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FM 4-107

WAR DEPARTMENT

# COAST ARTILLERY FIELD MANUAL

## BARRAGE BALLOON ORGANIZATION, TACTICS, AND TECHNIQUE

March 14, 1942

*RESTRICTED*

FM 4-107

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BARRAGE BALLOON

## ORGANIZATION, TACTICS, AND TECHNIQUE

*Printed at*

THE ARMY FIELD PRINTING PLANT,
THE COAST ARTILLERY SCHOOL
FORT MONROE, VIRGINIA: 1942

SAN DIEGO STATE UNIVERSITY 1897

WAR DEPARTMENT,
WASHINGTON, March 8, 1942.

FM 4-107, Coast Artillery Field Manual, Barrage Balloon, Organization, Tactics, and Technique, is published for the information and guidance of all concerned.

[A. G. 062.11 (12-24-41).]

BY ORDER OF THE SECRETARY OF WAR:

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DISTRIBUTION:

B and H 1 (3); R and H 4 (2); AA Bn 4 (3); IC and H 4 (10).

(For explanation of symbols see FM 21-6.)



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# COAST ARTILLERY FIELD MANUAL

## BARRAGE BALLOON

## ORGANIZATION, TACTICS, AND TECHNIQUE

## PART ONE
## GENERAL

## CHAPTER 1

## CHARACTERISTICS OF MATÉRIEL


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### SECTION I

### GENERAL

■ 1. DEFINITION.—The term "barrage balloons" refers to balloons used to support metal cables for the purpose of denying important air space to hostile aircraft in flight. When a number of balloons are sited according to a plan and are operating to defend a given point or area, the barrier presented to hostile aircraft is called a "balloon barrage."

■ 2. MATÉRIEL.—The characteristic matériel of a balloon barrage consists principally of balloons, inflation gases, cables and lethal devices, and winches.

### SECTION II

### BALLOONS

■ 3. DEFINITION.—Generally speaking, a balloon is a bag made of very light material which when inflated with any lighter-than-air gas rises and floats in the air.

■ 4. AEROSTATICS.—A barrage balloon maintains its position in the air because of static lift of the gas in the balloon

and dynamic lift from kiting action. Sufficient gas must be used to lift the balloon, rigging, ballast, lethal device, and cable and still have a sufficient extra lift for stability in flight. The lift of the gas in the balloon depends on the kind of gas and its purity, and on the atmospheric pressure, temperature, and humidity. A balloon once filled with gas will generally maintain its lift through all changes in pressure and temperature, provided no gas is lost by valving or leaking.

■ 5. TYPES NOW IN USE.—*a.* (1) *Dilatable.*—The dilatable balloon maintains its shape and pressure on the gas by means of internal elastic rigging.

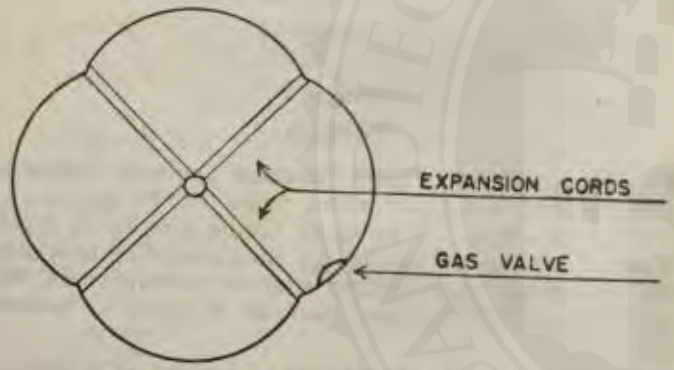



Figure 1.—Cross section of dilatable balloon.

(2) *Ballonet.*—The ballonet balloon has two chambers: a gas chamber in the upper portion, and an air chamber in the lower portion. The two chambers are separated by a fabric diaphragm which is pressed up or down as the gas contracts or expands.

*b.* Both types are streamlined in shape and have fins near the tail for stability. The lower vertical fin is air-inflated and acts as a rudder in pointing the nose of the balloon into the wind. For other details on balloons see appendix I.





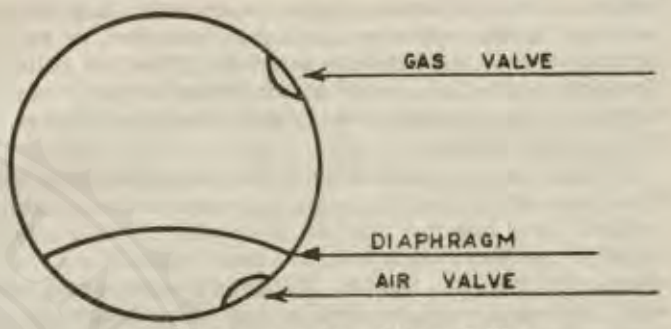



Figure 2.—Cross section of ballonet balloon.

■ 6. CLASSES.—*a.* Barrage balloons may be classed as "low-altitude," "high-altitude," and "special." Low-altitude balloons may be flown to an altitude of 7,500 feet; high-altitude balloons may be flown above 7,500 feet; and special balloons may be produced and flown to meet special situations or conditions for which the standard high-altitude balloons and low-altitude balloons are not suited. Generally speaking, the larger the balloon the greater the altitudes it will attain.

*b.* The low-altitude balloon is the type having the most universal application. Low-altitude balloons are flown within the cloud layer, whenever it is practicable to do so, for several reasons:

(1) To deny the use of the cloud layer by hostile aircraft as a means of concealment.

(2) To conceal the balloons and thus render them less vulnerable to attack.

(3) To render the dispositions of the balloons less visible from hostile aircraft.

(4) To prevent the dispositions of the balloons from disclosing the locations of defended areas on the ground.

(5) To prevent the superheating of the balloons by direct rays from the sun.

*c.* High-altitude balloons should be capable of being flown up to such altitudes as would preclude precision

bombing. Such altitudes can be reached by large single balloons, by connecting two balloons in tandem, or by attaching kites to the cables to assist the lift of the balloon. The large single balloon has an advantage in that it can be flown or hauled down more quickly than the tandem or kite-assisted balloons.

*d.* Small barrage balloons are effective only against low-flying aircraft employing hedge-hopping or dive-bombing tactics. They may be attached by cables to the masts of ships, or used for the protection of small installations which offer only precision targets. Mobile units, equipped with small balloons, could be used to accompany armies in the field and employed in the protection of vital routes, defiles, or installations against any form of low-flying air attack.

## SECTION III

## INFLATION GASES

■ 7. GASES COMMONLY USED.—*a. Hydrogen.*—Hydrogen is the lightest gas known, and therefore has the greatest lifting power. The ratio of its weight to the weight of air is 69 to 1,000. It can be manufactured economically in large quantities, but has the disadvantage of being inflammable and very explosive when mixed with oxygen.

*b. Hydrogen generation.*—At present, hydrogen is produced in the field for barrage balloon needs by the high-pressure ferrosilicon process. The chemical reactions taking place are—

$2\ NaOH + Si + H_2O = Na_2SiO_3 + 2H_2$ (iron acts as catalyst).

$Si + 3H_2O = H_2SiO_3 + 2H_2$ (NaOH acts as catalyst).

The relative quantities produced by the two reactions are variable, but average results show that to produce 1,000 cubic feet of hydrogen, about 60 pounds of ferrosilicon, 90 pounds of caustic soda, and 267 pounds or more of water are required. The high-pressure hydrogen generator now used is assembled on a trailer unit. It weighs about 18,000 pounds, and is capable of producing from 4,000 to 5,000 cubic feet of hydrogen per hour during operation.





*c. Helium.*—Helium has slightly more than 90 percent of the lift of hydrogen. It is noninflammable, but the supply is limited. At present, it is extracted from a mixture of natural gases near Amarillo, Texas. Since the supply is limited and will not maintain extensive balloon barrages, when large volumes of lifting gas are needed it will be necessary to resort to the use of hydrogen.

## SECTION IV

## CABLES AND LETHAL DEVICES

■ 8. PURPOSE OF CABLE.—The balloon anchoring cable, together with any lethal devices attached, constitutes the principal weapon for hitting hostile aircraft. The cable reaches from the winch to the junction assembly of the balloon. No nets or cables between balloons are used. The anchoring cable and attached lethal devices are sufficient to accomplish the mission of barrage balloons.

■ 9. CABLE TYPES.—The present flexible steel anchoring cable is 3/16 inch in diameter and is composed of 7 strands of 19 wires per strand. This cable weighs approximately 65 pounds per 1,000 feet, and has a tensile strength of approximately 5,100 pounds. A heavier cable is used where inaccessibility of the site makes operational control impractical, such as when the balloons are anchored to buoys, etc.

■ 10. SNAPPING.—The direction from which an aircraft hits a cable affects the snapping property of the cable. When an aircraft approaches down wind, it hits the cable inside the catenary formed by the suspended cable. When struck from this direction, the cable is more likely to snap under impact than when it is hit from the outside of the catenary and the slack is taken up more gradually.

■ 11. LETHAL DEVICES.—Because the cable may snap under certain conditions of cable tension and speed of enemy aircraft without causing damage to the aircraft, and also because of the possible future use of balloon sweeping devices attached to aircraft, lethal devices will be used in conjunction with cable.

## SECTION V

## WINCHES

■ 12. CHARACTERISTICS.—The winch is a gasoline-power-driven machine used to control the raising and lowering of a barrage balloon. The ability to store a great length of cable under even tension is a distinguishing feature incorporated in the design of the barrage balloon winch. The reeling in of cable is done by surge drums, and the cable is stowed on the storage drum under a constant tension.

