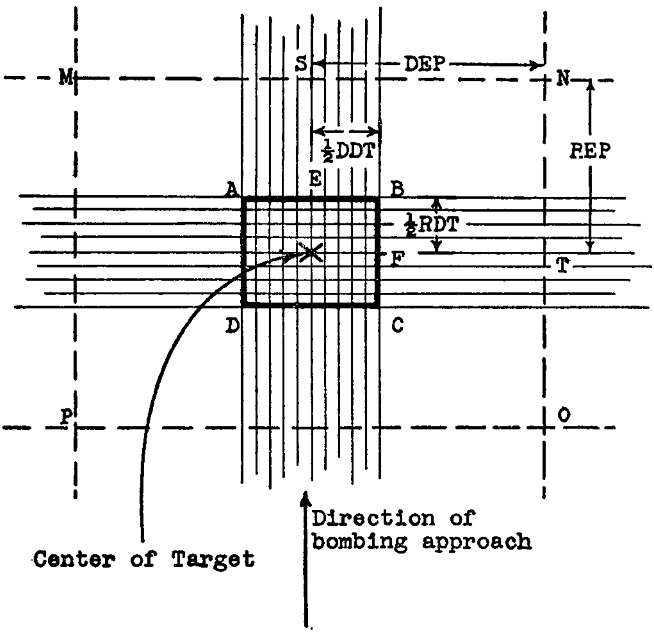

FIGURE 10.—Relation of target dimensions to probable errors.

■ 141. VULNERABILITY FACTORS AND PROBABILITIES.—Probabilities corresponding to known vulnerability factors up to a value of 6 are contained in tabular form in table VI and in graph form in chart No. 1. Having determined the vulnerability factor pertinent to the conditions under which bombing is to be done, the probability of the independent event of a hit in range or in deflection may be read off directly from either table VI or the curve of chart No. 1.

■ 142. SINGLE SHOT PROBABILITY.—The probabilities determined from table VI or from chart No. 1, as described in paragraph 141, are, respectively, the range single shot probability (RSSP) and the deflection single shot probability (DSSP) of hits with respect to those axes of the target, separately considered. The combined (range and deflection) single shot probability (SSP) is the product of RSSP multiplied by DSSP. A hit by a single shot is not possible except by the concurrence of the two events, a hit in range and a hit in deflection. For convenience and simplicity the "combined range and deflection single shot probability of a hit" will hereafter be referred to as the "single shot probability." The single shot probability of a hit on a circular target, using a known vulnerability factor, may be read directly on the curve of chart No. 2.

■ 143. BOMBS REQUIRED.—The single shot probability (SSP), determined as outlined above, is the basis for the calculation of the number of individually sighted (or aimed) bombs required to provide a certain percentage degree of assurance of securing one hit and/or the number of bombs required to provide a certain percentage degree of assurance of securing at least a given number of hits. The SSP does not indicate the percentage of hits to be expected from a given number of bombs. Curves showing the number of bombs required to give a predetermined chance (50 percent–99.5 percent) of one or more hits under various conditions of bombing are contained in chart No. 3. Charts Nos. 4 to 9, inclusive, show the number of individually sighted and released bombs required for a predetermined chance (50 percent–99.5 percent) of securing one or more, two or more, and up to ten or more hits. The percentage chance of obtaining at least one hit with from 1 to 10 bombs can be read directly from the curve of chart No. 10.

■ 144. TRAIN BOMBING PROBABILITIES.—*a. General.*—Train bombing is the release of two or more bombs in succession from the same airplane by a single sighting operation with an exact interval between the bombs. The important feature is that the distance between adjacent points of impact must be less than the vulnerable range dimension of the target in order not to bracket the target with any two adjacent bombs. This is accomplished by setting the calculated time interval on the release mechanism and should be obtained within the limits of average errors due to ballistic and other causes.

b. Line of attack.—The direction of approach and the line of attack or ground track of the airplane during the final part of approach and bomb release should be selected to assure the greatest probability of a hit, other conditions permitting. The sighting operation should attempt to put the center of impact of the bomb train on the center of the target. In the selection of the line of attack, the following points should be considered:

(1) The allowable error in range equals one half the vulnerable range dimension of the target plus one half the length of the bomb train.

(2) The range probable error of the center of impact of the train is the same as for an individually sighted bomb and should be so used in calculations.

(3) The probable error in deflection is the same as for an individually sighted bomb.

(4) The relative values of range and deflection probable errors of the particular bombing team will influence the direction of approach to elongated objectives. (See par. 189.)

c. Probability of hit.—Taking advantage of the fact that the allowable error in range is increased by one half the length of the train, the smaller dimension may be used as the range direction with a consequent greater increase in the probability of a hit than if this smaller dimension was used as the deflection dimension. Calculations of the probability of a hit by a single train should be made as explained above for an individually sighted and released bomb. The center of impact of the train should be considered as though it was the point of impact of a single bomb and increasing the allowable range error by one half the length of the train in the calculation. This, of course, will be the probability of a single hit by the train if the spacing between bombs is equal to or only slightly less than the vulnerable range dimension of the target.

■ 145. FORMATION OR PATTERN BOMBING PROBABILITIES.—*a. General.*—(1) A maneuvering target which makes a material change of speed or direction during the time of fall of a bomb will not be hit (except by chance) by a bomb which is accurately aimed at that target and released from a high altitude. Unless it is possible to predict those changes, the target cannot be expected to be hit, from high altitude, by an accurately aimed and delivered single bomb. Against such targets pattern bombing may be necessary. Against stationary targets such as railroad yards, oil tank farms, and, in some cases, airdromes, it is desired to place a great number of bombs with uniform distribution within a certain area. Point targets may be bombed from formation when the action of hostile pursuit aviation demands it. Many combinations may be used, and experience, practice, and established records of results must be depended upon to assist a commander in his decision as to how best to meet each condition.

(2) Bombs can be released individually or in train at varying time intervals. Airplanes may be flown individually or in large or small formations. The formations may be echeloned in depth, width, or altitude. The numerous combinations of these factors are sufficient to fit any pattern to any target. Only training and practice within each unit can determine which of these combinations is best suited to the several types of targets requiring pattern bombing, and the reliability with which a given pattern may be produced and duplicated by the tactical unit. The method of establishing reliability with which a given pattern may be produced and of placement is similar to the method of establishing reliable individual average errors.

b. Probability of hits.—(1) *General.*—The use of pattern dimensions to increase the allowable error of placement of the center of impact presupposes that the unit has had sufficient training and practice to have established reasonably reliable "average dimensions" for that type of pattern.

(2) *Area pattern probabilities.*—(*a*) The probability that any one bombing formation volley will result in geometric, uniform distribution is remote. It is equally true that distribution approaches geometric uniformity as the number of volleys dropped on a target approaches infinity. There are no

available data from which to determine the probability of "holes" in the pattern occurring in any one volley. Reliable results from training and practice must be depended upon to provide a measure of pattern size, shape, density, uniformity, and the degree of accuracy of placement thereof.

(*b*) Training and practice should include the several types of formations with various adjustments as to intervals and distances between airplanes, and with individual and train releases from each airplane. Types of sighting operation should include principal sighting operation by the leading bombing team, other bombardiers releasing on their own range sightings. Some method should be practiced involving a plan of convergence of airplanes while approaching the bomb release line, in such manner that each bombing team can perform its own complete sighting operation.

(3) *Train bombing from formation.*—The pattern produced by train release from a single airplane may not be sufficiently wide to secure a required probability of a hit on a point target. It may be desirable for tactical reasons to meet this requirement by use of several airplanes in formation, particularly to widen the pattern. Increased intervals between airplanes in formation or more airplanes may be used to widen the pattern within limits and with due caution against "holes" in the pattern. In calculating the probability of a hit, the allowable errors may be increased by one half the average dimensions, in range and deflection, of type patterns for which reliable averages have been attained by the unit.

(4) *Density of pattern.*—The density or number of points of impact per unit area, within the pattern produced by single bombs released simultaneously by the airplanes of a formation (bombing formation volley), may be increased by closing the formation to a more compact one, or by increasing the number of bombs to be released in train within a given time from each airplane of the formation. The probabilities of covering a target with a pattern are obviously greater when the size of the pattern is increased. The practical limitations of decreased density, probable lack of uniformity, or excessive numbers of bombs required must be balanced against the advantages of increased size of the pattern.

■ 146. **Bombing Probability Calculations.**—The calculations of bombing probabilities in accordance with the mathematical law of errors is a long and tedious task if a broad scope of conditions is to be covered. The curves shown on charts Nos. 3 to 9, inclusive, enable the bombardment commander to solve a wide variety of bombing problems with a minimum of mathematical computations. Having a knowledge of the capabilities of his unit and information of the objective and of the conditions under which the bombing is to be accomplished, he can then complete his solution by means of the curves on those charts.

■ 147. **Illustrative Problems.**—There are included here four typical bombing problems and their solutions. Familiarity with the use of the curves in the solution of problems can be acquired from a study of these problems. Additional problems should be devised and solved as a matter of training.

■ 148. **Problem No. 1.**—*a. Factors.*—It is urgent that a very important building be destroyed. The bombardment commander is ordered to destroy the objective with the least possible delay. His objective folder and other sources of data contain the information that the objective is 800 feet long and 300 feet wide; that it is defended by antiaircraft machine guns and 37-mm caliber cannon; that 100-pound bombs with delay fuzes will destroy the objective; and that eight direct hits are required for complete destruction.

b. Decision as to required chance of success.—He decides that the urgency of the situation and other tactical considerations demand that he take no less than 90 percent chance of success of accomplishing his mission in one operation.

c. Decision as to altitude.—The effectiveness of the antiaircraft defense of this particular target and other considerations cause him to decide that he will bomb from no lower than 8,000 feet.

d. Decision as to target dimensions.—His target in this case is the objective itself. He is required to obtain direct hits. Bombs striking within a few feet alongside the building may undermine walls, but the danger radius of these small bombs is so short that the dimensions of the target are substantially the same as the dimensions of the objective, i. e., 800 by 300 feet.

e. Decision as to direction of approach.—The directive from higher authority did not specify direction of approach. Study of objective folder indicates no controlling factor such as known or expected location of batteries of the antiaircraft defense guns. The commander considers the probable errors of his unit in range and deflection. Assume these to be as shown in table V. The range probable error is the smaller so his decision is to approach the bomb release line on a direction parallel to the shorter target dimension.

(For solution, see par. 152.)

■ 149. PROBLEM NO. 2.—A bombardment group commander is directed to attack and destroy section of a canal lock structure. Details of its location and antiaircraft defenses are furnished. Vulnerable dimensions are 100 by 800 feet. A direct hit is required. On the basis of the directive and study of the details furnished, the commander makes the following decisions and applies them to a solution of the force required:

a. Degree of certainty of one or more hits—90 percent.

b. Altitude to be used—16,000 feet.

c. Size of bomb to be used—2,000-pound.

d. Number of hits required—one.

e. To attack the structure at approximately 90° to its long dimension.

f. To drop one individually sighted bomb by each airplane on its arrival at the bomb release line.

(For solution, see par. 152.)

■ 150. PROBLEM NO. 3.—*a.* A bombardment group commander is directed to attack and destroy an enemy light cruiser which is being used as a commerce raider. The dimensions of the vulnerable area of the objective, including danger radius at sides and stern (table IV), are 130 feet in width and 610 feet in length. The target is free to maneuver. It has normal antiaircraft artillery.

b. It will be attacked in the manner indicated by figure 15. The force required will be estimated on the basis of formations (flights of three planes each) required if attack is along the axis of travel of the target considering no maneuver on the part of the target. Right and left wing flights will then be added to guard against failure of the mission because of target maneuver.

c. Four 600-pound bombs will be carried by each airplane. Bombs of each airplane will be released in train with spacing of 100 feet between adjacent bombs. The pattern width for each flight is 150 feet.

(For solution, see par. 152.)

■ 151. PROBLEM No. 4.—*a*. A bombardment group commander has been given the mission of destroying a bridge which is vital to the communication of the enemy. Heavy troop movements are in progress over the bridge. It is now defended by antiaircraft machine guns and there is some pursuit aviation defense of the area including the bridge. Antiaircraft artillery cannot be expected to be installed for about 24 hours. Details of the bridge are furnished and indicate the critical point of attack to be a pier whose vulnerable dimensions are 50 by 50 feet. These dimensions include the danger radius in all directions with respect to the pier and a vital part of the structure adjacent to the pier. One hit with a 600-pound bomb within the vital area will suffice to destroy the usefulness of the bridge.

b. On the basis of the directive and study of the details furnished, the commander makes the following decisions in the solution of the force required:

(1) Degree of certainty of one or more hits—90 percent.

(2) Altitude to be used—6,000 feet.

(3) Size of bomb to be used—600-pound.

(4) Number of hits required—one.

(5) To attack the structure in a direction perpendicular to the direction of the bridge at the pier.

(6) To attack with a formation of whatever size required in order to provide defense against probable pursuit interference.

(7) To require bombing team in leading airplane to direct the approach to the target.

(8) To specify the order in which other bombing teams will take the lead in case of casualties to leaders. All bombardiers to drop their bombs on their own range sighting.

(9) In order to limit the number of approaches to the target to one, each bombardier is to release 6 bombs in train, with a time interval to give 40 feet between adjacent points of impact.

c. From training and practice the commander has the following information regarding the capabilities of his bombing teams and units:

(1) Average range probable errors are as in table V.

(2) Average deflection probable errors are as in table V.

(3) Average pattern width, stagger formation (squadron), with uniform distribution is here considered to be 320 feet.

(4) Bombardier and bombing team average errors are substantially the same, and each is fully capable of directing the approach of the formation to the target.

(For solution, see par. 152.)

■ 152. SOLUTIONS OF PROBLEMS.—The solutions of illustrative problems Nos. 1 to 4, inclusive, itemized and tabulated for convenience of reference, are included in table VII.

TABLE VII

Item	Problem No. 1	Problem No. 2	Problem No. 3	Problem No. 4
		Value		
(1) Command (or tactical) decision as to percentage degree of assurance of success	90	90	90	90
(2) Command (or tactical) decision as to altitude to be used. (Ft.)	8,000	16,000	16,000	6,000
(3) Size of bomb to be used. (Usually specified in objective data.) (Lbs.)	100	2,000	600	600
(4) Number of hits required. (Usually specified in objective folder for point targets.)	8	1	1	1
(5) Range probable error (Rep). (For altitude selected and for individual or unit to do the bombing.) (Ft.) (Table V.)	65	142	142	55
(6) Deflection probable error (Dep). (For altitude selected and for individual or unit to do the bombing.) (Ft.) (Table V.)	91	182	182	75
(7) ½RDT. (One half of vulnerable range dimension of target. Involves command (or tactical) decision as to direction of approach, and the addition of ½ length of train to ½ RDT for train bombing, or of ½ range dimension of average pattern to ½ RDT for pattern bombing.) (Ft.)	150	50	455	125

TABLE VII—Continued

Item	Problem No. 1	Problem No. 2	Problem No. 3	Problem No. 4
	Value			
(8) ½DDT. (One half of vulnerable deflection dimension of target. Involves command (or tactical) decision as to direction of approach, and addition of ½ deflection dimension of average pattern to ½DDT for pattern bombing.) (Ft.)	400	400	140	185
(9) Vulnerability factor in range. (Item (7) divided by item (5).)	2.31	.352	3.2	2.272
(10) Vulnerability factor in deflection. (Item (8) divided by item (6).)	4.4	2.198	.77	2.468
(11) Range single shot probability. (From table VI or from chart No. 1 for factor shown as item (9).)	.88	.188	.97	.875
(12) Deflection single shot probability. (From table VI or from chart No. 1 for factor shown as item (10).)	.99	.862	.395	.904
(13) SSP (single shot probability). (Item (11) multiplied by item (12).)	.87	.162	.383	.791
(By use of charts)				
(14) Number of individually sighted and released bombs required for percentage degree of certainty, item (1), of at least the required hits, with SSP of item (13)	10	13	(1)	(1)
Procedure: Select chart showing certainty of success specified in item (1), find coordinate of calculated SSP, item (13), follow horizontally (if using any one of charts Nos. 3 to 9, incl.) to intersection with curve of required number of hits, then follow vertically to index to read number of bombs required.				
(15) Number of individually sighted trains of bombs for required percentage degree of certainty of at least *one* hit. Involves decision as to number of bombs in train and spacing desired between points of impact. (Use charts as though the train were an individually sighted bomb.)	(1)	(1)	(1)	(1)

[1] Not applicable to these problems.