■ 13. CLASSES.—*a.* There are two general classes of winches: mobile and fixed. The mobile winch is attached to a truck as an integral part thereof, and the fixed winch is demountable from a truck for emplacement on the ground.

*b.* The present standard fixed winch is the type A-9. It weighs 3,150 pounds complete, and consists of five main assemblies: the power plant, the clutch and transmission assembly, the winch assembly, the lead-off gear assembly, and the frame assembly. The winch is transported on a 6 by 6 (4-dt.), 2½-ton cargo truck, and is so designated that it can be bolted to the chassis of the truck. This winch can also be mounted on a boat for use at water-borne sites.

■ 14. METHODS OF USE.—The balloon may be flown from the winch by either of two methods, direct or indirect. In the direct method of flying, the balloon is fastened to the cable as it leaves the lead-off gear, and the ascension point is at the winch. In the indirect method, the cable from the winch passes through a snatch block anchored at a distant point, which becomes the ascension point.





## CHAPTER 2

## EFFECT OF WEATHER ON MATÉRIEL AND BALLOON OPERATION

■ 15. INFLUENCE OF WEATHER.—Weather conditions greatly influence barrage balloons and their operation, the number to be flown, and the altitudes at which they may be flown. The weather conditions having important effects are electrical disturbances (thunderstorms), wind, clouds, and precipitation.

■ 16. ELECTRICAL DISTURBANCES.—*a. Effect on balloons.*—Balloons are extremely susceptible to destruction by electrical action. Balloons have been destroyed under conditions where there would otherwise have been no actual lightning discharge to the earth, and by strokes so weak that thunder could not be heard at the ground. Experience has shown that there is great danger to balloons from lightning from all precipitating cumulonimbus clouds, commonly known as thunderheads, whether the precipitation consists of rain, hail, or snow. The danger of lightning strokes from nonprecipitating cumulus clouds must also be recognized.

*b. Effect on personnel.*—The balloon cable in flight is in reality a high-flying lightning conductor. The grounding of winches and cables is imperative. Electrical disturbances have an unnerving effect on personnel until the men understand the behavior of lightning and the methods for its control.

■ 17. WIND.—*a. Velocity.*—The velocity of the wind affects the maneuvering and flight of barrage balloons as follows:

(1) The greater the wind velocity above 15 mph at the surface, the greater the number of men required to maneuver a balloon.

(2) A ground wind of 35 mph prevents successful ground maneuvering with manpower.

(3) When the wind velocity exceeds 50 mph, or line squalls pass over the area, the possibility of balloons ripping or breaking their cables exists. The dynamic lift from wind passing over a balloon depends on the velocity of the wind and trim of the balloon.

(4) Whenever the wind pressure exceeds the gas pressure inside a balloon at the altitude at which the balloon is flying, the nose of the balloon will cup until the wind and gas pressures are equal. When this occurs, the balloon is likely to dive.

*b. Direction.*—The direction of the wind affects the maneuvering but not the flight of barrage balloons.

■ 18. CLOUDS.—The existence or nonexistence of clouds affects the altitude at which balloons may be flown as follows:

*a.* When the ground cannot be observed from the air owing to cloud formations, fog, or industrial haze, barrage balloons which are visible from the air act as ground target indicators. This is particularly true of small barrages around vital points.

*b.* The amount of cloudiness is an important factor in determining the effect of the direct rays of the sun on the balloon. The sun increases the temperature of the gas in the balloon above that of the surrounding atmosphere. This superheating is likely to occur from 4 hours after sunrise until 1 hour before sunset. The amount of superheat will affect the altitude at which a balloon may be flown without loss of gas.

■ 19. PRECIPITATION.—Snow falling upon a balloon must be removed if it materially increases the weight of the balloon. Snow and ice formation on the valves of a balloon will cause their malfunctioning. Rain alone does not materially affect the flying or maneuvering of a balloon.





# PART TWO
# ORGANIZATION

## CHAPTER 1
## FUNDAMENTALS OF ORGANIZATION

Paragraphs
SECTION I. Air defense ..... 20-25
II. Interceptor and region commands ..... 26-27

### SECTION I
### AIR DEFENSE

■ 20. GENERAL.—The fundamentals of organization discussed in FM 4-5 apply to barrage balloons. In addition, the following discussion of air defense organization also applies to barrage balloons.

■ 21. DEFINITION.—Air defense is the direct defense against enemy air operations. Operations such as reconnaissance and the bombing of enemy airdromes, and the operations of ground and naval forces to deny air bases to the hostile forces, do not properly fall within the scope of air defense.

■ 22. CATEGORIES OF AIR DEFENSE.—*a. Active.*—Active defense takes place in the air space through which hostile aircraft move. Active air defense is provided principally by pursuit aircraft and antiaircraft artillery.

*b. Passive.*—Passive defense takes place at the surface objective or area against which hostile air operations are directed. Passive air defense includes all measures taken to render surface objectives less susceptible to observation or bombardment, to control and protect personnel and matériel, and to restrict any activity that might constitute a direct aid to the enemy.

■ 23. FORMS OF AIR DEFENSE.—*a. Local.*—The purpose of local air defense is to provide defense for a specific objec-

tive or small locality. Local defense forces are disposed so as to prevent hostile movement toward the defended objective. Local air defense may be provided by antiaircraft artillery, antiaircraft artillery and barrage balloons, pursuit aviation, pursuit aviation in conjunction with antiaircraft artillery and barrage balloons, or pursuit aviation and antiaircraft artillery. Pursuit aviation is not ordinarily employed in local defense. Such employment fails to exploit its outstanding capability, which is tactical mobility.

*b. General.*—The purpose of general air defense is to defend a large area, embracing a greater number of potential objectives than can be defended effectively by local defenses. A general defense provides a measure of defense throughout a whole continuous air space, thereby affording a degree of protection to communications, large cities, and widely separated objectives not economically susceptible to local defense. A general air defense is conducted by pursuit aviation, supported by an Aircraft Warning Service. Any local defenses within the general defense area serve to support the general defense.

■ 24. Forms of Passive Air Defense.—*a. Control of direct aids to hostile aviation.*—These aids consist of illumination and radio emissions. Illustration is relatively simple to control, and if not controlled, constitutes a direct aid to hostile aircraft. Measures are therefore instituted for control of illumination and for blackout. Radio emissions may be used as an aid to hostile aircraft navigation. Radio stations may be used for position finding or homing. Radio is relatively simple to control, and measures to that end are taken.

*b. Air raid precautions.*—These precautions include all passive defense measures other than radio and light control. Air raid precautions include permanent protective measures, such as camouflaging, dispersing, bombproofing, sandbagging, construction of air raid shelters, enactment of legislation, organization of control systems, etc. In addition to these permanent measures, there are measures which are taken only when an air raid is imminent. These





measures initially take the form of emergency raid plans. When activated by the air raid warning system, the emergency plans are translated into terms of emergency raid action.

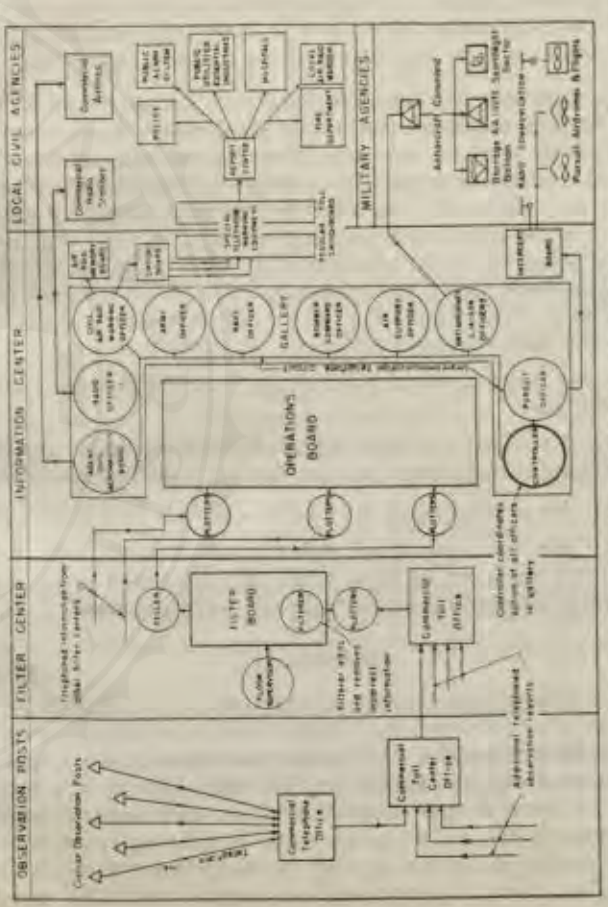



Figure 3.—Organization of Aircraft Warning Service.

c. *Responsibility.*—Passive defense of military personnel and installations is a responsibility of the local military commander. Passive defense of the civil populace and civil installations is a civil function. The active air defense commander, while not responsible for local passive defense, coordinates passive defense agencies so that sound policies will be established for control of direct aids to the enemy, and issues orders for putting these controls into effect.

■ 25. AIRCRAFT WARNING SERVICE.—*a.* The Aircraft Warning Service amasses information relative to the movements of aircraft over an area and disseminates this information to interested agencies. The Aircraft Warning Service is both an information service for friendly pursuit aviation and a general air raid warning service. It is so organized as to meet the requirements of pursuit aviation, thereby automatically being more adequate for all air raid warning functions. The organization of an Aircraft Warning Service and the flow of information are illustrated in figure 3.

*b.* Air raid warnings for barrage balloons are designated as follows:

(1) *Air raid warning RED.*—Hostile aircraft are approaching a defended area and an air raid is imminent.

(2) *Air raid warning YELLOW.*—An air raid is possible.

(3) *Air raid warning WHITE.*—Hostile aircraft have not been observed in the vicinity of a defended area; or an air raid is over and enemy aircraft have departed.

## SECTION II

## INTERCEPTOR AND REGION COMMANDS

■ 26. PURPOSE.—The interceptor command of an air force is charged with the general air defense of the area in which the air force is operating. If the area defended by an interceptor command is too large to be practically controlled by a single command, it may be divided territorially into regions. A region command is charged with the general air defense of a region.





■ 27. ORGANIZATION.—*a. Interceptor pursuit.*—The primary means of defense used by interceptor or region commands is pursuit aircraft. All pursuit forces in the interceptor command are under the control of the interceptor commander. When assigned to a region by the interceptor commander, pursuit aircraft are then controlled by the regional commander.

*b. Aircraft Warning Service.*—An Aircraft Warning Service is organized in each region for the purpose of supplying information concerning the movements of hostile aircraft. Although operated largely by civilian personnel, the Aircraft Warning Service is controlled by the interceptor or regional commander.

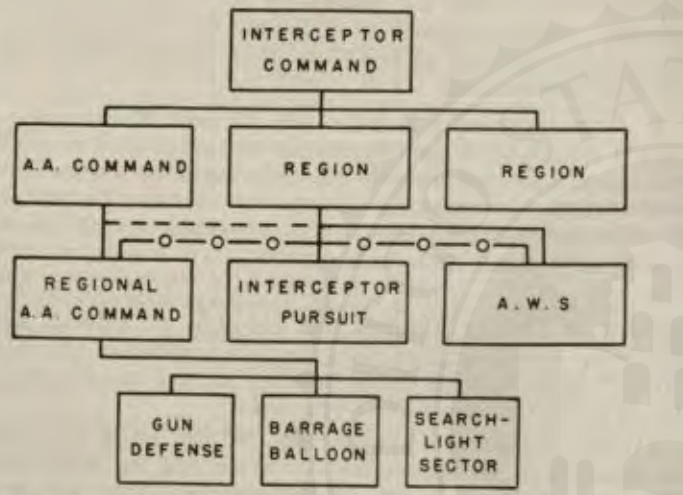
*c. Antiaircraft units in air defense.*—Pending the development of detailed doctrine and technical procedures, the following broad policies governing the operation of antiaircraft units with air force units in air defense are published for the guidance of all concerned:

(1) All antiaircraft and barrage balloon units assigned or attached to an interceptor command will be organized into an antiaircraft command, commanded by the antiaircraft commander, who will be directly under the interceptor commander.

(2) Antiaircraft commander of interceptor commands in continental United States (not in theaters of operations) will be assigned by the War Department. Antiaircraft commanders of other interceptor commands will be designated by theater of operations, department, or area commanders.

(3) Whenever an interceptor command is divided into regions, antiaircraft units within each region will be organized into a regional antiaircraft command. Regional antiaircraft commanders will be designated by the antiaircraft commander of the interceptor command.

(4) The interceptor commander will delegate such authority as is necessary to a region commander to insure the coordination of the action of antiaircraft units with the action of air units under the region commander's control.




Single lines indicate administrative relationships.
Double lines indicate tactical relationships only.

Figure 4.—Relationships of elements of active air defense.





# CHAPTER 2

# BARRAGE BALLOON UNITS

Paragraphs
SECTION I. General ..... 28-30
II. Barrage balloon units ..... 31-34

## SECTION I

## GENERAL

■ 28. GENERAL.—Barrage balloon troops are a part of the GHQ Reserve and as such are organized as separate battalions and as barrage balloon commands in order to meet the tactical requirements of any assignment.

■ 29. BALLOON BARRAGE.—*a*. The size of a balloon barrage will depend upon the size of the area to be defended and the amount of barrage balloon defense deemed necessary. A balloon barrage may be established by any barrage balloon unit from a platoon upwards to include two or more battalions.

*b*. The barrage commander is the senior coast artillery officer assigned to the unit or units operating the balloon barrage.

■ 30. ORGANIZATION.—The details of barrage balloon organization are discussed briefly in section II. Many changes resulting from further developments in this weapon may be expected from time to time, as research is constantly being conducted to improve both organization and technique. For complete information on organization, see current Tables of Organization.

## SECTION II

## BARRAGE BALLOON UNITS

■ 31. BARRAGE BALLOON COMMAND (T/O 4-312).—A barrage balloon command may be organized for the tactical

control, technical service, and supply of a single barrage operated by two or more battalions.

■ 32. BATTALION, SEPARATE, BARRAGE BALLOON (T/O 4-315).—The barrage balloon separate battalion is not an organic part of a larger unit. It is a self-contained unit, organized and equipped to operate independently in the field. A separate battalion may be assigned to a barrage balloon command, or may be employed as a separate unit for the protection of important areas or establishments.

■ 33. HEADQUARTERS AND HEADQUARTERS BATTERY, BARRAGE BALLOON BATTALION (T/O 4-316).—*a.* Headquarters and headquarters battery are organized for the purpose of providing the personnel necessary to assist the battalion commander and his staff in the performance of their duties.

*b.* Headquarters battery consists of—

Battery headquarters section.
Operations section.
Communication platoon.
Machine-gun section.
Supply section.
Motor transportation and maintenance section.
Service platoon.

(1) The battery headquarters section assists the headquarters battery commander (captain) and chaplain in the performance of their duties.

(2) The operations section furnishes personnel to assist the battalion adjutant, intelligence officer, barrage control officer, and plans and training officer in the performance of their duties. These staff officers are responsible for the technical and tactical training and employment of personnel of this section.

(3) The communication platoon maintains the battalion communication system, and is commanded by a second lieutenant, who is the battalion communication officer. He is responsible for the technical and tactical training of the platoon.

(4) The machine-gun section is at the disposal of battalion headquarters.





(5) The supply section is charged with supplying the battalion. It is commanded by a first lieutenant who is the battalion supply officer (S-4). This section handles and issues all supplies to the units of the battalion. It is composed of the personnel required to establish and operate the battalion supply office.

(6) The motor transportation and maintenance section supplies auto mechanics for the second echelon maintenance and, if necessary, some of the third echelon maintenance of the battalion transportation. It is also charged with supplying headquarters battery and messing battery personnel and officers of the battalion headquarters. It takes care of the machine guns and small arms of the battery.

(7) The service platoon is composed of matériel repair, gas service, and weather sections.

(*a*) The matériel repair section is responsible for maintaining balloons, winches, rigging, and other balloon equipment.

(*b*) The gas service section is charged with the purification of helium, manufacture of hydrogen, the delivery of gas to the batteries, and the maintenance and care of gas cylinders and gas generators.

(*c*) The weather section is responsible for supplying weather information to the battalion, keeping close watch on weather developments, and sending out timely weather warnings.

■ 34. BATTERY, BARRAGE BALLOON (T/O 4-317).—The barrage balloon battery consists of—

Battery headquarters.
Engineer and communication section.
Maintenance section.
Two platoons.

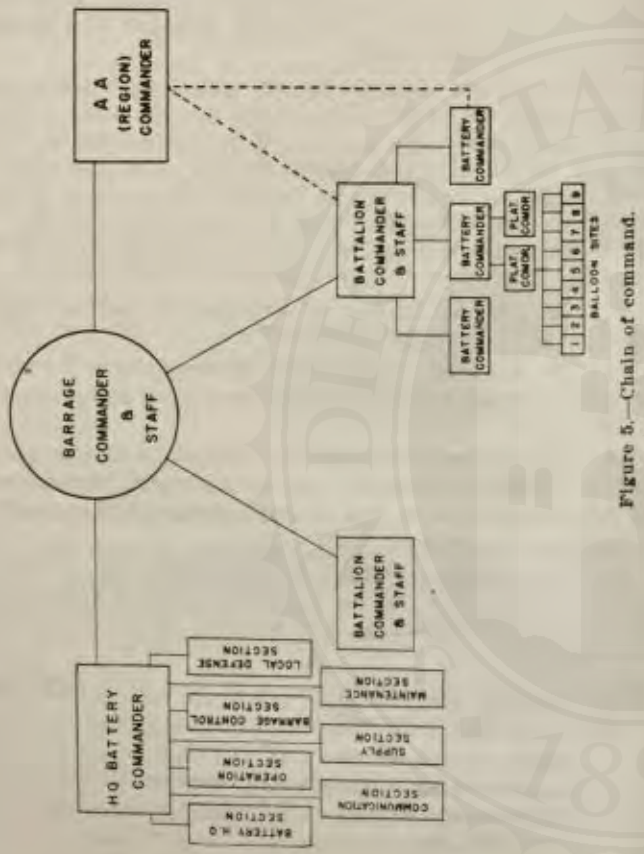



Figure 5.—Chain of command.





## CHAPTER 3

## DUTIES OF STAFF OFFICERS

■ 35. GENERAL.—*a.* Normal duties of staff officers are discussed in FM 101-5. However, there are certain duties peculiar to barrage balloon units which require special supervision by officers.