TABLE VII—Continued

Item	Problem No. 1	Problem No. 2	Problem No. 3	Problem No. 4
		Value		
(16) Total number of bombs required by item (15)	(1)	(1)	(1)	(1)
(17) Number of individually sighted trains for required percentage degree of certainty of "a given number or more" hits	(1)	(1)	(1)	(1)
(18) Number of bombs required by item (17)	(1)	(1)	(1)	(1)
(19) Number of patterns, sighted to place center of impact of average pattern on center of target, for required percentage degree of certainty of at least *one* hit. (Use charts as though the pattern was an individually sighted bomb.)	(1)	(1)	5	(1.5 or) 2
(20) Total number of bombs required by item (19)	(1)	(1)	60 [2]	108

[1] Not applicable to these problems.
[2] See also paragraph 153*c*.

■ 153. RESULTS.—*a. Problem No. 1.*—The bombardment commander finds that he must be prepared to drop not less than 10 bombs to be assured a 90 percent probability of securing the 8 hits required to accomplish this mission.

b. Problem No. 2.—The commander finds it necessary to drop 13 bombs under the conditions imposed. (It should be noted in connection with this illustration that a 50 percent probability of at least 1 hit could be attained with 4 bombs.)

c. Problem No. 3.—The commander finds it necessary to use 5 patterns using trains of 4 bombs from each of 3 airplanes or a total of 60 bombs. If bombs of both right and left wing flights are dropped because of target maneuver the total bombs expended will be 180.

d. Problem No. 4.—The commander finds it necessary to use (1.5 or) 2 patterns. Thus 2 squadrons of 9 planes each, releasing 6 bombs in train from each airplane, a total of 108 bombs, will provide a 96 percent chance of 1 hit. (See chart

No. 10, on which a single shot probability of .791 shows a 96 percent chance with 2 bombs (patterns). One pattern (54 bombs) provides an 80 percent chance of the one hit required.)

■ 154. ANTIAIRCRAFT OPPOSITION.—The above solutions indicate the numerical requirements in bombs and force to accomplish the missions stated if done under conditions comparable to those under which performance data (probable errors) used were determined. It is at this point in the solution that the judgment of the commander must be applied in estimating the probable effect of hostile antiaircraft measures and the extent to which his force should be augmented to accomplish the mission as planned despite anticipated losses.

SECTION III

MINIMUM ALTITUDE ATTACKS

■ 155. NATURE OF OPERATIONS.—The performance of minimum altitude attacks requires a highly maneuverable airplane, and, in general, only light bombardment and pursuit units engage in this manner of operations. The objectives of minimum altitude attacks frequently are targets of opportunity against which surprise is an important factor in obtaining the most effective results. Minimum altitude attacks habitually are performed at the lowest altitude consistent with security requirements at which it is feasible to operate the aircraft employed. Aircraft intended for use in such operations normally are equipped with forward firing fixed machine guns for the provision of protective covering fire against the defensive fire of hostile ground weapons.

■ 156. BOMBING RELEASES.—Minimum altitude attacks normally are conducted without the use of a precision sight. The release of bombs in train is normal. Release intervals are regulated to provide a bomb spacing which will not be wasteful of bombs and yet insure a continuous danger area throughout the length of the train.

■ 157. MUNITIONS.—The selection of type of fire depends upon the nature of the objective and whether the purpose of the mission is to destroy or to neutralize it. The munitions usually employed in minimum altitude attacks are demolition bombs, fragmentation bombs, chemical bombs, and other chemical agents.

■ 158. MANNER OF ASSAULT.—Minimum altitude attacks usually are accomplished, particularly when surprise can be effected, by aircraft making a single assault. The group is the largest combat command employed on minimum altitude missions. The combat command may be divided into smaller units, each of which is assigned a specific objective or portion of a large area target, whenever the circumstances require such action. Small targets which are clearly visible are most effectively attacked by airplanes assaulting singly. In the presence of hostile pursuit it may be necessary to employ either 3, 6, or 9 airplane assault units in order to provide adequate concentration of defensive fire. The attack of objectives defended by antiaircraft ground weapons is accomplished in one approach by each assault unit whenever practicable.

■ 159. TIME OF ATTACK.—Minimum altitude attacks may be performed either at night or during daylight. Targets of opportunity, incident to enemy troop movements, frequently will exist only during the hours of darkness. The time of attack should, whenever practicable, favor the attacker and surprise the enemy. When the minimum altitude attack is in support of a primary high altitude mission, close cooperation and accurate timing are essential to the most effective results. Liaison with the supported force is maintained by radio whenever practicable, otherwise by a time schedule.

■ 160. DIRECTION OF APPROACH.—The direction of approach is an important factor in the success of minimum altitude attacks. The position of the sun or moon, the terrain in the vicinity of the objective, the nature and extent of the target, also the location, composition, and strength of antiaircraft defense forces, are important factors in determining the most advantageous direction of approach. A down-wind approach facilitates surprise and minimizes the exposure of assault units to antiaircraft fire.

■ 161. AREA TARGETS.—Large areas such as cantonments, bivouac or entraining areas, large transportation parks, railway yards, or airdromes usually are attacked in formation by releasing bombs in trail or spraying chemicals. Large areas, particularly when strongly defended, should be attacked by a force of sufficient strength to cover the entire area in one assault. Large area targets are divided into portions, each of which is assigned as the objective of a separate assault unit.

■ 162. Linear Targets.—Long narrow targets such as troop columns, railway trains, railway tracks, or truck trains are best attacked by small assault units of from one to three airplanes, depending upon the width of the area to be effectively covered. When the objective is defended the assault units approach and depart obliquely, flying in prolongation of their target only during the actual delivery of fire. Very long targets are divided into sections, each of which is assaulted by a separate unit. Assaults are made simultaneously when practicable.

■ 163. Neutralization of Antiaircraft Artillery Defenses.—*a*. Bombardment operations against strongly defended objectives frequently can be given effective support by minimum altitude attacks for the purpose of interfering with or neutralizing the antiaircraft artillery defenses. The attack of such objectives at minimum altitudes may be required in support of both daylight and night operations.

b. Antiaircraft gun batteries are difficult targets because they are small, usually widely scattered, and are easily moved. They may easily be discovered when firing, but such batteries ordinarily will not disclose their positions by firing until the defended objective actually is threatened. The plan of assault normally is based on the direction of approach of the supported bombardment unit. In order to cover every avenue of approach, the defending batteries are likely to be distributed over a large area in such a manner that only a portion of them can fire on bombers approaching at high altitude, prior to their arrival at the bomb release line.

c. The primary attack is made from the most favorable direction, and the minimum altitude support need be directed against only those batteries which constitute a threat to the success of the primary bombing mission.

d. The commander of the supported force supplies the supporting unit with information of the time of attack, the direction of approach, and the specific targets that will be attacked. The neutralization of antiaircraft gun defenses can best be accomplished by the direct assault against the batteries which can fire upon the supported bombardment unit.

e. During daylight the laying of smoke to obscure artillery fire control stations may have a satisfactory neutralizing effect. The most effective use of smoke requires accurate laying in accordance with a prior knowledge of fire control station locations. Direct assault of firing batteries, with destructive munitions, is preferable to the use of smoke.

f. An assault unit of three airplanes usually is sufficient to silence an antiaircraft battery. It is desirable that three such assault units be assigned for the neutralization of each two known or suspected batteries of artillery, the third unit to remain in the vicinity of the initial point to cover any unanticipated battery or to support the fires of the other units as required. Assault units operate from initial points located just beyond the effective range of the organic automatic weapon defenses of the batteries to be neutralized.

g. Arrival at initial points must be accurately coordinated with the approach of the leading unit of the supported force to within range of the antiaircraft artillery. Radio communication between assault units and with the minimum altitude combat commander facilitates the conduct of the mission. A pyrotechnic code may be used to supplement radio when necessary.

■ 164. Daylight Method of Support.—*a.* During daylight attacks, under conditions which permit accurate determination of the route or routes of approach of the assault units of the primary bombing attack, it is feasible to confine the minimum altitude operations to a zone within which antiaircraft artillery batteries must be located in order to fire upon the supported bombardment force. The zone to be neutralized extends beyond the bomb release line, and on each side of the route or routes of approach of the high altitude bombers, to a distance corresponding to the maximum effective horizontal range of the defending antiaircraft artillery.

b. A plan for the minimum altitude support of a daylight bombing mission is shown graphically in figure 11. The figure shows the plan for a sector of approach for the several units of the primary (supported) bombing force. When the primary bombing force employs only one line of approach, the sector is reduced to a line or narrow lane, and the zone of effective antiaircraft gun locations is reduced accordingly.

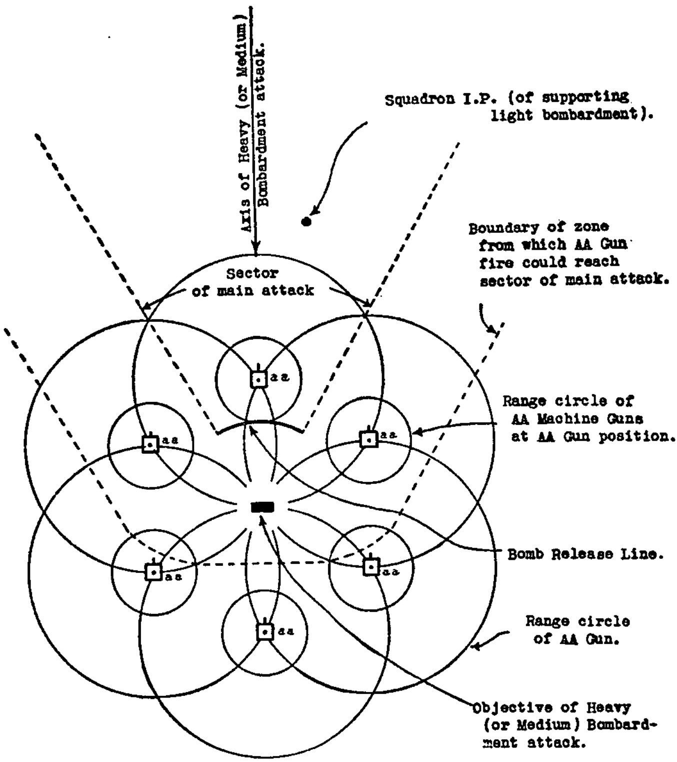

FIGURE 11.—Diagram of minimum altitude support for a high altitude (main) attack against antiaircraft artillery defended objective.

■ 165. NIGHT METHOD OF SUPPORT.—When supporting and supported forces approach their objective for night attack, searchlights of the opposing antiaircraft artillery will go into action. The supporting squadron leader directs his flights to the attack, one flight at a time. The flight moves to the attack with greatly extended interval, each individual airplane then attacking a single searchlight. If the searchlights attacked do not go out of action, or if others appear, the squadron leader dispatches a second flight. One supporting squadron of nine airplanes will normally be able to render ineffective all the searchlights that bear on the sector of approach of the supported force.

■ 166. EFFECTIVENESS.—The effectiveness of minimum altitude operations in overcoming antiaircraft defenses arises from both neutralization and destruction. The presence of aircraft flying at minimum altitudes in the vicinity of antiaircraft artillery defenses interposes a serious interference with the operation of the aircraft warning and fire control systems of the defending artillery. Such aircraft are vulnerable to the local machine gun defenses in the vicinity of the bombardment objective, and the plan of employment must provide for minimizing exposure to such fire.

SECTION IV

USE OF CHEMICALS

■ 167. PURPOSE.—*a*. Chemicals normally are used to produce effects which cannot be obtained by other means. The principal purposes for which chemicals are employed are to neutralize areas of terrain in order to deny their use to the enemy; to produce harassing and casualty effects on personnel or animals; to screen areas; to conceal our own or interfere with enemy operations; and to secure incendiary effects.

b. Harassing agents, such as tear gas, are used to obtain the immediate though temporary effect necessary to interfere with and delay enemy operations. Casualty effects may be obtained by direct placement of either persistent or nonpersistent agents upon personnel or by contamination, through the use of persistent chemicals, of areas which it is desired be denied to the enemy.

c. Screening and obscuring effects are obtained by the use of smoke producing chemicals. Accurate placement from minimum altitudes is essential to the most effective use of smoke.

d. Incendiary agents are used to start fires when the desired results cannot be obtained by explosive force or case fragmentation. In many situations the requisite incendiary effect can be obtained by demolition bombs as result of momentary high temperature of burning explosive and of metal fragments. (See par. 36.)

■ 168. PLACEMENT.—The placement of chemical agents, except chemical bombs, usually is accomplished from minimum altitudes. Placement is effected either by dropping chemical containers intact or by releasing the chemical agents directly into the air from containers which remain attached to the aircraft during release. Chemical containers attached to the aircraft are carried either externally or internally and may or may not be droppable during flight.

■ 169. CHEMICAL BOMBS.—*a.* Chemical bombs are designed to be carried on racks suitable for other types of bombs and are released in the same manner as other bombs. In order to contaminate areas attacked by demolition bombs, persistent chemicals contained in chemical bombs may be dropped during the same mission. A high concentration within a limited area and hence greater persistence of the chemical can best be obtained by the use of chemical bombs. All types of chemical agents may be dispersed in chemical bombs.

b. All chemical bombs may be dropped from minimum altitudes because of the comparatively small booster charge. The dispersion upward is not sufficient to endanger the airplane.

■ 170. CHEMICAL SPRAY.—The spraying of chemicals normally is accomplished at minimum altitudes. Smoke producing materials, tear gas, and toxic chemicals all can be effectively dispersed in this manner. It is an excellent means of dispersing tear gas, since the gas is effective in extremely low concentrations.

■ 171. DISPERSION PROCEDURE.—Chemicals are normally dispersed by aircraft operating singly or by small assault units in flight formation. When chemical spray is released in formation, steps must be taken to avoid contamination of aircraft by the spray released from others in the same formation. It is best to release spray either from single aircraft or by an arrangement of assault units, which does not require any airplane to follow closely in the path of another. The number and arrangement of assault units for the dispersion of chemicals depend on the capacity or number of chemical containers, speed of aircraft, nature and extent of area to be covered, enemy antiaircraft defenses, and atmospheric factors involved.

■ 172. CHEMICAL ATTACKS.—*a*. The indiscriminate dispersion of chemicals over a large or indeterminate area is both wasteful and ineffective. Each mission is directed against a definite area which the assault units can find and identify. The plan of attack is based on the size and shape of the area to be covered.

b. The path of the attacking aircraft should be across the wind so the chemical cloud will drift across the area instead of along the flight path of the dispensing aircraft. A cross drift is desirable regardless of the kind of chemical or method of application, whether by bomb or spray. Aircraft releasing chemical spray fly on the upwind side of the area it is to cover. The spraying of large areas requiring the release of chemicals along two or more flight paths always is initiated on the downwind side of the area, so that each succeeding airplane will release its spray along a flight path which is upwind from that of its predecessor, thereby avoiding contamination. The number of aircraft required to accomplish a mission in the desired concentration depends on the entire area to be covered as compared with that covered by a single airplane.

■ 173. CONCENTRATION.—The concentration requisite to effective results depends upon the chemical used and the nature of the objective. Chemical bombs afford a high concentration but the area of effectiveness of each bomb is relatively small. The concentration obtained in chemical spraying depends on the speed of the dispensing aircraft; rate at which the chemical flows from the spray orifice; altitude at which released; and wind velocity.