*b.* The officers who supervise these special duties include a barrage control officer and an assistant barrage control officer on the barrage balloon command staff and a barrage control officer on each battalion staff; a weather officer in the barrage balloon command and in each battalion; a gas service officer in the barrage balloon command and in each battalion; an engineer in the barrage balloon command and in each battalion; and an engineer and communication officer in each lettered battery. When the situation requires the presence of an officer 24 hours per day to perform any particular duty, such as in the case of the barrage control officer, other officers in the barrage balloon command or battalion may be delegated to perform these particular duties during certain shifts.

*c.* When two or more battalions combine to form a barrage or operate separate barrages in close proximity, the service platoons from the battalions' headquarters batteries may be combined at the barrage balloon command headquarters battery to form a service unit for the barrage or barrages.

■ 36. DUTIES OF BARRAGE CONTROL OFFICER.—*a. With barrage balloon command.*—(1) The barrage control officer on the staff of the barrage balloon command operates under the barrage balloon command S-3 as his assistant. He assembles data as to the tactical controls ordered by the interceptor or regional commander, wind and weather conditions, and all air activity; and maintains operation maps and charts. He keeps these data in a form that will assist

the barrage commander in making tactical decisions. He is also in command of the barrage control section of the barrage balloon command headquarters battery and uses this section to transmit to subordinate units the tactical commands of the barrage commander.

(2) The assistant barrage control officer assists the barrage control officer in the performance of his duties. He is second in command of the barrage control section and performs such duties as are delegated to him by the barrage control officer.

*b. With battalion.*—The barrage control officer on the battalion staff is charged with assembling and posting all data relative to the tactical control of the balloons in the battalion. He is stationed at the battalion command post and passes to subordinate units tactical commands of the battalion commander.

■ 37. WEATHER OFFICER.—*a. With barrage balloon command.*—The weather officer with the barrage balloon command is in command of the weather section of the service platoon of the barrage balloon command headquarters battery. He advises the barrage commander and his staff on matters pertaining to weather and supervises and coordinates the technical training of weather personnel under the direction of the barrage balloon command S-3.

*b. With battalion.*—The weather officer with the barrage balloon battalion is in command of the weather section of the service platoon of the battalion. He performs the following specific duties:

(1) Advises the battalion commander and staff on matters pertaining to weather.

(2) Supervises and coordinates the technical training of weather personnel under the direction of the battalion S-3.

(3) Establishes, maintains, and operates a weather section.





(4) Supplies the following services:

(*a*) Forecasts each 6 hours or more often if needed, including wind and lightning risks.

(*b*) When requested, makes hourly observations of wind and lightning conditions for record and distribution to batteries.

(*c*) Makes pilot balloon observations at 6-hour intervals.

(*d*) Supplies other weather information upon request.

(*e*) Reports unusual or emergency weather conditions when the occasion demands.

■ 38. GAS SERVICE OFFICER.—*a. With barrage balloon command.*—The gas service officer with the barrage balloon command is in command of the gas service of the barrage balloon command headquarters battery. He advises the barrage commander and his staff on matters pertaining to gas and supervises the procurement, preparation, and distribution of the gas used to inflate balloons.

*b. With battalion.*—The gas service officer with the barrage balloon battalion is in command of the gas service section of the service platoon of battalion headquarters battery. When the battalion is operating separately, he is charged with supervising the procurement, preparation, and distribution of the gas used to inflate the balloons assigned to the battalion. He performs the following specific duties:

(1) Advises the battalion commander and staff on matters pertaining to inflation gas.

(2) Supervises and coordinates the technical training of gas section personnel under the direction of the battalion S-3.

(3) Establishes, maintains, and operates a hydrogen generating plant, or a helium purification plant, or both as the occasion may demand.

(4) Controls distribution of all gas to the balloons in the battalion.

(5) Sends timely notification to the supply officer concerning materials and supplies needed.

(6) Maintains and stores gas cylinders.

(7) Makes aerostatic calculations and determines the proper volume of gas needed for initial inflation of balloons.

■ 39. ENGINEER.—*a. With barrage balloon command.*—The engineer with the barrage balloon command is in command of the matériel repair section of the barrage balloon command headquarters battery. He advises the barrage commander and his staff on matters pertaining to rigging, balloon repair, and winches; and supervises and coordinates the maintenance of balloons and winches assigned to the battalions in the command.

*b. With battalion.*—The engineer with the barrage balloon battalion is in command of the service platoon of battalion headquarters battery. When the battalion is operating separately, he is charged with the maintenance of balloons and winches assigned to the battalion, and with the following specific duties:

(1) Advises the battalion commander and staff on technical matters pertaining to rigging, balloon repair, and winches.

(2) Supervises major repairs to balloons, rigging, and winches that cannot be made by battery personnel.

(3) Supervises and coordinates the technical training of riggers, balloon repairmen, and winch operators under the direction of the battalion S-3.

■ 40. BATTERY ENGINEER AND COMMUNICATION OFFICER.—The battery engineer and communication officer is in charge of communication, gas working, balloon and fabric repair, and winches within each lettered battery. He commands the engineer and communication section of the battery.





# PART THREE
# TACTICS

## CHAPTER 1
## MISSION

■ 41. GENERAL.—*a.* The mission of the balloon barrage is similar to that of antiaircraft artillery; that is, to provide local protection for important ground establishments and ground forces against aerial attacks and activities both by day and by night. The balloon barrage forces the attacker to higher altitudes where more active means of defense (AA and pursuit aviation) may better accomplish destruction. The barrage accomplishes its mission in two ways: by actual destruction and by psychological threat of destruction. The barrage, in order to effectively impose this threat, should be able to present the maximum practical probability of destruction.

*b.* Specifically, the balloon barrage serves the following purposes:

(1) To deny the use of the cloud layer (within operational altitude) by hostile aircraft as a covered route of approach for surprise attacks, particularly during daylight.

(2) To prevent precision air attacks on vulnerable points by low-flying aircraft, including—

(*a*) Horizontal flight attack.

(*b*) Dive bombing.

(*c*) Mine laying.

(*d*) Torpedo launching.

(3) Drives the hostile aircraft up to higher altitudes over vital areas where they can be more effectively attacked by friendly fighter aircraft and antiaircraft artillery.

(4) Reduces the vertical distance in which friendly airplanes will have to fight.

■ 42. CAPABILITIES.—*a.* Through threat of destruction, hostile aviation is kept above the height of the barrage. The barrage thus becomes a mental as well as a material hazard.

*b.* The effectiveness of the barrage is increased by low visibility.

*c.* No warning to alert the crews is needed unless the balloons are in the close-hauled position or bedded down.

*d.* Less time is required for production of matériel and for training personnel than for other forms of active air defense.

*e.* It is believed to be the most effective defense against air attacks, within the operational altitude of the balloons, that has yet been devised.

*f.* Barrage balloons may be kept constantly in action, and therefore are a constant defense against hostile air attack.

■ 43. LIMITATIONS.—As in the case of all weapons, barrage balloons have certain limitations. Among them are the following:

*a.* Difficulty of raising lethal cables to high altitudes.

*b.* Vulnerability of balloons to adverse weather conditions, particularly sleet and snow, high winds, and lightning.

*c.* Necessity of minimum spacing of balloons, to avoid entangling, restricts their tactical disposition.

*d.* Inability of low-altitude balloons to prevent the indiscriminate bombing of large areas by hostile aircraft flying at high altitudes.

*e.* Lack of mobility of low-altitude balloons.

*f.* Static nature (once installed) of a barrage, because of the extensive installations required at an established barrage.

*g.* Operational control that must be exercised over balloon barrages requiring that the balloons be flown or





close-hauled on short notice, because of interference with or damage to friendly aircraft, and interference with the gun-laying instruments of antiaircraft artillery.

*h.* Vulnerability of balloons to enemy air attack.

*i.* Possibility of balloons being put out of action by friendly antiaircraft fire.

■ 44. DEFENDED OBJECTIVES.—Barrage balloons are employed strategically as one of the elements of the local defense system to protect—

*a.* Single isolated important factories.

*b.* Vulnerable points of large industrial areas.

*c.* Shipyards and docks.

*d.* Harbors and channels leading thereto.

*e.* Fleets at anchor.

*f.* Canal locks.

*g.* Supply centers.

*h.* Other vital and vulnerable installations.

# CHAPTER 2

# SITING OF BARRAGE BALLOONS


| | | Paragraphs |
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| II. | Siting | 49-51 |


## SECTION I

## GENERAL

■ 45. MISSION.—*a.* The mission of a balloon barrage is to deter hostile aircraft from entering a protected air space and to destroy hostile aircraft which attack a defended objective. The ability of a barrage to accomplish its mission is affected by the siting of balloons in a barrage. Balloons should be sited to present the maximum practical probability of hits, since the effectiveness of a barrage increases as the siting approaches the maximum probability.

*b.* As the mission of barrage balloons often requires that they be sited in cities and well-developed areas, it may frequently be impossible to find suitable sites so located as to give maximum probability of hits. However, wherever a choice of sites exists, the sites offering the greatest practical probability of hits should be chosen.

■ 46. MINIMUM ALLOWABLE SPACING.—In siting balloons, the minimum allowable spacing between balloon sites depends on the type of the balloon (its flying and maneuvering characteristics), the maximum operational height of balloons, and the variability of the winds to be encountered. If balloons were sited closer than minimum allowable spacing, they likely would interfere with one another. Experience in any locality will determine the minimum allowable spacing for that locality. In the discussions in this chapter, a minimum allowable spacing of 400 yards has been assumed.