■ 174. LONGITUDINAL COVERAGE.—The longitudinal coverage of a single airplane depends upon its speed, amount of chemical carried, and rate of discharge. The distance which the aircraft fly during the discharge of the full capacity of tanks at the rate requisite to obtain the desired concentration represents its maximum longitudinal coverage by chemical spray. The use of multiple tanks enables single airplanes to conform to lesser longitudinal coverages without undue wastage of chemicals and permits a degree of control of concentrations. When bombs are released in train, the length of the train represents the longitudinal coverage per airplane.

■ 175. LATERAL COVERAGE.—*a*. A single airplane can cover only a relatively narrow strip by the train release of bombs. The affected area becomes somewhat widened by the subsequent cloud drift resulting from a cross wind. The lateral coverage of a single airplane using chemical spray depends upon the velocity of the wind across the flight path and the altitude at which the spray is released. Accuracy of placement is difficult, except at very low altitudes, unless accurate information of the wind velocities at and above the surface is available. The cloud formed by chemical spray travels with the wind and retains its effectiveness in causing casualties and harassment for considerable distances. The rate of diffusion and cloud drift may vary considerably, but the figures contained in table VIII, based upon experimental determination, may be used as a general guide. The distances stated in the table are average results and are reliable within 10 percent for distances of more than 500 yards, in connection with the spraying of either lachrymation or vesicant chemicals on personnel or the laying of smoke screens.

TABLE VIII.—*Lateral coverage by chemical spray*

(Wind velocity 5 to 10 miles per hour)

Altitude of release	Distance from line of flight down-wind to first drops	Approximate width of cloud producing casualties to unprotected personnel	
		5 m. p. h. wind	10 m. p. h. wind
Feet	*Yards*	*Yards*	*Yards*
100	25	200	320
200	40	250	370
300	65	300	420
400	90	350	470
500	115	400	500
600	145	450	520
800	205	475	560
1,000	255	500	600
1,500	415	600	675
2,000	535	650	750

b. Lateral coverage is illustrated in figure 12 for the conditions stated thereon.

c. When the width of the area to be covered exceeds the lateral coverage obtainable by one airplane under the conditions attending the performance of the mission, the number of flight paths is increased accordingly.

■ 176. SMOKE SCREENS.—Smoke screens are used for purposes of concealment or interference, and their effectiveness depends upon the accuracy of placement and adequacy of the density of the smoke cloud produced. Concealment against the horizontal vision of an observer on or near the surface is assured only when the smoke screen is so laid as to extend downward to the surface. The requisite density for horizontal concealment is obtained by the laying of smoke along a single flight path. The screening of aircraft at high altitude against observation from antiaircraft fire control stations or other observers on the ground usually requires a smoke blanket of greater width than can be obtained by releasing smoke along a single flight path, and two or more lines of smoke are merged in order to form an effective blanket.

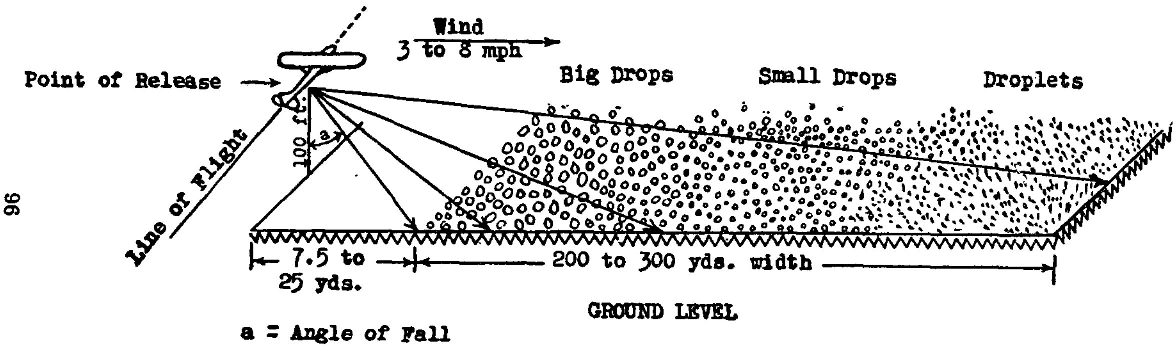

FIGURE 12.—Fall of liquid drops (two 22-gallon tanks operated simultaneously).

■ 177. DRIFT OF SMOKE CLOUDS.—*a.* The behavior and duration of smoke clouds depend on initial smoke density and on the character and velocity of air movements. The cloud will maintain its density for a considerable time in a steady wind of moderate velocity but may soon be dispersed by a strong or gusty wind.

b. A single line of smoke will provide a satisfactory screening effect while drifting from 3,000 to 4,000 yards from the original line, in steady winds of from 2 to 25 miles per hour velocity.

c. The wind carries the smoke upward and forward in such a manner as to spread it. The leading edge of the cloud usually travels approximately one and one-half times as fast as the wind velocity 6 feet above the ground, and the trailing edge, being retarded by contact with objects on the surface, moves at approximately eight-tenths of the wind velocity.

d. Computation of the probable drift and spread of a smoke cloud can be based on the figures stated above.

Example: To compute the approximate width of a sprayed cloud 6 minutes after it is laid across a surface wind of 10 miles per hour:

Leading edge:

$$6 \text{ min.} \times \frac{1{,}760 \times 10}{60} \text{ yds. per min.} \times 1.5 = 2{,}640 \text{ yds.}$$

Trailing edge:

$$6 \text{ min.} \times \frac{1{,}760 \times 10}{60} \text{ yds. per min.} \times .8 = 1{,}408 \text{ yds.}$$

The difference is the width of cloud, which equals 1,232 yards.

■ 178. MERGING OF SMOKE CLOUDS.—Clouds laid by separate airplanes along parallel flight paths drift and spread so as to form a continuous smoke blanket. Data relative to intervals between flight paths and rates of merging, determined by experimental test, are as follows:

Winds	Interval	Merging time	Cloud travel
M. p. h.	*Yards*	*Minutes*	*Miles*
4–10	400	4–5	1.6
10–16	300	3–4	1.5
16–20	200	2–3	1.4
Above 20	100	1–2	1.6

NOTE.—The above data are based on release of the spray as near the surface as possible and in no case at more than 100 feet altitude.

SECTION V

ATTACK OF NAVAL OBJECTIVES

■ 179. GENERAL.—*a.* The attack of naval objectives is required in bombardment operations performed in lieu of or in support of naval forces.

b. Important naval objectives normally will be defended both by antiaircraft guns and by fighter aviation. The technique of minimizing losses from hostile antiaircraft fire is the same in the attack of naval objectives as in the attack of objects on land.

c. The requirements of successful attack against naval objectives are fourfold:

(1) Naval objective must be located.
(2) Location must be reported to assault units.
(3) Attacking aircraft must reach the target.
(4) Requisite number of hits must be obtained.

d. The differences in the technique of air attack of naval objectives and of objectives located on land arise principally from the need for search operations to locate the objective, and the maneuvering tactics which the objective may employ during the actual bombing.

■ 180. SEARCH METHODS.—The search operations required for air attacks of naval objectives will be conducted in general accordance with the provisions of FM 1–20. Where possible, widespread search operations over long periods of time are to be avoided since they exert an uneconomical wear and tear on personnel and equipment. Usually consideration of economy of force will dictate the utilization of a portion of the force in search, another in shore reconnaissance or surveillance, and another, preferably the major portion, in reserve in some convenient locality prepared to strike en masse after the objective has been located. The proportions devoted to search, surveillance, and mass attack depend upon the character and strength of the naval objective, probable mission of the enemy and his most probable route, and amount of friendly bombardment force available.

■ 181. COMMUNICATION.—Radio silence is normally maintained during bombardment attacks against naval objectives. It is broken only to make necessary contact reports which are kept as brief as practicable and rendered without delay. Other aircraft of the attacking force converge upon the airplane reporting contact and thereafter visual signals are utilized. It is desirable that the several elements of an attacking force maintain continual visual contact whenever practicable. The assembly of an attacking force solely by the utilization of radio homing devices depending on brief contact reports for guidance is extremely difficult and also dangerous, because hostile fighter aviation forces may use the same signals to effect interception.

■ 182. ADVANCE TO OBJECTIVE.—Striking forces may proceed seaward against naval objectives in one of three ways:

a. The striking force may be held at some convenient location prepared to proceed to the objective after its location is reported by reconnaissance agencies.

b. The striking force may proceed as a unit in the general direction of the objective, departing its base area prior to the target being located, and depending on the reception of radio advices en route concerning the exact location of the hostile naval force.

c. The striking force may proceed seaward in search attack, planning to assemble and attack after location of the target.

■ 183. SEARCH FOLLOWED BY ATTACK.—*a.* When widespread areas extending long distances seaward must be searched for naval objectives that require the effort of a squadron or more of aircraft for their destruction, it is preferable to operate by the first method outlined in paragraph 182, that is, search followed by mass attack. The necessity for carrying bombs reduces the operating radius of the searching aircraft. Also the best disposition of aircraft for searching an area does not permit the participating aircraft readily to be assembled for the performance of air attack. However, the time required by the search, the fleeting nature of the objectives, and the limitations imposed upon successful air attack by periods of unfavorable weather and/or darkness may in some situations demand attack without the delay incident to the first method of paragraph 182. It is, therefore, usually essential that naval objectives be attacked with minimum delay. Except under very favorable conditions, the attack of naval vessels is restricted to periods of daylight. The exceptions occur when excellent moonlight and visibility favor tracking and bombing missions without artificial illumination, or when the location of the target in a river, harbor, or other small water area makes feasible the use of flares.

b. The conduct of bombardment units in formation flight to the initial points for assault involves considerations similar to those governing the attack of land objectives.

■ 184. DEPARTURE EN MASSE PRIOR TO TARGET DISCOVERY.—The second method of reaching the objective, listed in paragraph 182, can be employed to reduce the limitations imposed on air attack by the darkness period, especially when the direction of travel and general locality of the enemy are known or canalized by circumstances. If, however, the width of the zone in which the enemy may appear is great, darkness may intervene and render attack difficult.

■ 185. SEARCH ATTACK.—*a.* This operation finds its most effective application in the attack of cargo vessels and other naval forces requiring for their destruction only a small bombardment unit effort. It is useful also in the execution of a minor search, such as the search of a position circle of a discovered target with which contact has been only recently lost. Although search attack of widespread areas should be avoided whenever practicable, occasions will arise where, due to the necessity for using bombardment airplanes for reconnaissance or to save time in delivering the attack, search attack will be required.

b. When the coverage required permits, and visibility is variable or not reliably known, search attack is preferably conducted by scouting units of a flight or larger on each scouting path. This disposition of the force favors increasing the number of scout paths when areas of reduced visibility are encountered, and also provides some small measure of mutual protection.

c. An alternate method of search attack when the visibility and the size of the area to be searched permit is to cover the area with a portion of the force spaced on scout paths, following in a centrally located position with the remainder of the force as a unit.

■ 186. ASSAULT OF NAVAL OBJECTIVES.—*a.* The naval objectives against which bombardment aviation may operate include the armed vessels of a hostile fleet, auxiliary vessels, supply ships, troop transports, merchant vessels carrying war supplies, and vessels serving as reporting stations of an aircraft warning service. The appropriate sizes of bombs for use against various categories of naval objectives are shown in table IV

b. The type and size of bombs carried on missions against naval objectives are determined by the character of the objective of first priority. The number of bombs carried in each airplane is dependent upon the bomb rack capacity, amount of fuel required for the accomplishment of the mission, and over-all permissible load of the airplane. The size of the force required is determined by the number of bombs required to insure the requisite number of hits under the controlling probability factors.

c. The objectives normally are attacked in the assigned order of their priority. The entire area of probable target location is searched for objectives of first priority before attacking those of lower priority. A prescribed order of priority is justified by the comparative importance of the several types of vessels and by the variation in suitability of the various sizes of bombs against the several types of vessels. Bombs somewhat smaller than those most appropriate to the attack of any particular class of naval vessel, though not as effective as the correct size, will cause serious damage and may be used when necessary.

d. Armed vessels normally operate in formations suited to the conduct of naval warfare. They usually are well protected by antiaircraft guns of both small and large calibers. Large naval forces are likely to have strong pursuit forces for use in antiaircraft defense. Unarmed vessels, constituting important objectives for air attack, are likely to be provided with an armed convoy possessing strong antiaircraft defenses. The technique of penetrating antiaircraft defenses of naval objectives is similar to that for the penetration of the antiaircraft defenses of land targets, with such modifications as are made desirable by differences between naval and land defensive equipment.

e. The attack of naval objectives defended by antiaircraft artillery with demolition bombs is accomplished by precision bombing methods normally from high altitude. Such high altitude operations may be supported by minimum altitude missions to lay smoke or otherwise neutralize antiaircraft guns. Dive bombing attacks are effective against naval objectives.

f. Minimum altitude attacks with fragmentation bomb, machine guns, and toxic chemicals are effective against expeditionary forces on transports during debarkation and landing operations.

g. The axis of attack should be selected after balancing the advantages accruing from the use of the various directions of approach. Advantages must be considered both from the offensive and the defensive point of view. The axis selected will be a tactical decision in each case.

(1) Considerable masking of antiaircraft artillery gunfire can be secured by attacking along the fore and aft axis of the defensive surface vessels.

(2) High speed through the antiaircraft fire zones materially reduces the number of shells that can be fired at the attacking aircraft. Therefore, a defensive advantage accrues from attacking from that direction which, considering wind velocity and the speed of the target, provides the greatest relative speed between the objective and the attacking aircraft. Offensively, the accuracy of bombing is somewhat reduced by the higher relative speed.

(3) Normally, a direction of attack within 30° of the direct sun-battery or moon-battery line causes considerable loss to the antiaircraft artillery defenders in their ability to pick up the approaching planes, and thus delays the initiation of the defensive artillery fires.

(4) Penetration of the gun defenses in a weak sector is very desirable. In this case the effective range of the antiaircraft guns will vary with the equipment used by the enemy.

(5) From the offensive point of view, an attack from the stern down the direction of the target travel makes feasible a method of minimizing the effects of the defensive maneuvering of the vessel.

■ 187. TARGET MANEUVER.—Naval objectives are capable of sufficient maneuver adversely to affect high altitude bombing accuracy. Their maneuverability includes change of speed and change of direction, the latter being the most effective in avoiding aerial bombs. The degree to which vessels in battle formation can maneuver, particularly during an active naval engagement, is materially restricted because of the necessity of maintaining proper position in the battle formation and because of the adverse effect of maneuver on gunnery accuracy. Aircraft carriers, even when not restricted by the necessity of conforming to the movements of other vessels, cannot engage in abrupt maneuvers during the launching or landing of their aircraft. Computations based on the observation of the approaching bombers will facilitate the initiation of a change of direction practically coincident with the release of bombs. There is an appreciable interval after the movement of the rudder before the naval vessel actually changes its direction of motion. This interval varies for different vessels. Under favorable circumstances an experienced bombardier can observe the change in the wake, resulting from rudder movement, and thereby anticipate by several seconds an impending change of direction. A change of direction results in sufficient departure from the original course to avoid aerial bombs only when the vessel has a fairly high forward speed. Reversing engines or materially reducing speed is not favored by naval authorities, because by so doing the vessel sacrifices its ability subsequently to change its position by maneuver.

■ 188. MANEUVER AREA.—*a.* After an accurately aimed bomb has been correctly released from high altitude, a maneuvering naval objective may change course and avoid the bomb impact, even though vessels which are profitable bombardment targets are of such size as to have a relatively low rate of change in speed or direction or both. However, a satisfactory probability of hitting a maneuvering target can be attained by the application of a bombing pattern of adequate density to the entire area in which the target vessel can possibly be when the bombs strike. This method of attack is wasteful of bombs, and it is necessary, therefore, that the size of the maneuver area be ascertained fairly accurately in order that bombs may not be dropped where they cannot possibly be effective.

b. The actual size of the maneuver area available to the vessel during the fall of the bomb varies with the bombing altitude, the bomb ballistic characteristics, and the vessel speed, tactical diameter, and design conveniences for reversing power. This area may also be reduced if the vessel fails to initiate its maneuver at the proper instant. Obviously some variations in the plans of attack will be advisable against varying equipment and enemy doctrines of operation. An example follows of one method of attack which presumes, for the surface vessel, perfection in the timing of its maneuver and full use of changes in speed and direction. In this example the objective is a vessel that by the application of standard rudder can turn 180° in 1,000 yards, which is therefore by definition the tactical diameter. The vessel speed is assumed to be 30 knots. Reasonable average data are used elsewhere throughout this example.

c. Figure 13 shows a situation in which at zero time standard rudder was applied to the vessel, but in this case turning initiated at zero plus 18 seconds. At precisely this time the bomb is assumed to be released at an altitude of 18,000 feet. By use of different rudder settings at full speed, the center of gravity of the vessel may reach in the times indicated any point on the various loci shown.

d. The position of the vessel may further be affected by changes of speed. Of particular importance to the bombardier is the area in which the vessel may be located at the instant of impact of the bomb. This area is shown in figure

14 by shading superimposed on a diagram similar to that of figure 13. Variations in the data, such as changes in assault altitude or vessel characteristics, will modify the maneuver area.

■ 189. ASSAULT METHODS.—*a*. Considering the maneuver area shown in figure 14 as the target, the method selected for assault should be adaptable to pattern bombing covering this area. When assault units consist of waves of nine bombers in squadron stagger formation, the area can be covered in the manner described below.

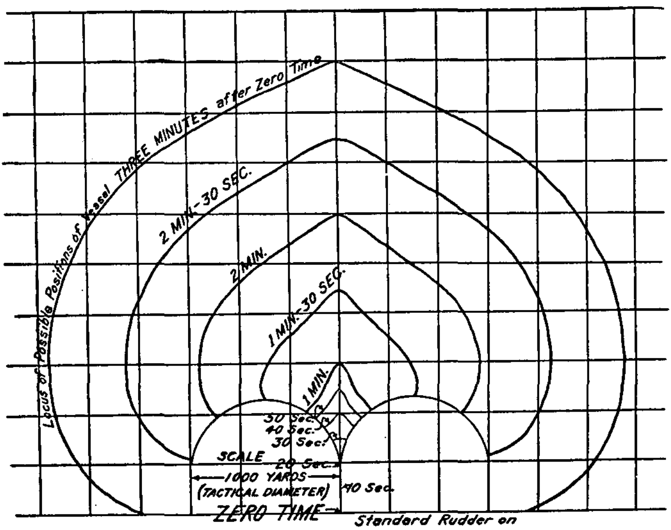

FIGURE 13.—Areas of possible locations of vessels (maneuvering targets) having 30 knots' speed at zero time and tactical turning radius of 500 yards.

b. On nearing the vicinity of the bomb release line, the right and left flights diverge to the right and left, respectively. The three flights then converge in their bombing approach to the bomb release line as shown in figure 15. For an altitude of 18,000 feet, and for the example in figure 14, the angle of convergence of flight axes of attack is approximately 30°.

The angle of convergence increases with the bombing altitude. In figure 15 are shown three flight patterns of twelve bombs each, released in train at ½ second intervals at 200 miles per hour. Superimposed on the maneuver area is the silhouette of a vessel with a danger space surrounding it. The leading flight has bombed as though no maneuver was anticipated, the right and left flights covering the flank portions of the maneuver area with their patterns.

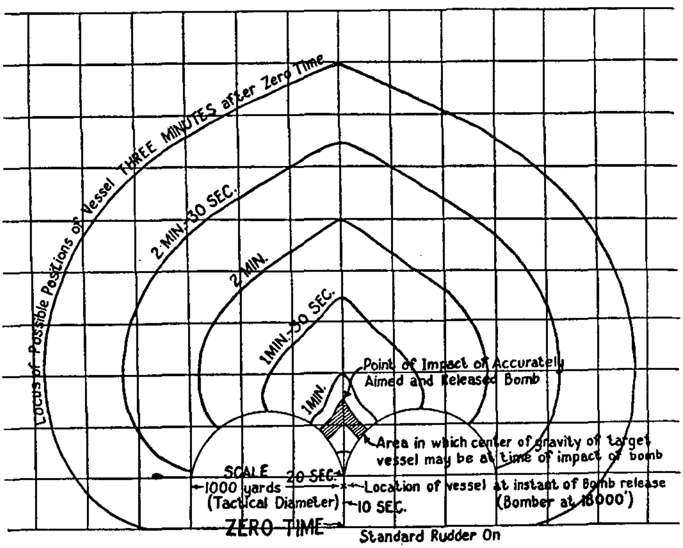

FIGURE 14.—Area in which vessel (maneuvering target) can be at time of impact of bomb.

c. Bombs should be released in train at such interval that the space between bombs is small enough to prohibit bracketing the target with two adjacent bombs irrespective of its location. The train length should be such as to provide full coverage of the maneuver area. Obviously a compromise between these two desirable details is necessary when the bombload that can be carried is insufficient to permit proper density throughout the maneuver area.

d. Since the bombs of the flight away from the direction of vessel maneuver are wasted in the method discussed in *b* above, an alternate method of assault may be used, wherein the flights approach the bomb release points at a specified short interval, to permit succeeding flights to sense the direction of vessel maneuver prior to release of their bombs.

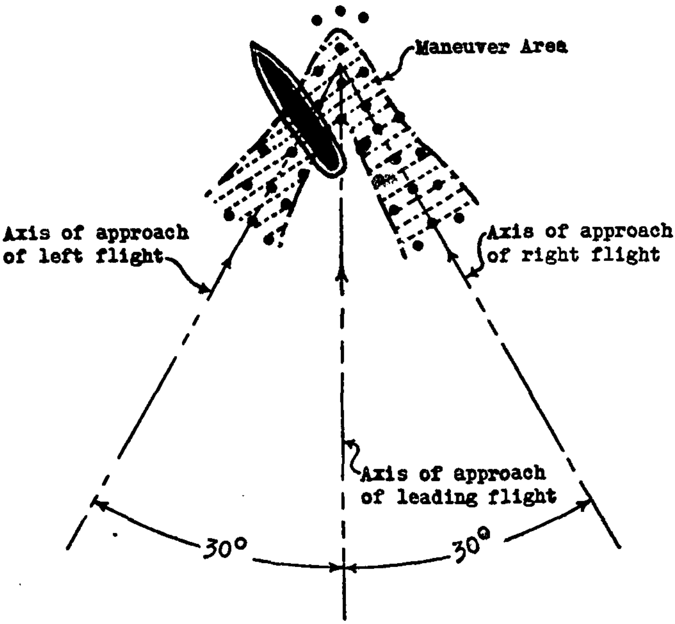

FIGURE 15.—Diagram for assault of vessel (maneuvering target).

■ 190. SIZE OF FORCE.—*a.* The size of the force to be used against naval objectives depends on the nature and number of target vessels, their defenses and ability to maneuver, the desired degree of certainty of success (usually 90 percent), the bomb capacity of the aircraft on the mission, and the accuracy of the bombing crews under the conditions of the assault. Maximum economy of bombs and minimum strength of force are achieved against still targets when each bomb can be separately sighted and dropped from an individual assult airplane. Airplanes may attack naval objectives singly when they are undefended and other conditions are favorable to that method of assault. However, naval targets which are free to maneuver should normally be attacked by aircraft in formation in order to secure the requisite bomb pattern.

b. Objectives defended by antiaircraft guns should, when practicable, be attacked by a force of such size that the number of individual airplanes exceeds the estimated number of enemy antiaircraft fire control directors able to operate against the attacking aircraft. Usually against strong naval dispositions this will not be the controlling factor in determining the size of the attacking force, since the desired assurance of success will require many more aircraft than the number of hostile naval antiaircraft directors.

c. As in the case of the attack of land targets, attacks of naval objectives should be made as nearly simultaneously as possible, with a force sufficient in size to assure that, with deductions for losses en route, the proper number of bombers will reach the bomb release line to effect the desired destruction.

■ 191. Bombing Altitude.—Naval objectives free to maneuver are bombed from the lowest altitude consistent with bombing accuracy and proper security measures. Obviously, the lower the bombing altitude, the smaller the opportunity of the vessel to avoid the bombs by maneuver. Strong antiaircraft gun defenses may require a high bombing altitude to reduce the effectiveness of the antiaircraft guns. Normally, due to their importance and fleeting character, strong naval forces require a 90 percent chance of success on each mission. This high percentage may necessitate so large a force of bombers, if employed at high altitude, that some compromise with security will be justified by the importance of destruction of the objective.

■ 192. Minimum Altitude Attacks.—*a.* Bombing attacks against naval objectives may be accomplished at minimum altitudes by the use of torpedoes under circumstances which do not permit the employment of normal bombing methods. Examples of such conditions occur when, due to the presence of low clouds, attacks must be made at altitudes so low as to make relatively dangerous or ineffective the use of aerial bombs. In very low altitude attacks, the explosion of the bomb dropped with instantaneous fuze is likely to damage the attacking aircraft. On the other hand, the bomb fuzed with sufficient delay to assure the safety of the airplane may explode at too great a depth to injure the surface vessel.

b. Minimum altitude attacks in support of the high altitude bombing attacks are useful in neutralizing the fire of antiaircraft guns. Such attacks are more difficult over water because of the absence of the cover usually provided in land operations by irregularities in the terrain and the presence of wooded areas. The smoke screens laid by surface vessels during naval engagements provide excellent horizontal cover to aircraft engaged in minimum altitude attacks. The minimum altitude technique employed against objectives on land is effective against naval objectives. (See pars. 94, 108, 110, 116, and 186*f*.)

Section VI

COUNTER AIR FORCE OPERATIONS

■ 193. General.—*a.* In counter air force operations, bombardment aviation is employed in air attack to deny the enemy all or partial use of his aviation forces. Such operations are offensive in nature, as distinguished from antiaircraft defense action against enemy aircraft in flight. Bombardment objectives for counter air force action should be selected after consideration of the following factors:

(1) Relative importance of the targets, from the point of view of the immediate, lasting, and cumulative effect of their destruction or neutralization.

(2) Capacity of the friendly air force to effect destruction or neutralization.

(3) Probable losses involved in the counter air force operations.

b. If reasonably within the capacity of the force and not prohibitive in losses of friendly aircraft, the priority of counter air force objectives is as follows:

(1) Aircraft.

(2) Operating personnel.

(3) Air base facilities, including landing areas, maintenance and overhaul shops, local supplies, and routes of communication.

(4) When the enemy aircraft are carrier based, the destruction of the carrier or carriers is the primary objective of counter air force action.

(5) Advanced refueling airdromes essential to the enemy.

(6) Concentrated supplies, either stored or in transit.

(7) Lines of communication essential to supply and replacement.

c. Because of the difficulty of counter air force action, occasions may arise where the force available may be too small to achieve complete success, no matter how employed. In some instances, losses may be severe. However, where counter air force action is of paramount importance, that method of operation which promises to inflict the greatest handicaps on the enemy should be adopted, though only partially successful. In balancing our losses against those inflicted upon the enemy, it must be borne in mind that the loss of use of airplanes is actually the loss of potential destructive power. From this point of view, it may be profitable to accept heavy losses of our own aircraft, if we deny the enemy air action against our vital ground installations within his radius of action.

■ 194. ATTACK OF AIRCRAFT.—*a.* Aircraft are particularly vulnerable to air attack when at rest in the open on the surface. Their destruction is by no means simple, however, because of their fleeting character and because of the difficulty of locating them. This latter is especially true of water-based seaplanes that may utilize sheltered waters and the cover of protective foilage along shore lines. Such craft constitute an elusive objective that can maneuver on the water or even take-off if sufficient warning of an attack is given them. Landplanes do not, in general, have the wide choice of landing points, but, when revetted, form unprofitable point targets. The general revetment area containing hostile aircraft should be regarded as an area target, and bombs distributed therein. During refueling and loading operations, an attack directed against aircraft finds them in a most vulnerable location, and usually results in incidental losses to personnel and matériel essential to the enemy's sustained operations.

b. Within a given weight of loading, small fragmentation bombs are the most effective against aircraft in the open. Demolition bombs with instantaneous fuzes may be used. For a given weight of bombs, the small demolition bombs are more effective than the larger sizes. Chemicals may be used to neutralize aircraft on the ground, but are relatively ineffective against seaplanes when the enemy is prepared for decontamination. Against aircraft in revetments, small demolition bombs or chemical bombs are effective. The chemical bomb is effective in contaminating and damaging the airplane if a hit inside the revetment is secured. At the same time contamination of the revetment area is accomplished by those bombs that miss. The small demolition bomb requires a hit within a revetment to be effective.

c. Seaplane anchorages will not usually be adequately defended by active elements of antiaircraft defense, due to the difficulty of maintaining an effective aircraft warning service. Landplanes will, on the other hand, be well defended whenever the enemy's facilities permit.

■ 195. ATTACK OF PERSONNEL.—The operating personnel of hostile air forces usually are so dispersed that they alone do not constitute a profitable bombardment target. Casualties in enemy aviation personnel are incidental to air attacks against matériel objectives. Fragmentation bombs and toxic chemicals are the most effective bombardment munitions for producing personnel casualities.

■ 196. ATTACK OF AIR BASE FACILITIES.—*a*. Enemy air operations can be seriously hampered by both the destruction and/or chemical contamination of their air base facilities. These include the landing areas, local maintenance and supply facilities, and adjacent routes of communication. If aircraft are present, they become a first priority objective.

b. It can be expected that supplies and maintenance facilities will be well dispersed and camouflaged to an extent that will make their attack difficult or unprofitable. If concentrations of such facilities can be developed by reconnaissance agencies, their attack is indicated. This is especially applicable to floating concentrations such as tenders, barges, or supply vessels.

c. Seaplane landing areas such as natural lakes or sheltered inlets are not suitable objectives unless occupied. Landplane landing areas, either that of the headquarters base airdrome, base landing fields, or advanced refueling airdromes, can usually be discovered. They are suitable objectives for bombardment attack with demolition bombs or persistent chemicals. The use of the latter is normally to be preferred, especially in populated communities, well organized for construction work. Small demolition bombs of an equivalent total weight are much more effective in the attack of landing areas than large bombs.

d. Although the effect of its destruction or the denial of its use is not immediate, the continued neutralization of a line of communication essential to an air base will render it useless. In a well-developed countryside, it will usually be beyond the capacity of the available force to deny the enemy all routes by which his base may be supplied. Under other circumstances, where only one or a few lines of communication are available, their attack may be most profitable since, in general, strong enemy defenses at all points of a line of communication are not practicable. Attacks against lines of communication may be directed against the roadways themselves, especially at defiles, against terminal handling facilities, or directly against the carriers.

■ 197. ATTACK OF ADVANCED REFUELING AIRDROMES.—When the enemy is operating landplanes from advanced refueling airdromes, without which he cannot reach his objectives in our territory, the neutralization of these airdromes and the facilities thereat becomes of primary importance when, as will often be the case, our aircraft cannot reach hostile main bases or other vital installations.

■ 198. ATTACK OF CONCENTRATED SUPPLIES.—Concentrations of supplies may be in storage in warehouses or other sites, or they may be in land or water transit. In any case the effect of their destruction is deferred until local supplies in the theater of operations are exhausted. However, the enemy supply situation will become critical if supplies are choked off.

Hence, one method is to destroy the supplies that will replace those in the possession of combat units or in dumps locally available to them. Such supplies may be in rear depots or in transit by water, motor, or rail. In any case they can readily be destroyed by suitable demolition bombs, once their location is ascertained.

■ 199. Attack of Supply Lines.—*a.* Supply lines of a theater of operations are just as essential to its continued functioning as are the local supply lines servicing an air base. Sustained air operations are not possible in the absence of adequate lines of communication to the theater. Air forces will have to depend on adequate movement of supplies over lines of communication which, therefore, become an important item in our counter air force operations.

b. In general, the attack of supply lines serving a theater of operations differs little from the attack of similar lines essential to the operation of an air base (par. 196).