■ 47. FACTORS AFFECTING PROBABILITY.—The number of balloons and the arrangement of balloon sites affects the probability of attacking aircraft hitting the balloon cables as follows:

*a.* The greater the number of effective balloons within an area, provided no balloon is behind another balloon, the greater should be the probability of securing hits.

*b.* The closer an effective balloon is to the defended object, the greater the probability of that balloon securing a hit.

*c.* A barrage may be sited to give the maximum protection against one type of aerial attack, thereby possibly weakening the defense against another type of attack.

*d.* A barrage may be sited to increase the probability of securing hits in some sector through which an attack is deemed more possible.

■ 48. ROW METHOD OF DETERMINING PROBABILITY.—It may be desired to estimate the total probability of hitting an aircraft that flies through a barrage in a particular direction, or to estimate the strength of a barrage in any direction. The following gives a rapid method for making this estimation:

*a.* In actual practice a bombing aircraft will not always fly straight toward its target. The horizontal plot of the path of an approaching aircraft shows that due to course setting errors, etc., the aircraft really wavers over an area near the direction of approach, and does not approach in a straight line. For modern aircraft it is estimated that the area of approach includes a strip about 15 times as wide as the wing span of the aircraft.

*b.* To estimate the total probability of hitting an aircraft that flies through a barrage on a certain path, a strip of paper is cut to scale 15 times as wide as the wing span of the aircraft and laid over a plot of the balloon barrage, with the center of the strip on the line of approach to be analyzed. The number of balloons covered by this strip is counted, and the table shown below is entered to determine the estimated probability of hitting.

| *Number of balloons in strip* | *Probability of hitting (percent)* |
|---|---|
| 1 | 6.7 |
| 2 | 12.9 |
| 3 | 18.7 |
| 4 | 24.1 |
| 5 | 29.2 |
| 6 | 33.9 |

## SECTION II

## SITING

■ 49. SITING FOR DEFENSE AGAINST DIVE BOMBARDMENT.—*a.* Dive bombardment aircraft, when attacking, approach their objective on lines radiating upward and outward from the objective and release their bombs at low altitudes close to the objective. Barrage balloons sited for defense against this type of attack must be clustered close about the defended point. All paths of approach converge at the objective, so one or more balloons should be flown within or close to the objective. If the total number of balloons is limited, priority in tactical siting should be given to the establishment of a defense against dive bombardment attack, if hostile aircraft employ dive bombing tactics.

*b.* In siting balloons around an objective for protection against dive bombing, the following should be taken into consideration:

Altitude of barrage.
Angle of dive of attacking aircraft.
Minimum allowable spacing of balloons.

The first two factors determine where the aircraft will enter the barrage space, and therefore the area beyond which balloons would not be effective. The radius of this effective area is the altitude of the balloons multiplied by the cotangent of the angle of dive, as shown in figure 6. For example, with a barrage altitude of 6,000 feet and an angle of dive of 80°, the radius of the effective area would be 353 yards. For an angle of dive of 70°, the radius of the effective area would be 728 yards, and for an angle of





dive of 60°, the radius would be 1,156 yards. The third factor, minimum spacing, fixes the maximum number of effective balloons which can be located for defense. (See fig. 7.)

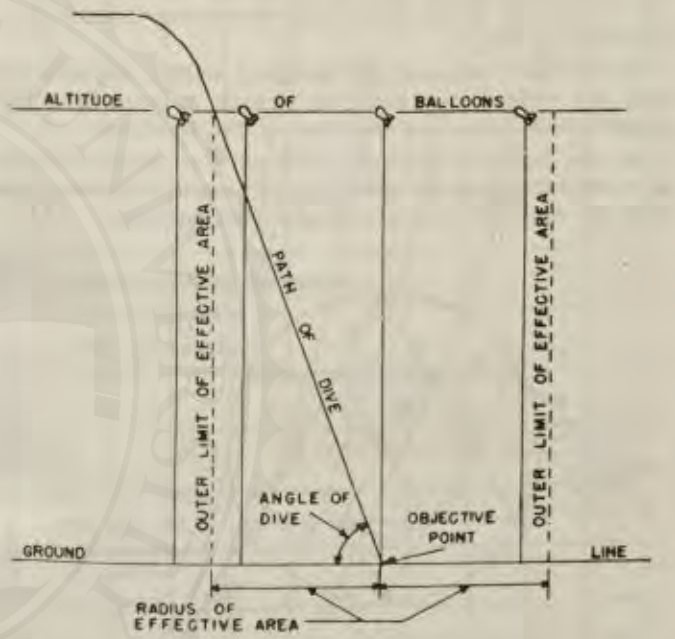


Figure 6.—Radius of effective area.

*c.* The following method of siting balloons should give the maximum probability of securing hits against hostile dive bombardment aircraft (see fig. 7):

(1) With the objective as center, a circle with radius equal to minimum allowable spacing is described.

(2) A regular hexagon is inscribed in this circle.

(3) One balloon is placed on the objective, and balloons are placed on each vertex of the regular hexagon.

(These balloons will give the maximum close-in protection with seven balloons.)

(4) The characteristics (mainly angle of dive) of the dive bombardment aircraft most likely to attack the objective and the altitude obtainable by the barrage balloons are considered. From these data determine the radius of the effective area.

(5) If more balloons can be sited within the effective area, six balloons are sited on apexes of equilateral triangles whose bases are the sides of the hexagon.

(6) Six balloons are sited between the last six as near as minimum allowable spacing will permit, but not in line with the objective and previously sited balloons.

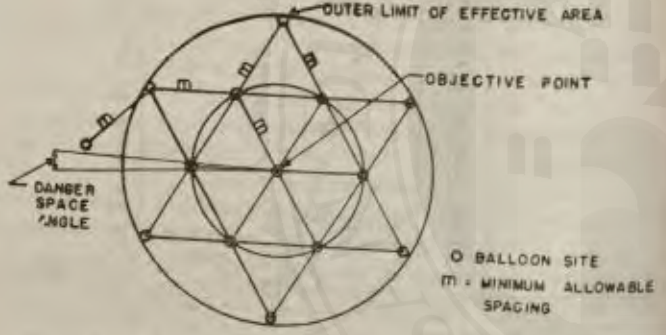


Figure 7.—Balloons sited for defense against dive bombardment.

■ 50. SITING FOR DEFENSE AGAINST LEVEL FLIGHT BOMBARDMENT.—*a.* This discussion of the balloon defense against level flight bombardment is applicable to level flight bombardment of ordinary ground objectives by aircraft flying at altitudes up to the maximum operational height of the balloons; to mine-laying attacks on harbors or other narrow inland waterways; and to torpedo attacks launched by aircraft against ships at anchor in, or passing through, such waterways. During periods of good visibility, aircraft can bomb targets with precision from altitudes above that at





which the balloons are flown, in which case the defense against such attacks relies upon defensive pursuit aviation and antiaircraft artillery. Recently, however, there has

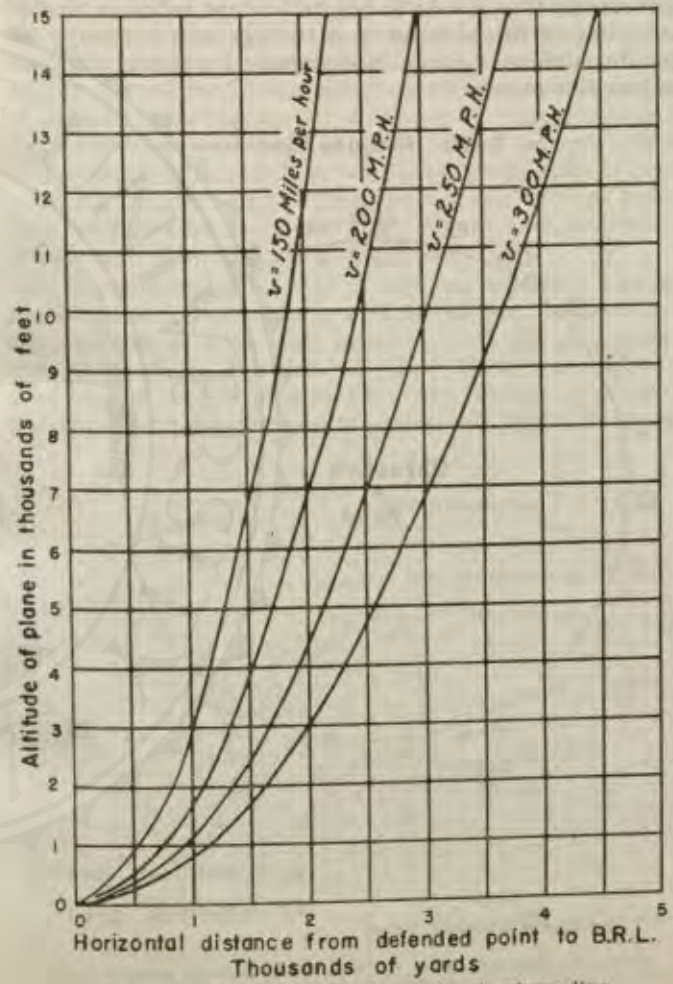


Figure 8.—Horizontal distance to bomb-release line.

been a decided tendency toward the bombing of ground objectives by level flight attacks just above the housetops, or by shallow diving attacks from low clouds, especially against objectives not defended by barrage balloons. Therefore, some of the balloons in a barrage will ordinarily be sited for defense against low-altitude horizontal flight or shallow dive attacks.

Figure 9.—Balloons sited for theoretical defense against level flight bombing.





b. Because of their relatively low altitudes, barrage balloons play a limited role in the defense of large area targets which can be bombed from altitudes above the balloons. When employed in the defense of multiple areas, the balloons will be sited for the defense of specific vital objectives. Figure 8 is a graph which may be used for determining the horizontal distance from the defended objective to the bomb-release line for airplanes of various speeds at the maximum operational altitude of the balloons. From a theoretical standpoint, it would be preferable to force attacking aircraft to fly through part of the barrage before they reach the bomb-release line. Figure 9 illustrates this theoretically desirable siting of balloons.

c. In practice, the number of balloons available may not permit the siting of balloons outside the bomb-release line, and balloons so sited will interfere with the antiaircraft guns as normally disposed. If a low-flying bomber has a good chance of striking a balloon cable before he can turn and get out of the barrage, the pilot will prefer to launch

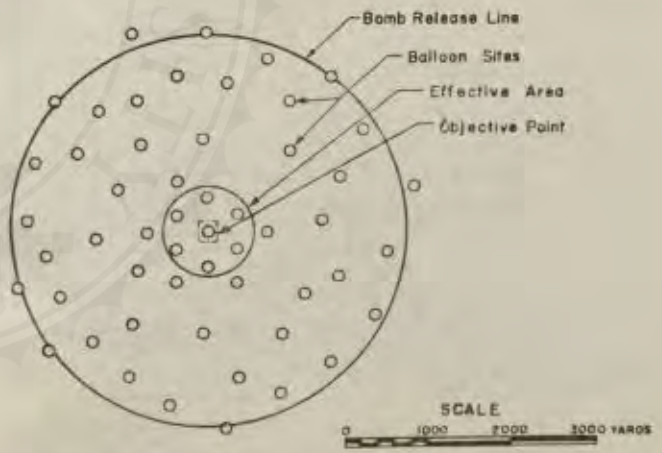


Figure 10.—Typical barrage balloon defense of single objective.

his attack from above the altitude of the barrage. Therefore, barrage balloons ordinarily need not be sited outside the bomb-release line for the maximum operational height of the balloons. Figure 10 shows a typical disposition of 54 balloons employed in the defense of a single vital objective, such as an aircraft factory. This is composite defense against all possible forms of low-flying air attack, considering at the same time such balloon sites as actually may be available.

■ 51. SITING BARRAGE BALLOONS IN DEFENSE OF MULTIPLE AREAS.—*a.* Barrage balloons employed in the defense of multiple areas will be sited for the defense of specific vital objectives in such areas. Such a defense offers an opportunity for the most economical employment of balloons when the individual vital objectives are located within 5,000 yards of one another, so that the bomb-release line around the adjacent objectives will intersect, enabling some of the balloons to contribute to the defense of more than one objective. This is represented in figure 11, which illustrates the employment of a 100-balloon barrage in the defense of three vital objectives in a multiple area.

Figure 11.—Disposition of 100 balloons protecting multiple area.





*b.* Figure 12 illustrates a balloon barrage established by two battalions, with a total of 108 balloons, for the defense of four objectives. In this situation the distance between adjacent objectives, in two cases, is more than 5,000 yards, with the result that the balloon defenses of these objectives are hardly mutually supporting. The use of two waterborne sites is contemplated in this situation. The relative dispositions of the balloons with respect to the antiaircraft guns are also illustrated.

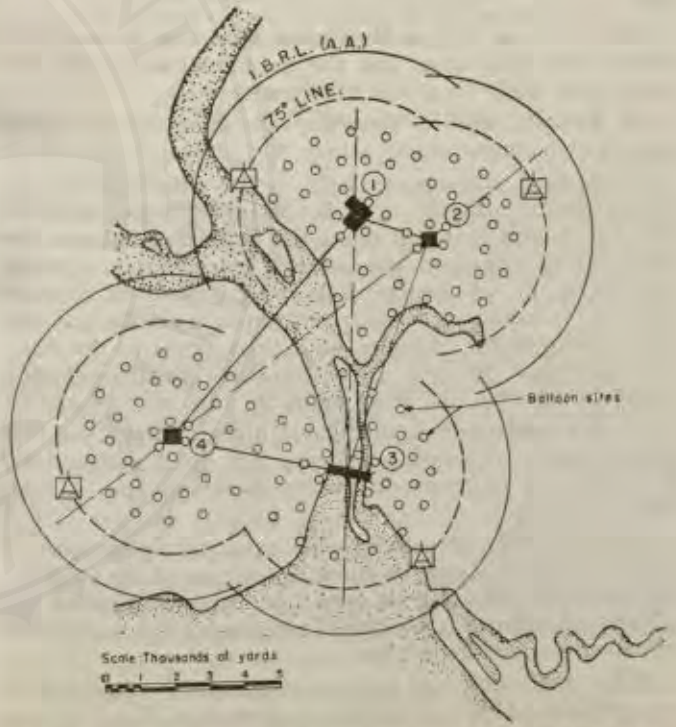


Figure 12.—Disposition of 108 balloons protecting multiple area.

c. As a general rule, the governing factor in the siting of barrage balloons will be the number and location of available areas suitable for balloon sites. Only when a choice of sites exists can there be siting for theoretical maximum probability of hitting. The following practical method of siting balloons should be satisfactory:

(1) On a map of the area to be defended (scale 1:10,000 or 1:20,000), the vital areas to be defended are colored. These areas are numbered in the order of their importance to the military effort.

(2) All balloon sites available are marked in a different color.

(3) The type of bombing most likely to be employed against the vital areas and the characteristics of the aircraft most likely to attack are considered.

(4) Priority should generally be given to a defense against dive bombardment attack.

(5) Around the areas likely to be attacked by dive bombardment aircraft, in order of importance, available sites are chosen that will make the pattern of balloon sites most nearly approach the pattern for maximum probability (fig. 7). A method for doing this is to draw to scale on celluloid or transparent paper a continuous system of equilateral triangles with sides equal to the minimum allowable spacing. By shifting this transparent sheet about on the map, the most desirable sites may be chosen.

(6) For protection against level flight and shallow dive bombardment, remaining balloons are sited between the dive bombing defense and the bomb-release line as indicated in figure 10

(7) A number of colored pins equal to the number of balloons available may be stuck in the map at the available balloon sites. Adjustments may then be made until the best all around defense is obtained, considering the availability of balloons and balloon sites.

d. For the number of balloons required to obtain certain probabilities of hitting aircraft, see appendix III.





# CHAPTER 3

# OPERATIONS


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## SECTION I

## OPERATIONAL CONTROL

■ 52. GENERAL POLICIES.—a. Operational control of a balloon barrage will be exercised by the barrage commander, under instructions issued by the antiaircraft commander, interceptor command, through the regional AA commander. The interceptor or region commander may send orders directly to the barrage commander when the occasion demands.

b. The barrage commander is specifically charged with changing operational height of balloons, and close-hauling or bedding down the balloons when he considers the weather conditions make such action desirable. The barrage commander may also designate certain emergency conditions under which a balloon chief may haul down his balloon without orders from barrage headquarters.

c. (1) Upon receipt of an air raid warning YELLOW, the barrage commander will order balloon crews to stand by. If balloons are bedded down when the order is received, he will order them to be placed in the close-hauled position, weather permitting.

(2) Upon receipt of air raid warning RED, balloon commanders will fly their balloons at ruling operational height (ROH) without further orders.

## SECTION II

## OPERATIONAL HEIGHT

■ 53. RULING OPERATIONAL HEIGHT.—*a.* The ruling operational height (ROH) is the altitude at which balloons will be flown and is designated by the barrage commander. This may be the maximum operational height or a lesser height according to cloud or other weather conditions. The maximum operational height at which the present low-altitude balloons may be flown is 6,500 to 7,500 feet, depending on the particular type of balloon and atmospheric conditions.

*b.* Whenever the cloud layer is so low and dense as to interfere with precision bombing from aircraft at medium or higher altitudes, balloons will ordinarily be flown within the base of the cloud layer. The reasons for flying balloons in the base of the cloud layer are—

(1) To deny to hostile aircraft the use of the cloud layer as a covered position from which to launch surprise attacks.

(2) To conceal the balloons from hostile aircraft in order to render the balloons less vulnerable to air attack.

(3) To render the disposition of the balloons less visible to observation from hostile aircraft, thereby preventing disclosure of the location of the defended area.

(4) To prevent the superheating of the balloons by the direct rays of the sun.

■ 54. ROH OF LAND-BORNE BALLOONS.—When ordering the ROH of land-borne balloons, the barrage commander will observe the following procedures:

*a.* When the sky is less than six-tenths obscured by clouds, the ROH should be near the maximum operational height. This maximum operational height cannot be attained in all weather conditions, and care must be taken to avoid a sudden loss of height and consequent sagging of the balloon cable.

*b.* When the sky is more than six-tenths obscured by clouds and the cloud layer is low enough, full advantage





should be taken of the cover provided by clouds, and balloons should be flown well inside the cloud layer. However, action must be taken to insure that balloons do not protrude through the clouds and act as target indicators. If there is doubt concerning the thickness of the cloud layer, balloons should be flown so that they are just visible in the cloud base.

*c.* During hours of darkness, when there is no moonlight, cloud conditions will be disregarded and the ROH may be near the maximum operational height. When there is sufficient moonlight to reveal the location of balloons, the ROH should be controlled as in daylight conditions.

*d.* When adverse weather conditions prevail, balloons in the proper class should be flown at the ROH dictated by such conditions.

■ 55. STAGGERING BALLOON HEIGHTS.—The heights of balloons should normally be staggered. The height of the lowest balloon should be about 1,500 feet below the ROH. When cloud cover is being used, the balloons should not be staggered.