■ 200. Counter Air Force Directives.—*a.* Because of the immediate, lasting, and cumulative effect of the destruction of aircraft, orders of higher commanders directing counter air force activities should place aircraft in first priority. The higher commander must appreciate the difficulties involved and should designate as fleeting or secondary objectives floating supply and maintenance matériel and known fixed installations of importance.

b. Group orders for counter air force activities should stress action against known aircraft locations, both moored seaplanes or landplanes on or in the vicinity of landing areas.

■ 201. Supporting Operations.—Wherever possible, reconnaissance aviation will render assistance to bombardment, either by initial discovery of aircraft and aviation facilities, or by keeping bombardment units constantly informed of the current location of enemy aircraft and their supporting activities.

■ 202. Assault Methods.—A plan for counter air force action must, in general, contain details similar to those contained in any attack plan. However, due to the character of the targets, certain items of the plan have special significance for counter air force activities.

a. Well-defended airdromes or revetment areas should be attacked at night whenever posible to do so.

b. Attacks of revetment or camouflaged areas of aircraft concealment or of shore lines utilized by hostile seaplanes will normally be made as against area targets. Since the aircraft will be located, in general, along the shore line or route of communication, offensive considerations indicate that better bomb distribution will be obtained by bombing down the shore line or route as an axis of attack. Defensively, a better axis for security against antiaircraft artillery may be obtained by attacking across the shore line or route.

The decision as to the axis of attack is a tactical one, to be made either by the unit commander or higher authority.

Section VII

SUPPORT OF GROUND FORCES

■ 203. General.—*a*. Combat aviation in support of ground forces operates in a manner that will most effectively contribute to the successful execution of the mission of the supported forces. The nature of these support operations will be influenced to varying degrees by the following factors:

(1) Mission of the ground force.

(2) Potential opposition and characteristics of enemy aviation forces.

(3) Strength and characteristics of supporting aviation forces.

(4) Location, disposition, and relative security of air base installations and operating areas available to the opposing aviation forces.

(5) Strength and disposition of enemy antiaircraft defenses.

(6) Visibility and weather conditions obtaining during the conduct of operations.

(7) Mobility and fire power of the supported ground force.

(8) Strength, disposition, and characteristics of hostile ground opposition.

(9) Vulnerability of hostile signal communications and routes of movement.

(10) Nature of terrain over which operations are conducted.

(11) Nature and extent of the road, signal, railway, and/or water communication system within and leading to the area of the supported ground force operations.

(12) Period of time over which support operations are to be conducted.

b. In planning for operations by combat aviation in support of ground forces, a proper evaluation of the influence of the above factors will indicate the strength and composition of supporting aviation required and appropriate procedure for the conduct of supporting air operations, including coordination, communication, etc.

c. Aviation in support of ground troops may engage in one or more of the following operations:

(1) Destruction or neutralization of enemy aviation forces opposing the supported ground forces by antiaircraft defense and counter air force operations.

(2) Reconnaissance, liaison, and observation.

(3) Delivery of fire on the immediate front of ground forces.

(4) Air attack against targets in the hostile rear areas.

(5) Support, both in the air and on the ground, of parachute troops and air Infantry.

■ 204. LOCAL AIR SUPERIORITY.—*a*. Offensive operations by ground forces will be seriously jeopardized if conducted in the face of effective enemy air opposition. In the face of effective hostile fighter opposition, friendly air attacks against ground objectives will normally result in excessive losses to the air attacking force. For the above reasons the mission of first priority of combat aviation in support of ground force units is, whenever possible, the destruction or neutralization of effective hostile air resistance from the decisive area of ground operations for the period of time during which those ground operations are being conducted. Coordination should insure that the decisive phase of ground force operations is not initiated prior to the execution of effective counter air force missions by directly supporting or other friendly combat aviation. Bombardment aviation and such pursuit aviation as is not required for its primary task of protection against hostile air attacks are employed in counter air force operations within their respective radii of action. Pursuit as well as bombardment aviation weapons are effective against aircraft at rest on their bases.

b. During offensive operations by ground forces in the presence of potential air opposition, supporting pursuit aviation operates to deny air observation and attack on the supported forces by the local concentration of its forces, and provides air security for operations of supporting observation and bombardment aviation. By the effective execution of these tasks, pursuit aviation makes its greatest contribution to the success of ground force operations. When air opposition does not threaten the success of supported ground operations, pursuit may operate against those ground objectives that are vulnerable to its weapons.

c. While the most effective results from supporting aviation are obtained through the neutralization of effective hostile air resistance in the area of operations, the lack of assured local control of the air does not prevent the use of aviation in direct support of ground forces where the operation is critical and the end to be accomplished warrants the acceptance of the risk of heavy losses in the friendly aviation forces.

■ 205. DIRECT SUPPORT OPERATIONS.—*a. Observation and reconnaissance.*—Observation aviation performs reconnaissance before and during the offensive operations of ground forces. Bombardment aviation augments the operations of observation aviation by executing combined reconnaissance—bombing missions, and by directing armored, mechanized, and motorized columns around hostile ground resistance when appropriate and practicable, or by assisting the mobile ground columns by direct attacks to neutralize strong ground opposition.

b. Attack on defensive organization.—Air attacks are executed against fortifications and strong defensive organizations in the path of supported ground forces, particularly mechanized and armored forces, when it is not practicable to employ other means of attack upon the desired objective in the time available, or when the added fire power and moral effect of air attacks are essential to insure the success of the operation of the ground forces. In such employment the end to be accomplished must warrant the aviation losses to be expected, and the previous joint training of participating forces should be such that there will be prompt exploitation by the ground forces of the results of employment of combat aviation.

c. *Isolating battle area.*—Air operations are conducted to render inoperative all lines of communication leading to the area of operations of the hostile ground forces. Telegraph and telephone lines, vital points on the road, and railway systems, including railway centers which might be used for the movement of troops and supplies, are particularly suited for air bombardment. Railway rolling stock, either stationary or in motion, are appropriate targets of opportunity for air attack. Locomotives are vulnerable to the fixed cannon and heavy machine-gun fire of pursuit aircraft.

d. *Blocking movement of enemy reserves.*—Hostile ground forces moving toward the operations area of the supported force are subjected to air attack for the purpose of blocking or delaying movement and for effecting their destruction or demoralization. Formed bodies of troops and their transportation are highly vulnerable to attacks by bombing and machine-gun fire.

e. *Attacks on hostile mechanized forces.*—Supporting combat aviation attacks and destroys approaching mechanized forces and antitank units before they gain contact and engage the supported force. The supply and maintenance elements of hostile mechanized and armored formations are essential to their continued operation, and opportunity should be sought constantly to accomplish early destruction of these hostile supply elements. Horizontal, glide, and dive bombing are employed by bombardment aviation in attacks on defensive organizations, hostile mechanized forces, and antitank units. When the threat of hostile air opposition is not present or when the situation is critical, supporting pursuit aircraft attack hostile mechanized vehicles with fixed cannon and heavy machine gun fire. Supporting aviation should be continuously on the alert to detect preparations for and to block any counteroffensive operations against the supported ground force. Prompt warning must be given friendly ground forces of the location or direction of movement of hostile mechanized or antitank units and weapons.

f. *After break-through.*—After a break-through has been effected, supporting aviation continues to operate in close coordination with armored forces to complete the disorganization of hostile rear areas and to protect the flanks of the penetrating force against major counterattacks.

■ 206. SUPPORT OF ARMORED FORCES.—In order that combat aviation may furnish effective support to armored forces, it must be able to concentrate rapidly the mass of its fire power on successive attack objectives with a precision timed to the high mobility of the supported armored unit. To meet this tactical requirement every effort should be made to retain a maximum of flexibility in the employment of supporting aviation units. Rapidity in execution of support missions is vital to success, limiting the time for counteraction by enemy forces. To insure both the prompt execution of aviation support missions and the exploitation thereof by mobile ground troops positive advance arrangements must be made for simple, prompt communication between the ground forces and supporting aviation.

■ 207. COORDINATION WITH ARMORED FORCES.—The effectiveness of joint operations by armored and aviation forces will be directly dependent on the degree of coordination achieved in the execution of missions. The following procedure for the conduct of combined operations should contribute to efficient coordination:

a. Control.—Temporary decentralization of control of combat aviation in direct support of armored forces may be necessary in order to insure the timely employment of aviation in close coordination with the supported forces for the accomplishment of a specific task.

b. Communication.—Direct radio telephone communication between armored and supporting air units should be provided. For other than simple prearranged signals the necessity for speed will eliminate the need for messages in code immediately preceding and during actual attacks. Pyrotechnics, panels, and other air and ground signaling devices should be fully exploited in joint operations. Mutual understanding of the signals employed by the cooperative ground and aviation forces must be assured.

c. Liaison.—The extensive interchange of liaison officers by the participating forces will contribute to a thorough understanding of the operating capabilities of each force. Efficient liaison will facilitate proper employment and coordination.

d. Planning.—Thorough and detailed planning and preparation for projected operations based on sound information of enemy strength and capabilities are essential to assured success in the execution of joint armored force—aviation missions.

e. Reconnaissance.—Continuous, systematic reconnaissance must be executed by the supporting aviation for the purpose of locating obstacles, defiles, and enemy antitank dispositions, and transmitting this information to the supported forces.

■ 208. CONTINUITY OF OPERATIONS.—Pressure must be maintained continuously throughout each campaign on hostile aviation that threatens the success of supported ground force operations, on communications within and leading to the area of operations, on reserves within tactical supporting distance, and on all troop movements, mechanized or otherwise.

■ 209. TRAINING.—Effective teamwork is essential to success in combined air-ground operations. This can only be achieved through intensive training and indoctrination of both forces. Aviation used in direct support of ground forces must be thoroughly famliar with ground warfare through intensive peacetime training and should be fully trained to participate promptly and effectively anywhere on the battlefield to destroy resistance that impedes the advance of our ground forces. Thorough joint training and tactical exercises will further tend to develop sound tactical doctrines of employment. The following should be stressed both in aviation unit training and in joint training:

a. Ready identification of friendly aircraft by ground troops; and friendly troops and equipment, especially mechanized and armored vehicles, by aircraft personnel.

b. Communication with ground units, to include—

(1) Designation of targets by maneuver of aircraft, signal lamps, pyrotechnics, tracer ammunition, etc.

(2) Drop and pick-up message procedure.

(3) Use of panel codes.

(4) Radio telephone and code.

c. Use of liaison personnel to facilitate cooperation of supporting and supported units.

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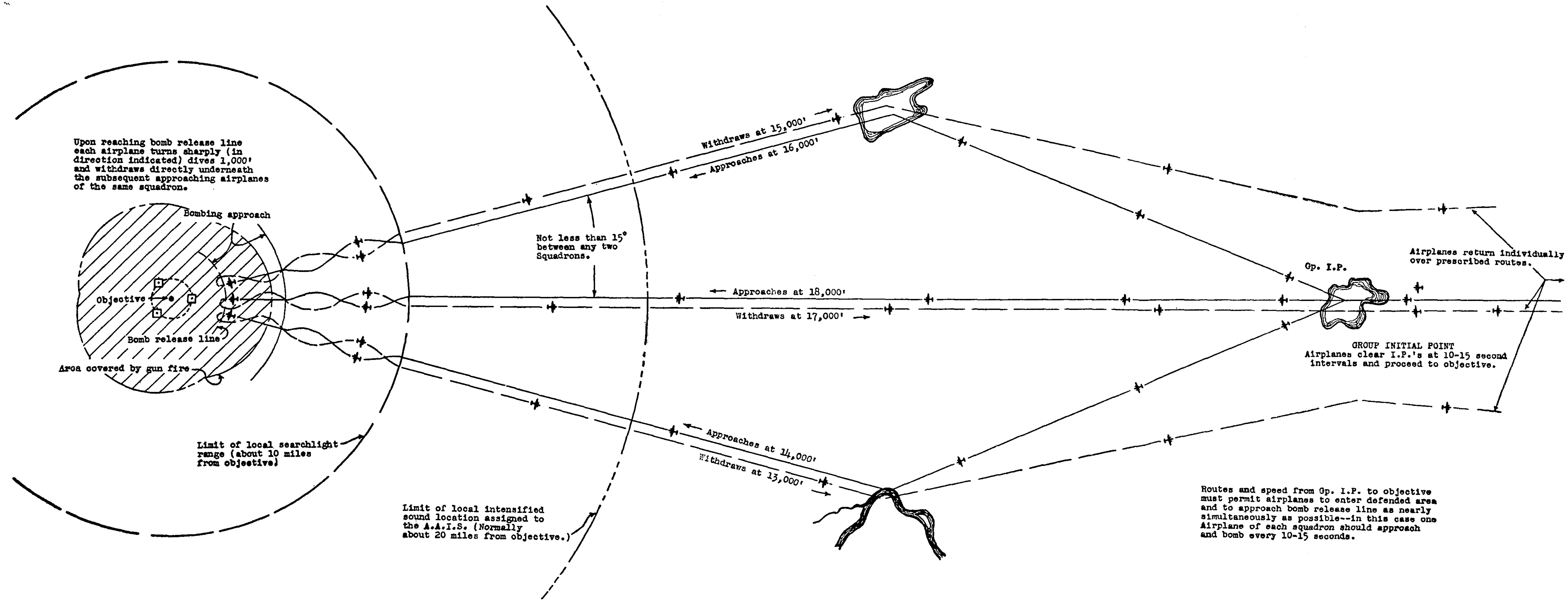


FIGURE 8.—Schematic diagram of flight method of attack at 10 to 15 second intervals from 18,000 feet altitude.

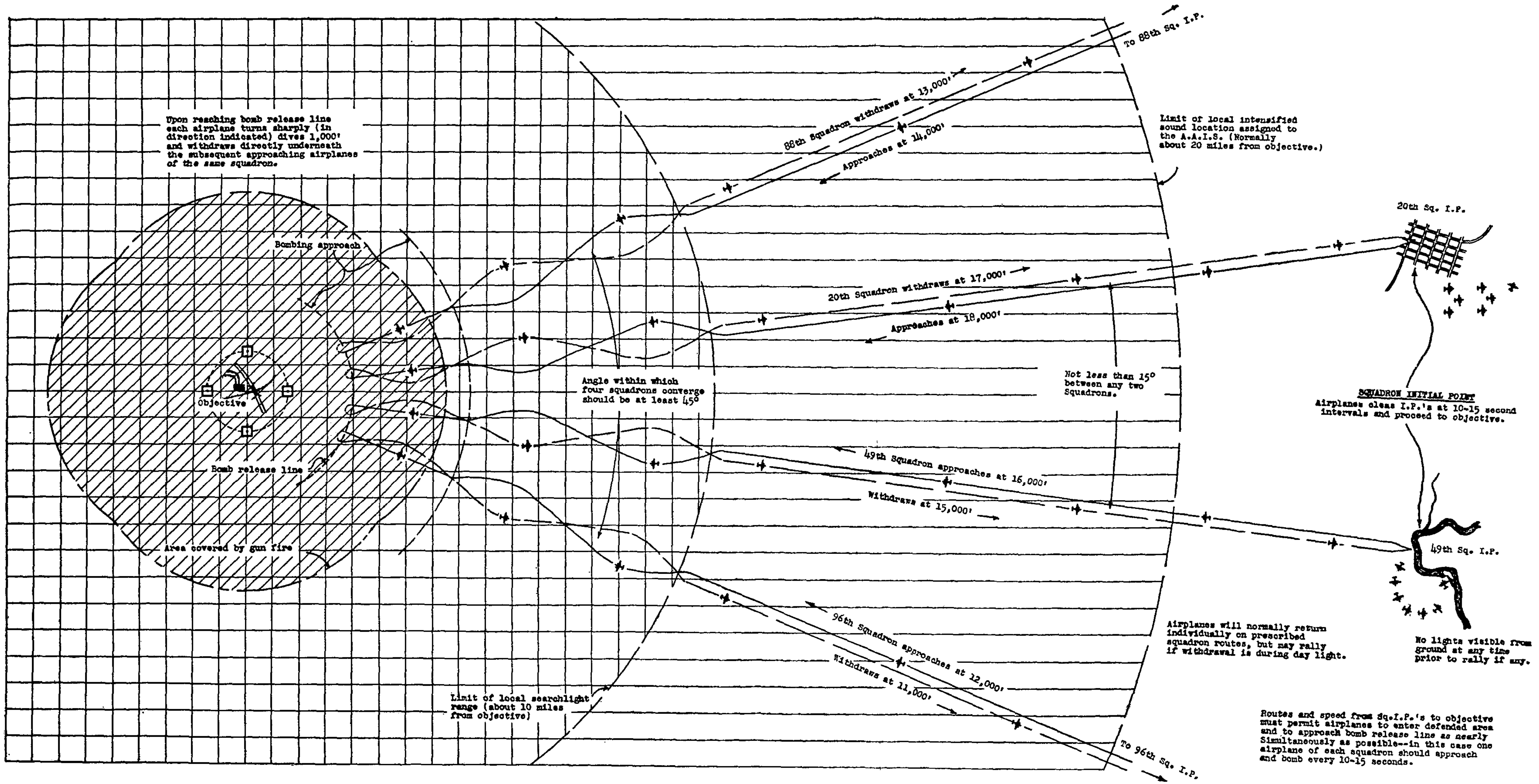


FIGURE 9.—Schematic diagram of squadron method of attack at 10 to 15 second intervals from 18,000 feet altitude.

Table VI.—*Vulnerability factors and probabilities*

(Using range and deflection factors separately)

Showing the proportionate chance of a hit with one bomb, which corresponds to each factor shown

$$\text{Vulnerability factor} = \text{Vf} = \frac{\text{allowable error in range (or deflection)}}{\text{probable error in range (or deflection)}}$$

Vf	0	1	2	3	4	5	6	7	8	9
0.0	0.0000	0.0054	0.0108	0.0161	0.0215	0.0269	0.0323	0.0377	0.0430	0.0484
0.1	0538	0591	0645	0699	0752	0806	0859	0913	0966	1020
0.2	1073	1126	1180	1233	1286	1339	1392	1445	1498	1551
0.3	0.1604	0.1656	0.1709	0.1761	0.1814	0.1866	0.1919	0.1971	0.2023	0.2075
0.4	2127	2179	2230	2282	2334	2385	2436	2488	2539	2590
0.5	2641	2691	2742	2793	2843	2893	2944	2994	3044	3093
0.6	0.3143	0.3192	0.3242	0.3291	0.3340	0.3389	0.3438	0.3487	0.3535	0.3584
0.7	3632	3680	3728	3775	3823	3871	3918	3965	4012	4059
0.8	4105	4152	4198	4244	4290	4336	4381	4427	4472	4517
0.9	0.4562	0.4606	0.4651	0.4695	0.4739	0.4783	0.4827	0.4871	0.4914	0.4957
1.0	5000	5043	5085	5128	5170	5212	5254	5295	5337	5378
1.1	5419	5460	5500	5540	5581	5621	5660	5700	5739	5778
1.2	0.5817	0.5856	0.5894	0.5932	0.5971	0.6008	0.6046	0.6083	0.6121	0.6157
1.3	6194	6231	6267	6303	6339	6375	6410	6445	6480	6515
1.4	6550	6584	6618	6652	6686	6719	6753	6786	6818	6851
1.5	0.6883	0.6915	0.6947	0.6979	0.7011	0.7042	0.7073	0.7104	0.7134	0.7165
1.6	7195	7225	7255	7284	7313	7343	7371	7400	7428	7457
1.7	7485	7512	7540	7567	7594	7621	7648	7675	7701	7727
1.8	0.7753	0.7778	0.7804	0.7829	0.7854	0.7879	0.7904	0.7928	0.7952	0.7976
1.9	8000	8023	8047	8070	8093	8116	8138	8161	8183	8205
2.0	8227	8248	8270	8291	8312	8332	8353	8373	8394	8414
2.1	0.8433	0.8453	0.8473	0.8492	0.8511	0.8530	0.8549	0.8567	0.8585	0.8604
2.2	8622	8639	8657	8674	8692	8709	8726	8743	8759	8776
2.3	8792	8808	8824	8839	8855	8870	8886	8901	8916	8930
2.4	0.8945	0.8959	0.8974	0.8988	0.9002	0.9016	0.9029	0.9043	0.9056	0.9069
2.5	9082	9095	9108	9121	9133	9146	9158	9170	9182	9194
2.6	9205	9217	9228	9239	9250	9261	9272	9283	9293	9304
2.7	0.9314	0.9324	0.9334	0.9344	0.9354	0.9364	0.9373	0.9383	0.9392	0.9401
2.8	9411	9419	9428	9437	9446	9454	9463	9471	9479	9487
2.9	9495	9503	9511	9519	9526	9534	9541	9548	9556	9563
3.0	0.9570	0.9577	0.9583	0.9590	0.9597	0.9603	0.9610	0.9616	0.9622	0.9629
3.1	9635	9641	9647	9652	9658	9664	9669	9675	9680	9686
3.2	9691	9696	9701	9706	9711	9716	9721	9726	9731	9735
3.3	0.9740	0.9744	0.9749	0.9753	0.9757	0.9762	0.9766	0.9770	0.9774	0.9778
3.4	9782	9786	9789	9793	9797	9800	9804	9807	9811	9814
3.	9570	9635	9691	9740	9782	9818	9848	9874	9896	9915
4.	0.9930	0.9943	0.9954	0.9963	0.9970	0.9976	0.9981	0.9985	0.9988	0.9991
5.	9993	9994	9995	9996	9997	9998	9998	9999	9999	9999
6.	9999	1.0000	---	---	---	---	---	---	---	---

Example.—(1) Assume: Allowable error in range = 120 ft.
Probable error in range = 96 ft.

then Vulnerability factor $= \text{Vf} = \frac{120}{96} = 1.25$

(2) Enter table in extreme left hand (Vf) column at 1.2, follow in that horizontal line to column headed 5, and read range single shot probability=RSSP= 0.6008.

CHART NO. 1

Curve for determining SINGLE SHOT PROBABILITY
(considering range and deflection errors separately)

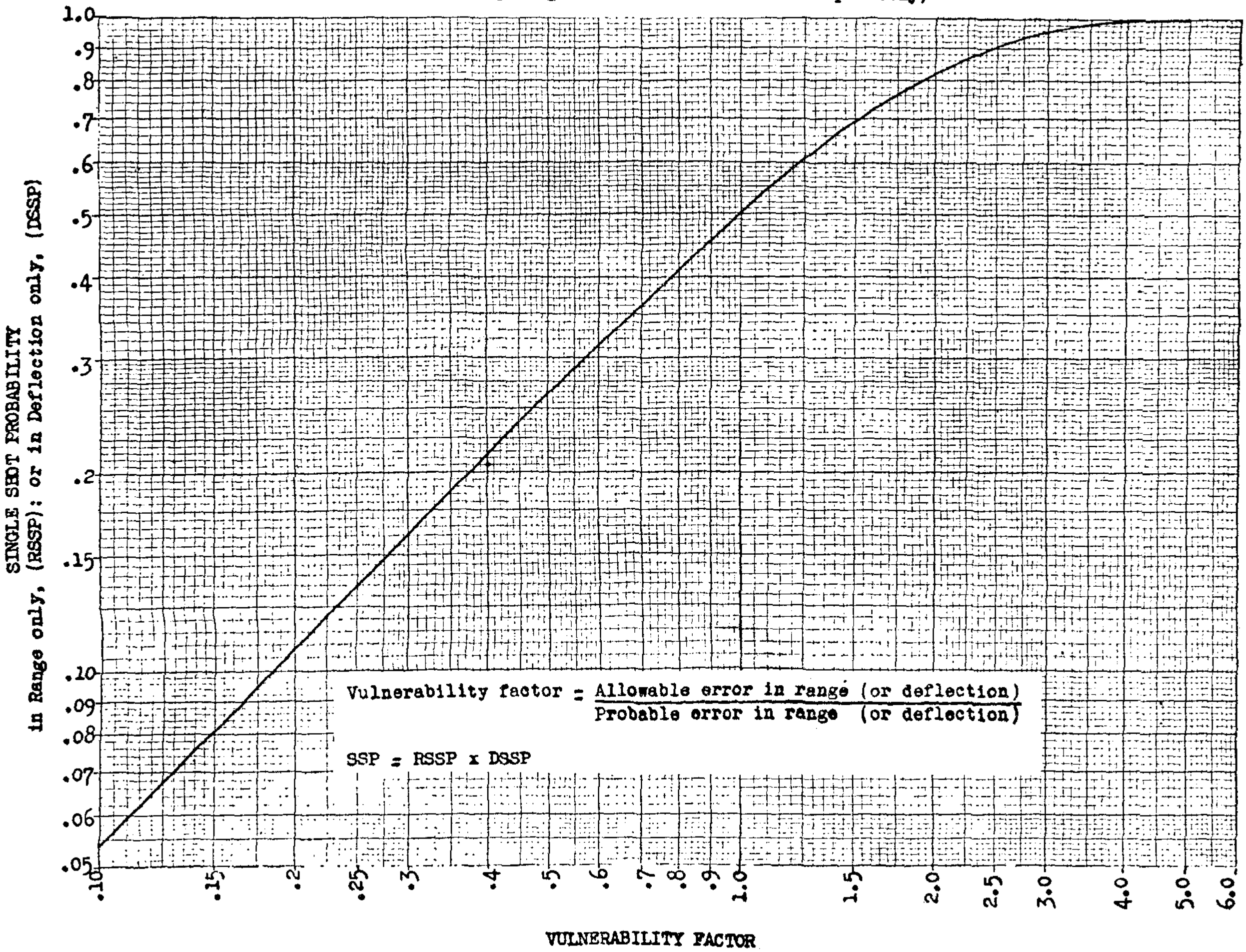
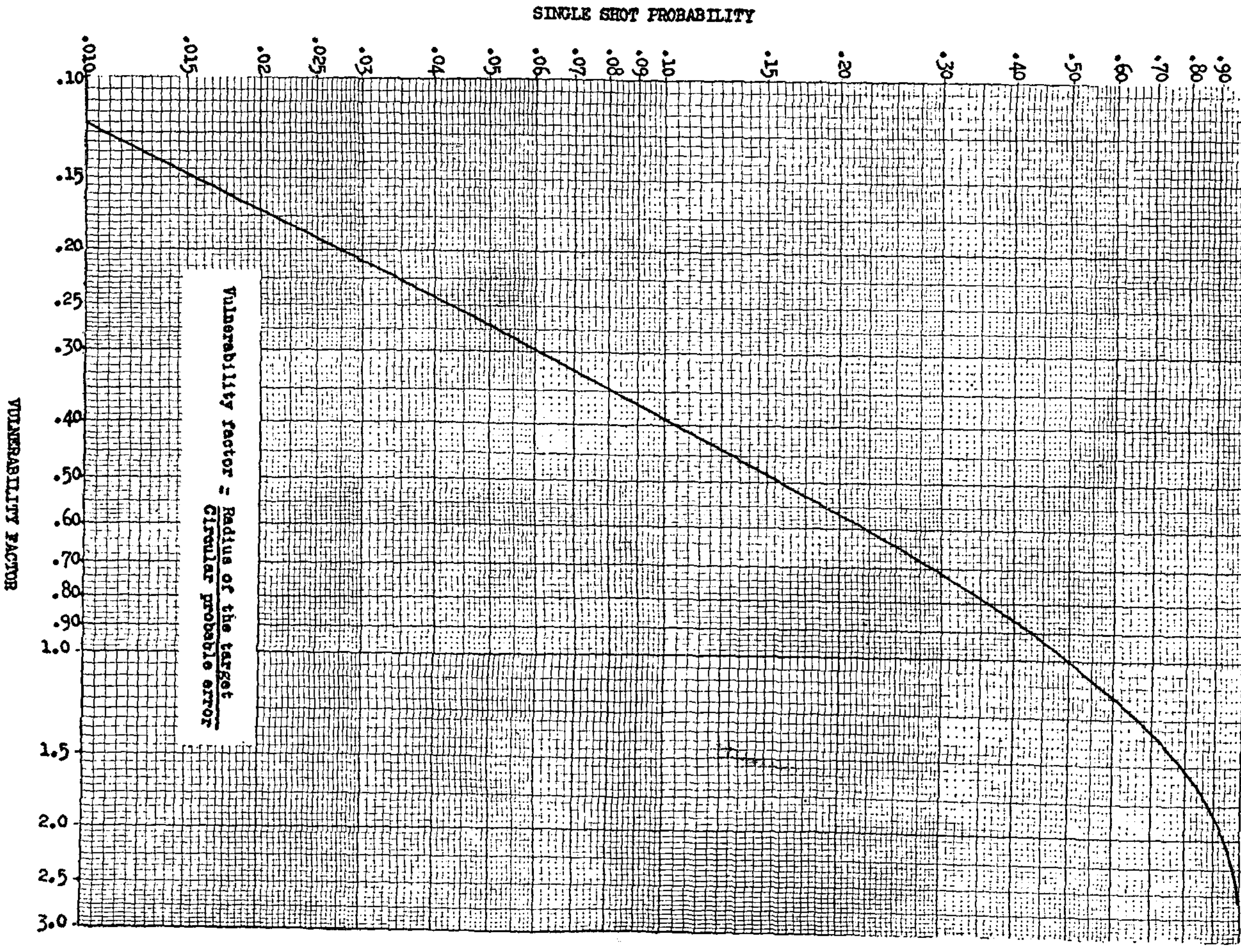


CHART NO. 2

Curve for determining **SINGLE SHOT PROBABILITY**
(Considering circular targets and circular probable errors)



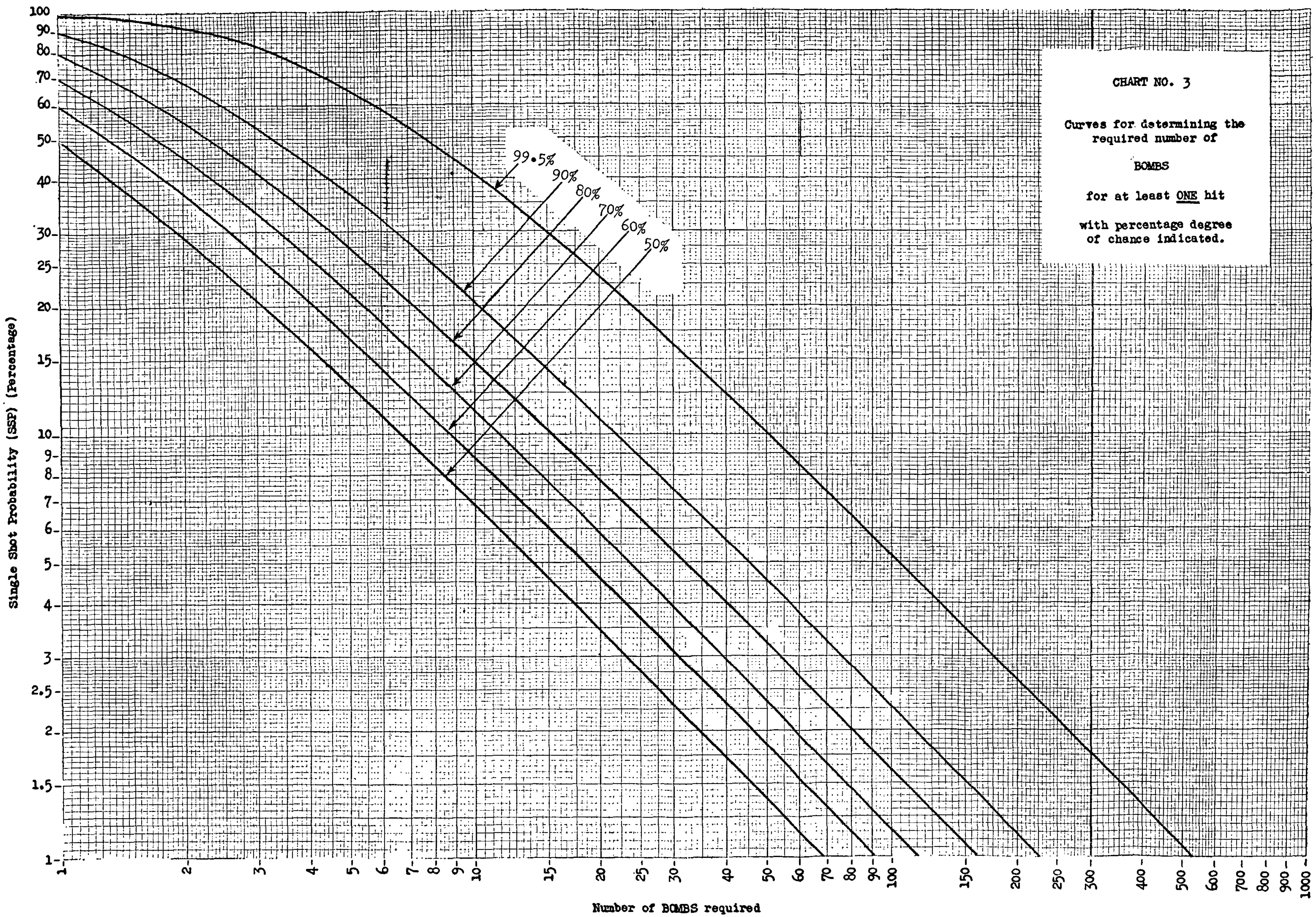


CHART NO. 3
Curves for determining the required number of
BOMBS
for at least ONE hit
with percentage degree of chance indicated.
99.5%
90%
80%
70%
60%
50%
Single Shot Probability (SSP) (Percentage)
100
90
80
70
60
50
40
30
25
20
15
10
9
8
7
6
5
4
3
2.5
2
1.5
1
1
2
3
4
5
6
7
8
9
10
15
20
25
30
40
50
60
70
80
90
100
150
200
250
300
400
500
600
700
800
900
1000
Number of BOMBS required