■ 56. TARGET INDICATION.—If balloons can be observed from the air, they act as ground target indicators when, due to clouds, fog, or industrial hazes, the ground cannot be observed from the air. This is particularly true of small barrages around vital points. The ROH used should avoid this indication. Under certain conditions, however, protection is more important than avoidance of target indication. They are as follows:

*a.* When the fog or haze is not sufficiently dense to completely obscure the target area from enemy aircraft, the balloons may be flown at any safe altitude up to maximum operational height. If the fog completely obscures the ground from the air, the balloons should be bedded down, even during air raid conditions. These special conditions should be determined from advice of the weather officer and information from the local air units.

*b.* Low cloud conditions suitable for a surprise attack may be prevalent at the same time as strong winds, in which

case the likelihood of break-aways would be increased if balloons were flown just in the base of the clouds. Under such circumstances, the barrage commander may order an ROH of any safe height up to maximum operational height.

■ 57. SUPERHEAT CONDITIONS.—During hot days or in the Tropics when the direct rays of the sun on the balloon are likely to cause extreme superheating, balloons are normally flown at around 4,000 feet under non-air-raid conditions. This superheating is likely to occur from 4 hours after sunrise until 1 hour before sunset. If the balloons are raised for an air raid, nothing will be gained by reducing the height when the raid is over, as superheating has already taken place.

## SECTION III

## SPECIAL OPERATING CONDITIONS

■ 58. OVER WATER.—*a. Weather conditions.*—Weather conditions over water will in general be the same as over nearby land, except that surface winds will be considerably higher over the water. It is probable that icing conditions will be more frequently encountered over the water, due to larger quantities of water in the lower levels of the atmosphere. The maximum amount of low clouds over the water will occur at night.

*b. Anchoring point needed.*—The normal method of flying a barrage balloon over water is from a powered boat which may be anchored, or can maintain its position against the tide and wind by using the engine when the water is extremely rough. Since the balloon is hauled down close to the deck for topping-up with hydrogen, steam-powered boats should not be used as sparks from the fireboxes might ignite the balloon. In rough salt water, the boat should be large enough to provide space below deck for the winch, and sleeping, cooking, and eating facilities for the crew. The size of the boat used depends on the roughness of the water and whether it is fresh or salt. For friendly balloons, probably an 80- to 110-foot boat will be used. Sometimes anchored barges, of the type used to haul





freight, are used. Whenever boats or barges are not available, balloons may be flown from buoys. Buoys should be of the type that float with the top close to the water with the greater part of the buoy submerged. Buoys should be of the size required to moor ships of 10,000 tons. When balloons are flown from buoys, a special heavy cable must be used, since there is no crew present to haul down the balloon for protection against storms. This heavy cable restricts the altitude of the balloon, but it will still fly high enough to be hit by low-flying mine laying and torpedo launching airplanes.

*c. Winch and cable.*—While it is always desirable to mount the winch inside the hull of a boat on salt water, the winch can be mounted on deck if the water is ordinarily not too rough. If the winch is mounted in the hold, the cable should not extend vertically upward from the winch, but should go fore or aft to a pulley in the hold and then to an extra winch pulley mounted on the deck as far from any obstructions above deck as possible.

*d. Topping-up.*—A 60-foot length of hose (it may be strong garden hose) suitably valved, is attached to all water-borne balloons and lashed to the balloon cable, so that the balloon can be topped-up with the balloon flying a few feet above the deck, and with the long axis of the balloon parallel to that of the ship.

*e. Communication.*—In a barrage having water-borne sites, messages are sent from a shore station to the sites by means of visual signals or radio.

■ 59. TROPICAL CLIMATES. — Weather conditions affecting operations in tropical climates will be chiefly air mass thunderstorms and tropical storms. During the season for tropical storms, a constant watch must be kept for the development and approach of these disturbances. The velocity of the upper winds in a tropical storm, even if the wind is of slight intensity at the surface, probably will be sufficient to damage barrage balloons. Thunderstorms will occur mostly during the rainy season. In fact, the development of thunderstorms during the rainy season will be an almost

daily occurrence. Weather during the dry seasons will be in general very favorable. Icing conditions, frontal thunderstorms, and line squalls will seldom, if ever, be encountered.

■ 60. COLD CLIMATES.—During the summer months, air mass thunderstorms will occur at irregular intervals. Aside from air mass thunderstorms, the summer weather conditions will be favorable. During fall, winter, and spring, line squalls and frontal thunderstorms will be encountered. A constant watch must be maintained for frequent meteorological phenomena because of their violence and sudden onset. During winter and early spring, fronts will be accompanied by icing conditions.

## SECTION IV

## NON-AIR-RAID CONDITIONS

■ 61. GENERAL.—When it is probable that no balloon casualties will be caused by weather, an established barrage will fly balloons at all times during non-air-raid conditions. Non-air-raid conditions are considered to exist when—

a. No hostile aircraft are in the barrage area or approaching the barrage area.

b. Conditions are unfavorable for a surprise attack by day, by enemy aircraft using cloud cover.

■ 62. DEGREE OF RISK TO BE ACCEPTED.—No stated degree of the risk to be accepted can be prescribed for operational flying when air raid conditions are not present. Generally, barrage commanders will order balloons grounded during unfavorable weather conditions if this is necessary to prevent damage or loss of the balloons or damage to adjacent property.

## SECTION V

## AIR RAID CONDITIONS

■ 63. GENERAL.—During air raid conditions the operational control of barrage balloons is exercised by the interceptor or regional commander. Barrage commanders will fly as





many balloons as possible commensurate with weather conditions. A large measure of risk to balloons from wind and lightning must be accepted, particularly by day. It may not be necessary to accept such a large measure of risk at night, since surprise low-flying attacks are less likely, except under bright moonlight conditions.

■ 64. ACTION: AIR RAID WARNING YELLOW.—All balloons are to be flown at ROH, except when the weather forecast indicates lightning risks of classes II or III, or wind risk class III. If any or all of the risks listed above are forecast, then only those balloons scheduled to fly under air raid warning RED will be flown or prepared for ascension if bedded down.

■ 65. ACTION: AIR RAID WARNING RED.—All balloons are to be flown at ROH, or at maximum operational height as

TABLE I.—*Classes of weather risks to balloons and proportion of balloons to be flown during air raid warning RED*

| Class | Definition | Proportion of balloons flown |
|---|---|---|
| Lightning I | Lightning risk very slight, or there is no lightning risk. | All |
| Lightning II | It is expected that over the actual region of the barrage there will be large cumulus clouds which may develop into cumulonimbus clouds, but there is no actual lightning in the meteorological vicinity of the barrage. | 2/3 |
| Lightning III | There is practical certainty that cumulonimbus clouds will be over the barrage area and lightning has been observed in the meteorological vicinity of the barrage. | 1/3 |
| Wind I* | All wind conditions except those under wind class III. | All |
| Wind III | Wind at ROH is 50 mph or more; or line squall risk exists. | 1/3 |

*There is no wind class II corresponding to lightning class II.

ordered by the barrage commander, except when the weather forecast indicates lightning risks of classes II or III or wind risk class III. The balloons to be flown under these conditions are shown in table I.

■ 66. ASSIGNMENT OF BALLOONS TO CLASSES.—*a.* In order to determine which balloons are to be flown under different weather conditions on receipt of air raid warning RED, balloons in each barrage are to be assigned to the following classes:

(1) *Class I.*—All balloons in this barrage will ordinarily be placed in this class. Class I balloons will normally be flown under class I wind and lightning risks, or when it is desired to fly balloons in the barrage during an air raid.

(2) *Class II.*—Two-thirds of the balloons in the barrage will ordinarily be placed in this class. Class II balloons will normally be flown when class II lightning risk exists.

(3) *Class III.*—One-third of the balloons in the barrage will ordinarily be placed in this class. However, the barrage commander may determine that the minimum number of balloons to be flown should be greater than one-third of the balloons in the barrage. In this case, he may assign the desired minimum number of balloons to class III. Class III balloons will be flown when class III lightning or wind risks or both exist.

*b.* The assignment of balloons to classes should be made so as to insure the most effective barrage when classes II or III are flown.

## SECTION VI

## WIND AND LIGHTNING CONDITIONS

■ 67. FLYING DURING LIGHTNING CONDITIONS.—When a lightning risk has been forecast, all balloon site guards will be particularly watchful for thunderstorm conditions. If a storm is observed to be approaching the barrage area, an immediate report will be made to the barrage headquarters. If a balloon is struck by lightning, the barrage commander





will immediately order only class III balloons to be flown, and the proper balloons will be grounded. If lightning continues to strike balloons, and it appears likely that the remainder may be lost, the barrage commander may order all balloons grounded. This latter action will be taken only in extreme cases, and will always be reported to higher headquarters.

■ 68. FLYING IN HIGH WIND.—When wind speeds of more than 50 mph at ROH or line squalls are forecast, the barrage commander should ground all balloons except those in class III. The groundings should be completed before ground winds reach 30 mph. Balloons will not be flown in dangerously high winds during non-air-raid conditions. Balloons cannot be instantaneously brought down, and therefore notification should be given in advance when dangerous wind conditions are developing. While balloons may be grounded for high winds, the tactical situation may require that some balloons be flown under dangerous conditions. Under these circumstances the barrage commander will attempt to fly a portion of the balloons in class III, and will observe results. If results are satisfactory, the remainder of the balloons in class III will then be flown. If the trial balloons cannot be flown, or when it appears that they may break away, the barrage commander will exercise judgment and may keep the entire barrage grounded. Should the weather improve, immediate attempts should be made to fly the proper number of balloons. The barrage commander will keep higher headquarters informed of any unusual circumstances.