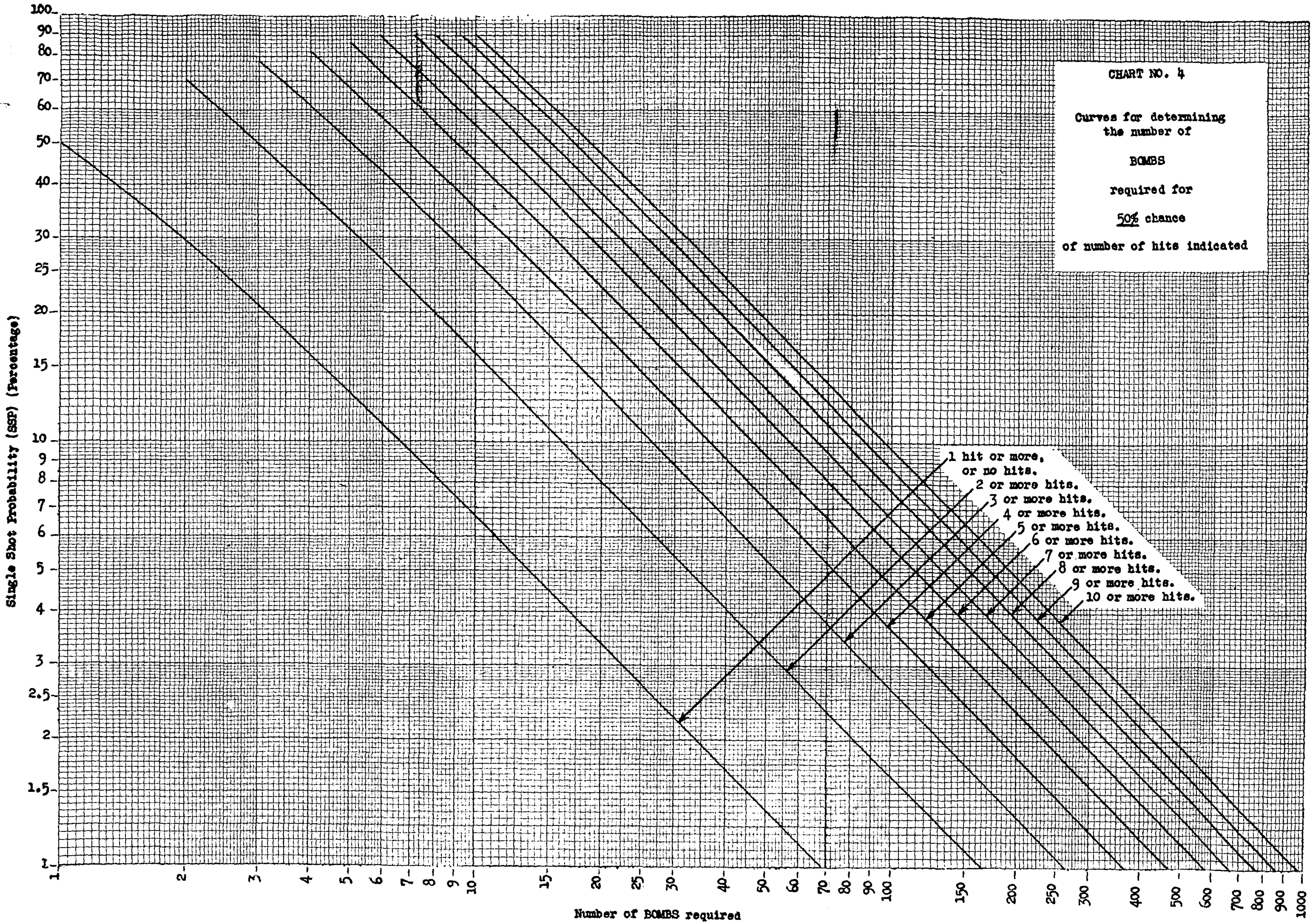


CHART NO. 4
Curves for determining the number of
BOMBS
required for
50% chance
of number of hits indicated
1 hit or more, or no hits.
2 or more hits.
3 or more hits.
4 or more hits.
5 or more hits.
6 or more hits.
7 or more hits.
8 or more hits.
9 or more hits.
10 or more hits.
Single Shot Probability (SSP) (Percentage)
Number of BOMBS required

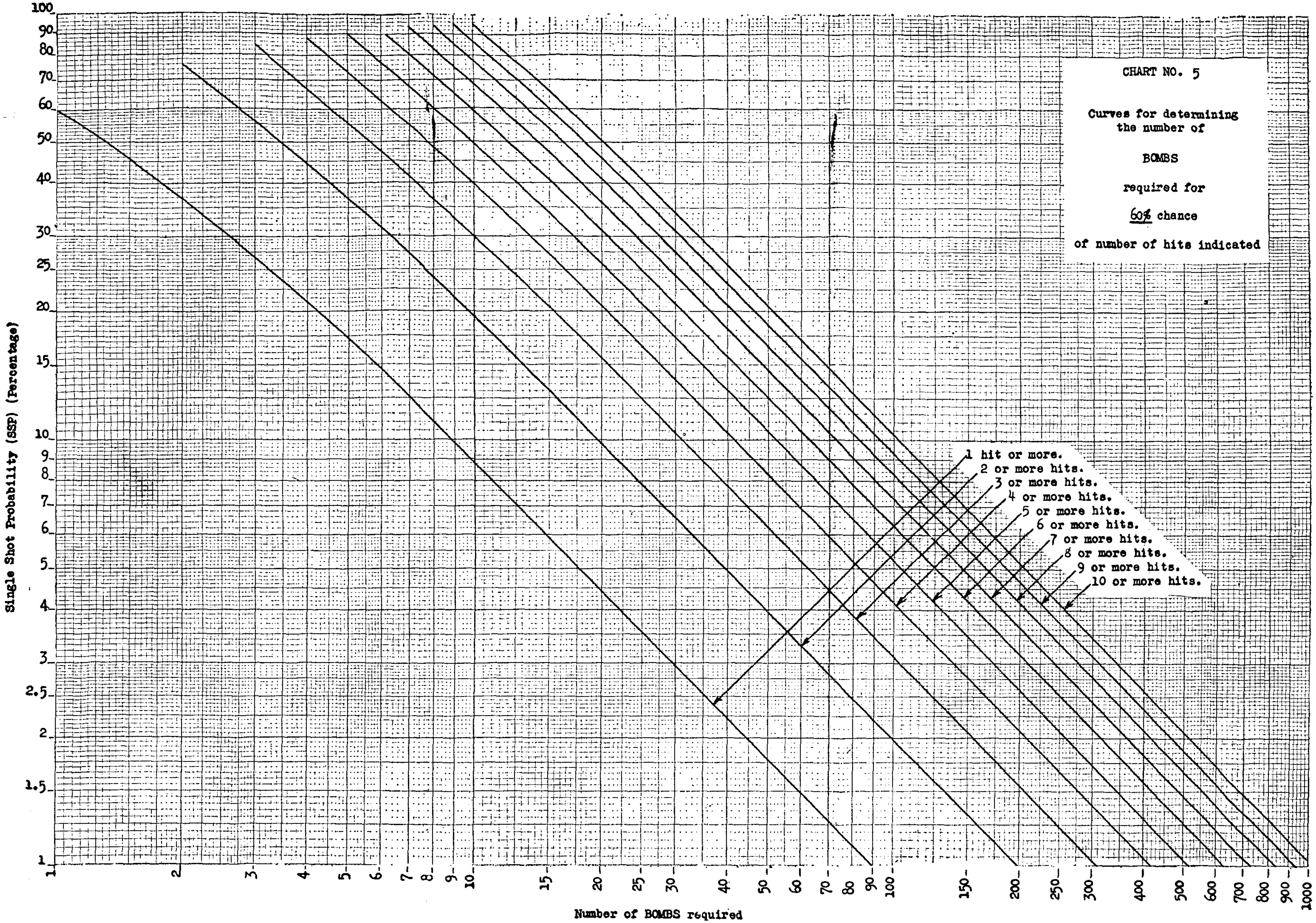


CHART NO. 5
Curves for determining the number of
BOMBS
required for
60% chance
of number of hits indicated
1 hit or more.
2 or more hits.
3 or more hits.
4 or more hits.
5 or more hits.
6 or more hits.
7 or more hits.
8 or more hits.
9 or more hits.
10 or more hits.
Single Shot Probability (SSP) (Percentage)
100
90
80
70
60
50
40
30
25
20
15
10
9
8
7
6
5
4
3
2.5
2
1.5
1
1
2
3
4
5
6
7
8
9
10
15
20
25
30
40
50
60
70
80
90
100
150
200
250
300
400
500
600
700
800
900
1000
Number of BOMBS required

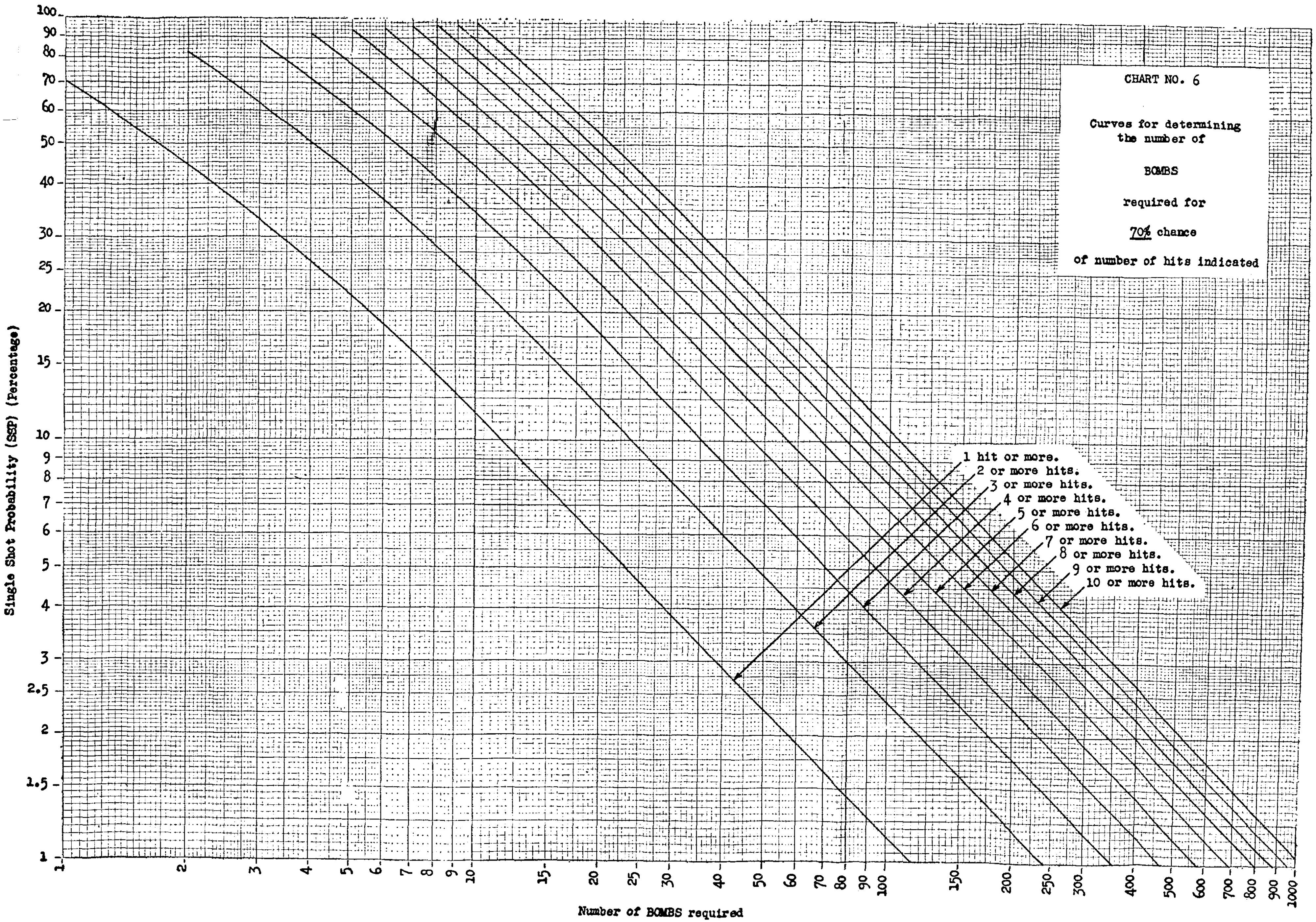


CHART NO. 6
Curves for determining the number of
BOMBS
required for
70% chance
of number of hits indicated
1 hit or more.
2 or more hits.
3 or more hits.
4 or more hits.
5 or more hits.
6 or more hits.
7 or more hits.
8 or more hits.
9 or more hits.
10 or more hits.
Single Shot Probability (SSP) (Percentage)
Number of BOMBS required

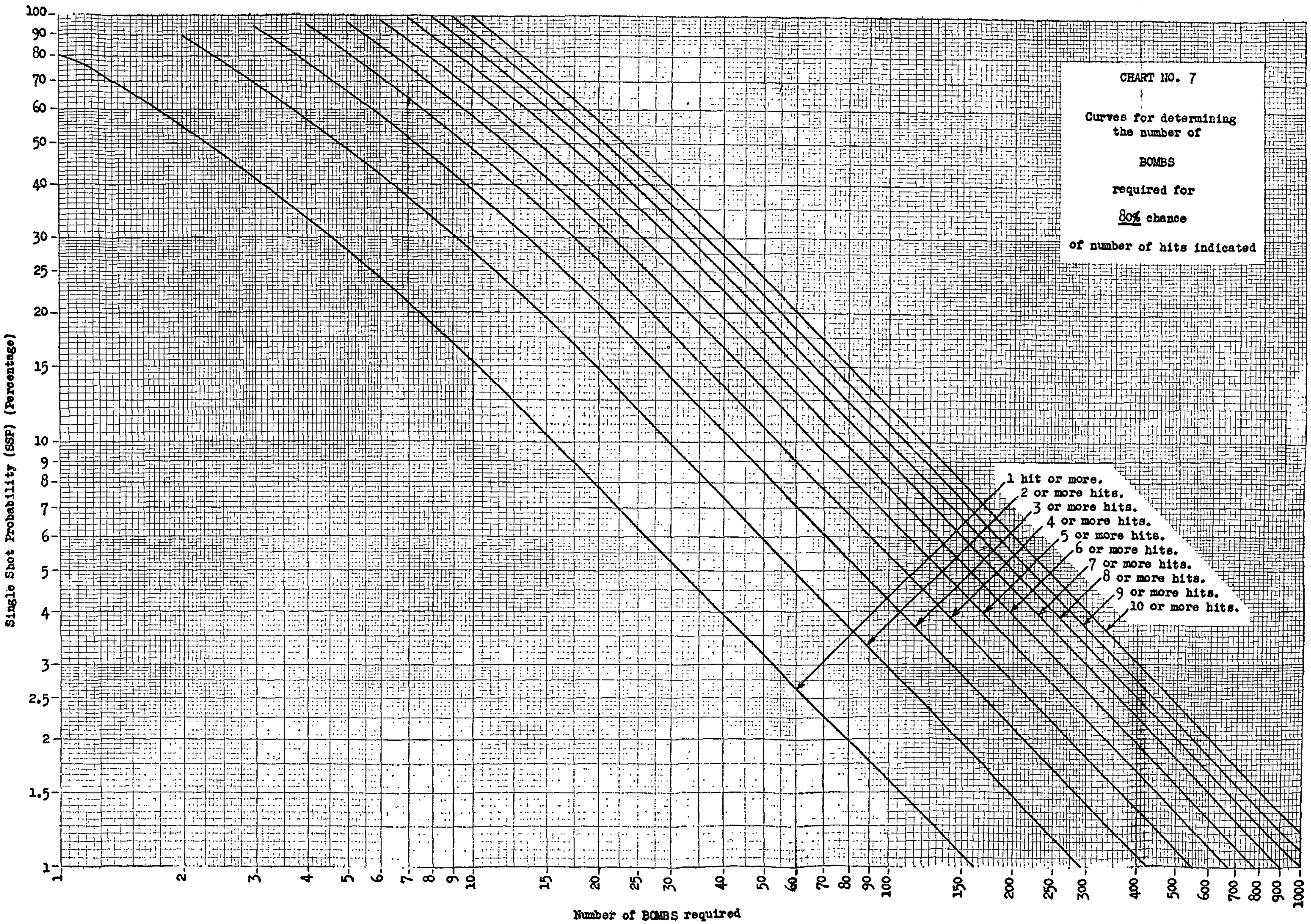


CHART NO. 7
Curves for determining the number of
BOMBS
required for
80% chance
of number of hits indicated
1 hit or more.
2 or more hits.
3 or more hits.
4 or more hits.
5 or more hits.
6 or more hits.
7 or more hits.
8 or more hits.
9 or more hits.
10 or more hits.
Single Shot Probability (SSP) (Percentage)
Number of BOMBS required
100
90
80
70
60
50
40
30
25
20
15
10
9
8
7
6
5
4
3
2.5
2
1.5
1
1
2
3
4
5
6
7
8
9
10
15
20
25
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400
500
600
700
800
900
1000

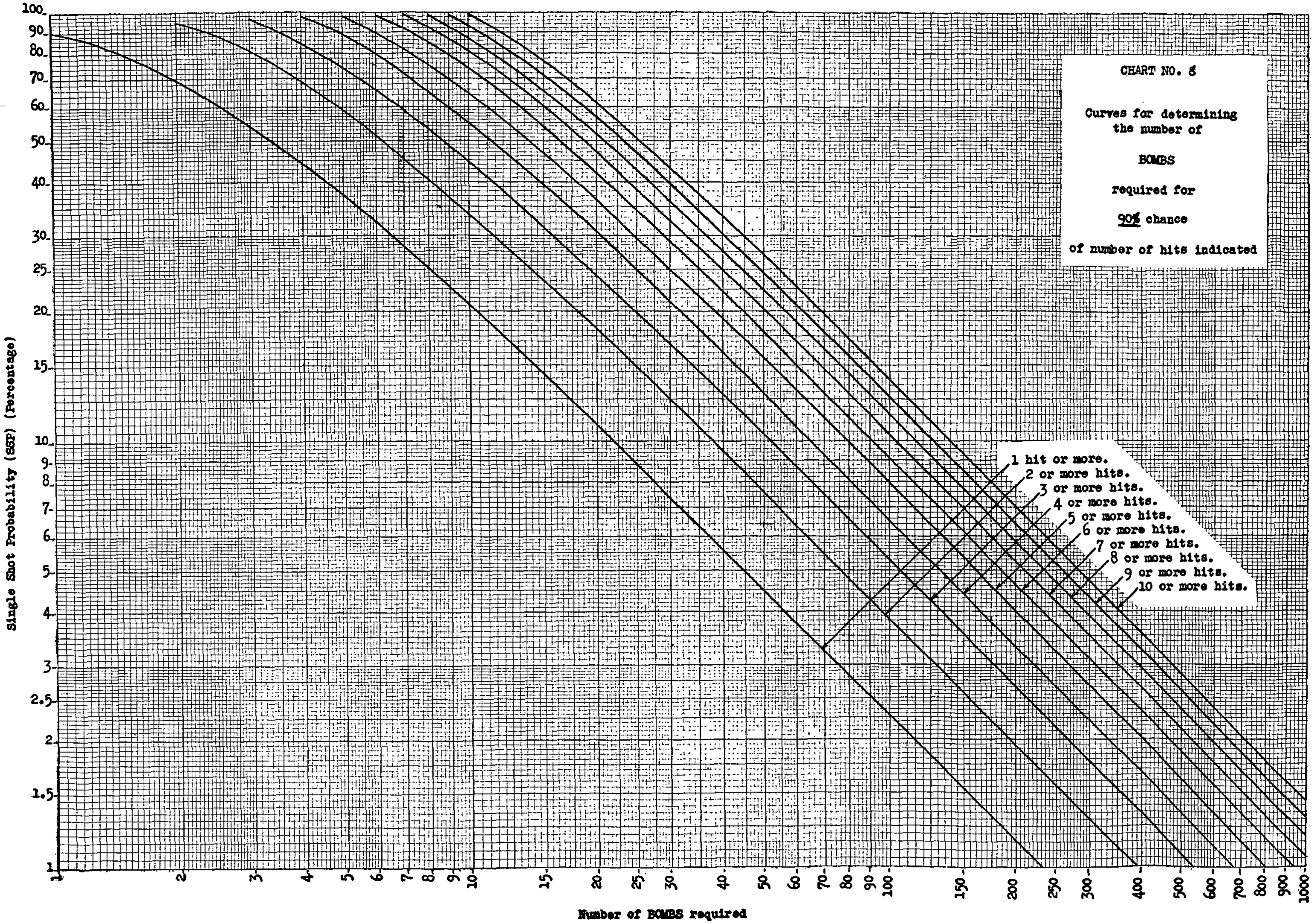


CHART NO. 8
Curves for determining the number of
BOMBS
required for
90% chance
of number of hits indicated
1 hit or more.
2 or more hits.
3 or more hits.
4 or more hits.
5 or more hits.
6 or more hits.
7 or more hits.
8 or more hits.
9 or more hits.
10 or more hits.
Single Shot Probability (SSP) (Percentage)
Number of BOMBS required

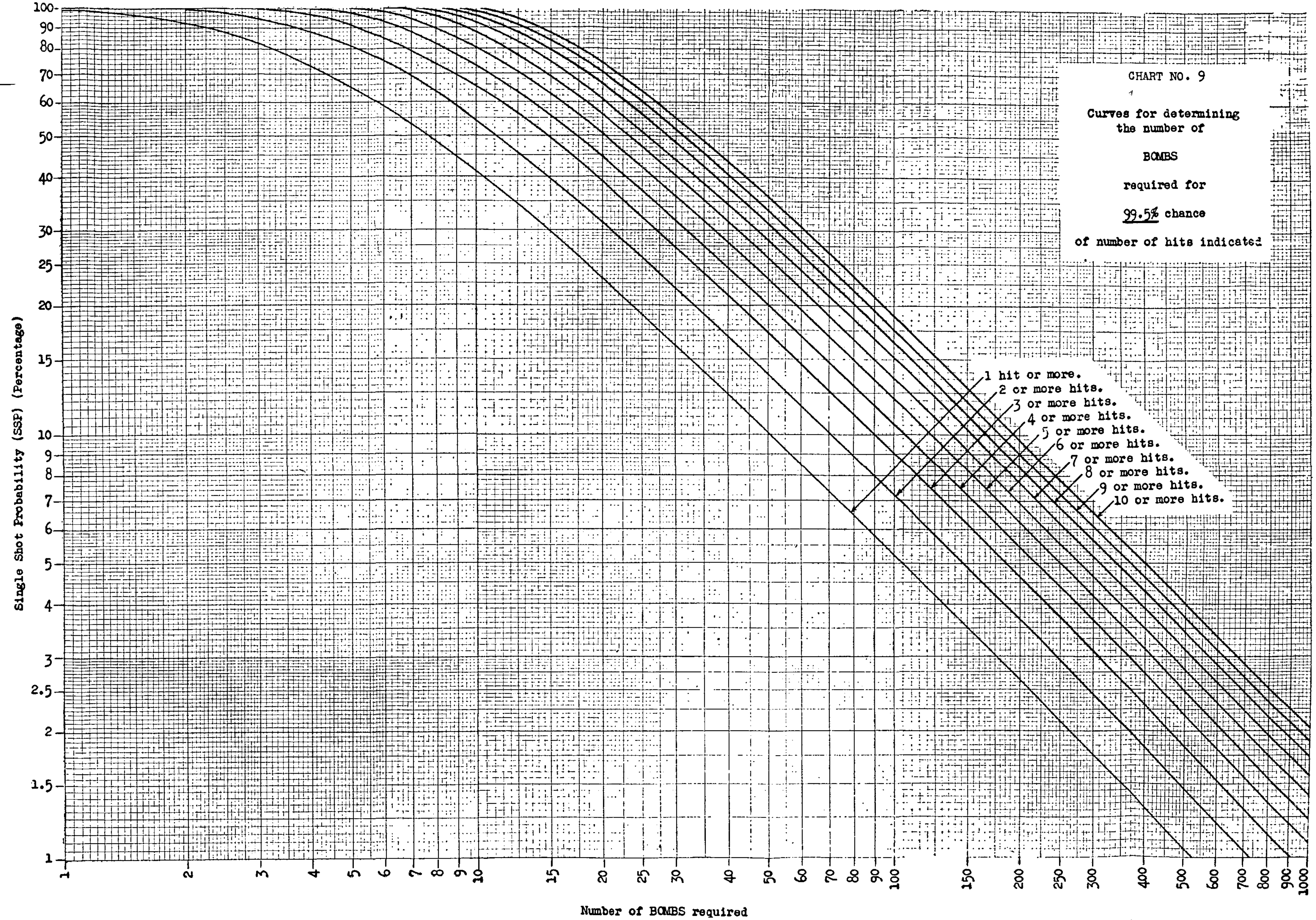
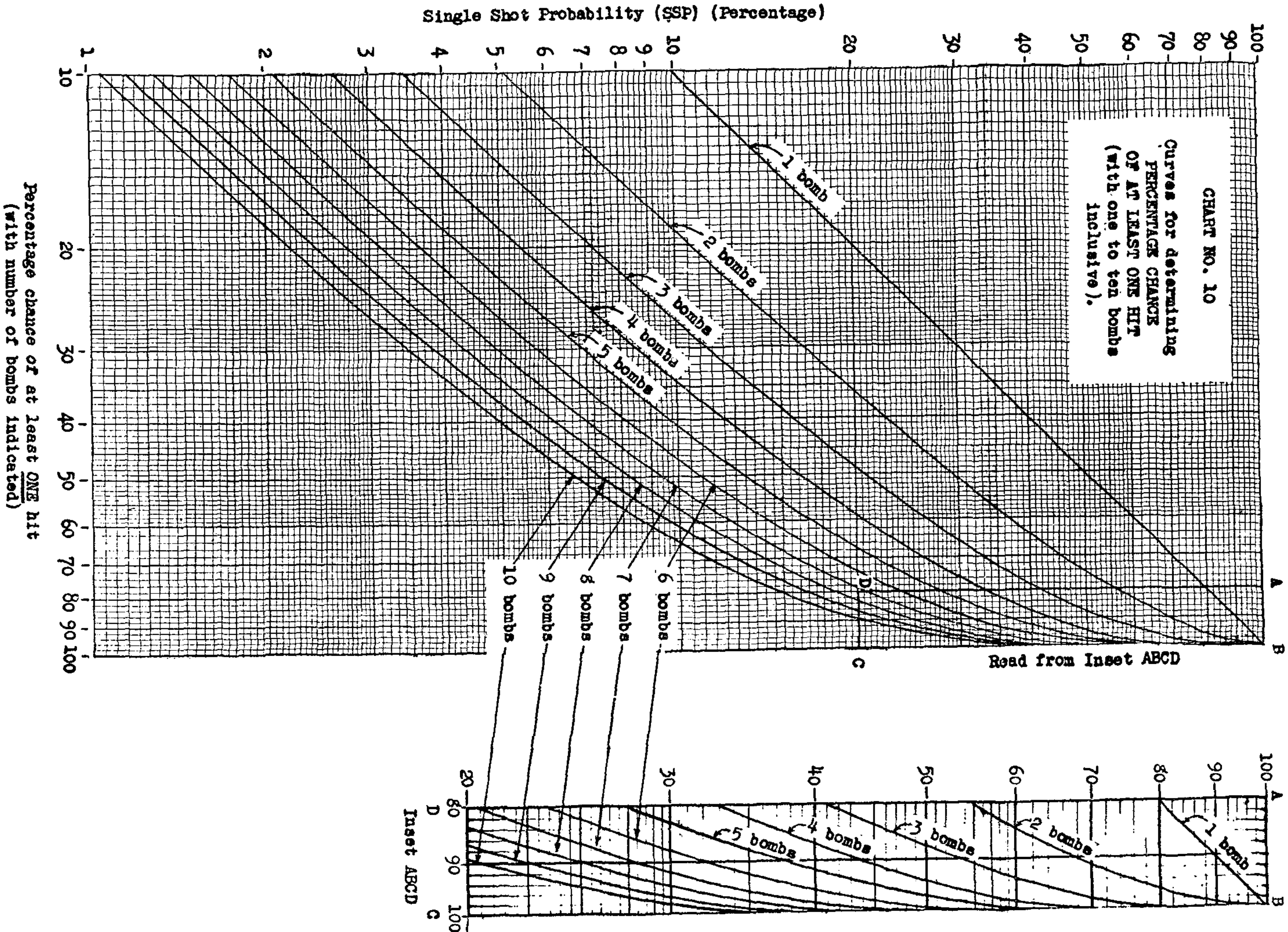


CHART NO. 9
Curves for determining the number of
BOMBS
required for
99.5% chance
of number of hits indicated
1 hit or more.
2 or more hits.
3 or more hits.
4 or more hits.
5 or more hits.
6 or more hits.
7 or more hits.
8 or more hits.
9 or more hits.
10 or more hits.
Single Shot Probability (SSP) (Percentage)
Number of BOMBS required


Single Shot Probability (SSP) (Percentage)
CHART NO. 10
Curves for determining PERCENTAGE CHANCE OF AT LEAST ONE HIT (with one to ten bombs inclusive).
Percentage chance of at least ONE hit (with number of bombs indicated)
1 bomb
2 bombs
3 bombs
4 bombs
5 bombs
6 bombs
7 bombs
8 bombs
9 bombs
10 bombs
Read from Inset ABCD
Inset ABCD
A
B
C
D