## SECTION VII

## BREAK-AWAY, COLLISION, OR DESTRUCTION; ACTION AND REPORTS

■ 69. IMMEDIATE ACTION.—If a balloon breaks away or is destroyed, the first concern of the commander responsible should be to get another balloon into the air as quickly as possible.

■ 70. BREAK-AWAY BALLOONS.—*a. General.*—The junction assembly of each balloon is equipped with a shear pin which has a shearing strength of less than the tensile strength of the cable. If the stress nears the tensile strength of the cable, the shear pin should shear before the cable breaks. The rip cord of the balloon is attached to the cable below the shear pin, and if the shear pin breaks, the rip panel should pull out and cause the balloon to be quickly deflated, so that it will descend near the area over which it was flying. However, the cable strength may not always be according to specifications, or there may be an unknown weakness in the cable, such as kinks, loops around winch gears, etc. In either case, the cable may break below the point at which the rip cord is attached. In this event, the balloon will be free to drift in the wind.

*b. Action taken.*—(1) Whenever a balloon breaks away, the barrage commander should be notified through the chain of command. He should send immediate notification by the most rapid means (teletype, telephone, telegraph, or radio) to the interceptor or regional commander. If the barrage unit is on either an Air Corps or Civil Aeronautics Administration teletype circuit, immediate notification should also be sent over this circuit. If the balloon is drifting out to sea, coast guard stations in the vicinity should be notified. If the balloon drifts inland, the State highway patrol should be notified. Telephone numbers of local electrical power companies should be known in advance, so that these companies may be notified immediately in case a dragging cable endangers electrical transmission lines. The following information should be given:

(*a*) Time and place of break-away.
(*b*) Estimated length of cable attached.
(*c*) Approximate direction of drift.
(*d*) Estimated time balloon will be in the air.

(2) The officer responsible should take steps to recover that part of the cable remaining attached to the winch, and should post guards if the cable falls across a highway or power line in such a manner as to constitute danger to passing vehicles or persons.





(3) Each barrage commander will organize a "Retriever Detachment," properly equipped with such special equipment as tying-down ropes, shovels, brush-cutting tools, and specially trained as to road nets, power lines, and railroad lines within a radius of 100 miles. Transportation will be earmarked on call for the use of this detachment whenever balloons are flying. This detachment will follow and recover all break-away balloons of the barrage. This detachment is also charged with the examination of all aircraft that fall within the general area of the barrage and the examination of captured enemy equipment.

(4) The officer immediately responsible will submit a written report (5 copies) at the earliest possible time to the barrage commander, giving the result of his personal investigation of the cause of the break-away, with pertinent comments, and the names of all witnesses or of several qualified witnesses. Four copies of this report will be available to the responsible property officer, who will take immediate steps to initiate a report of survey covering all separate items of property lost or damaged beyond repair. He will attach the report of investigation to the report of survey.

■ 71. COLLISION WITH AIRCRAFT.—*a.* In case of a collision between an aircraft (friendly or hostile) and a balloon or balloon cable, the platoon commander will submit a report through channels to the local air defense commander, containing the following information:

(1) Whether enemy or friendly aircraft, type of aircraft is known, and all information which will enable identification to be made.
(2) Raid number for the day.
(3) Name of barrage and site number.
(4) Time and date.
(5) Height of balloon.
(6) Type of cable.
(7) Whether lethal device was used.
(8) Height of impact.

(9) Effect on aircraft: whether destroyed, probably destroyed, damaged, or effect unknown.

(10) Present location of aircraft and crew, and distance from site that the aircraft crashed.

*b.* If the aircraft was hostile, the following additional information will be given:

(1) Map coordinates of crash.

(2) Whether aircraft was engaged by AAA fire before or after impact.

(3) Whether aircraft is claimed exclusively by balloon barrage.

(4) Brief statement of events immediately prior to and after impact.

(5) Any further details.

*c.* This report will be given priority in transmission.

*d.* A written report more in detail will be submitted in triplicate to the local air defense commander, a copy being retained for file at barrage headquarters. In addition to the items in *b* above, the following information will be given:

(1) More complete description of effect on aircraft and crew.

(2) Direction of impact with a relation to the wind.

(3) Whether aircraft was in a turn, a climb, or a dive.

(4) Speed of impact if known.

(5) Effect on cable and winch.

(6) Whether the lethal device operated, or reason for failure to operate.

(7) Date lethal device was last inspected or serviced.

(8) Eye witness account of collision.

■ 72. DESTRUCTION BY LIGHTNING.—If a balloon is destroyed by lightning, the balloon chief will take steps to salvage the cable, and will post guards if the cable falls across a highway in such a manner as to constitute danger to passing vehicles. A report to the barrage commander will be submitted in the same manner as in the case of breakaway balloons.





## CHAPTER 4

## SECURITY AND PROTECTION

■ 73. CAMOUFLAGE AND CONCEALMENT.—Camouflage of aluminized balloons is impractical. Concealment of balloons by flying them just in the lower level of cloud strata should be practiced. Camouflage of headquarters and service units should follow the fundamentals prescribed for similar antiaircraft units.

■ 74. COVER.—Cover for matériel and personnel for protection against bomb blast and fragments must be provided. Balloon sites located close to military objectives likely to be bombed require bombproof shelters for the crew. Sites located on the outer edge of a barrage and some distance from the objective may not require bombproof shelters. When better means have not been provided, a slit trench or dugout for personnel protection and sandbag walls around generating plants and nurse bags may be constructed.

■ 75. LOCAL DEFENSE.—*a. Defense against aerial attacks.*—No defense of balloons or balloon sites from aerial attack is specially provided. The mission of barrage balloons requires the siting of balloons so that ordinarily incidental protection is provided by friendly fighter forces and friendly antiaircraft artillery. However, some loss of balloons by friendly antiaircraft fire is to be expected. Except when balloons are flown inside dense cloud layers, the altitudes of balloons should be staggered in each barrage so as to make their destruction by hostile aircraft more difficult. The difference in altitude between the lowest and highest balloon may be 1,500 feet. Organic weapons will be used to fire on suitable targets within their range.

*b. Defense against ground forces.*—Barrage balloons will generally be located within the security lines established by other forces. However, balloon sites may be subjected

to various forms of attack, such as by parachute troops, mechanized forces, small naval craft and landing parties, and saboteurs. In all cases, protection should be provided by organization of the ground for defense, and with the organic weapons furnished for local protection. An armed sentry should always be on duty at each balloon site. Protection of balloon sites from mechanized units is conducted in the manner prescribed for other rear area installations. The use of antitank mines should be thoroughly understood by all barrage balloon units. (See FM 4-5 and TC 3, W.D., 1940.)





## CHAPTER 5
## COORDINATION WITH OTHER ELEMENTS OF AIR DEFENSE

■ 76. GENERAL.—Ordinarily barrage balloons are employed for local defense in conjunction with antiaircraft artillery or pursuit aviation or both. In order that the balloons may assist and not hinder the employment of antiaircraft artillery or pursuit aviation, close coordination between these units of defense is essential. Balloons are reduced in height or grounded when the occasion demands, through the use of certain operational controls.

■ 77. TYPES OF OPERATIONAL CONTROL.—*a. Interceptor control.*—This control is used to facilitate active operations by pursuit units against enemy aircraft. It may be imposed at any time at the discretion of the interceptor or regional commander, and remains in effect even during air raid conditions until canceled by the interceptor or regional commander. The term "fighter night" implies that friendly pursuit ships will assume control of the air space above barrage height. Whenever fighter night has been ordered by the interceptor or regional commander, all balloons will be flown at ROH during the period so ordered. Any control imposed during fighter night for the safety of friendly aircraft takes precedence.

*b. Gun operational control.*—(1) In order to facilitate the night operation of gun-laying instruments, the interceptor command or regional AA commander may direct that certain balloons be grounded, close-hauled, or reduced in height. Under this authority only the minimum reduction of height or grounding of the minimum number of balloons will be ordered to avoid interference with the efficiency of gun-laying, in order to insure that the effectiveness of the barrage defense is not unnecessarily weakened. Waterborne balloons will not be lowered below 1,000 feet.

(2) Under circumstances where balloons have been lowered, the AA commander will immediately inform the barrage commander if information is received of the approach of hostile aircraft at heights of 7,500 feet or less.

(3) Barrage balloons which interfere with night operation of gun-laying instruments will not ordinarily be

lowered until after dark, and will be again raised to their ROH before daylight. When fighter night has been ordered, the maximum number of balloons will be flown. Unless otherwise directed the barrage commander will order all balloons to ROH when warning is received that hostile aircraft are approaching at 7,500 feet or less.

(4) The interceptor or regional commander may vary the application of this control if he considers this to be tactically necessary.

*c. Local safety control.*—The interceptor or the regional commander may cover in his Standing Operating Procedure, instructions for the close-hauling or grounding of specified balloons in the immediate vicinity of airdromes, where such close-hauling or grounding is necessary to insure the safety of aircraft taking off and landing at the airdrome.

*d. Distressed aircraft control.*—Authority to exercise this control at any time is granted to pursuit groups over any balloon barrage within the general defense area. The object of this control is to safeguard friendly aircraft in distress, when their safety is seriously endangered by the balloons. The pursuit commander ordering this control is responsible for terminating it as soon as the emergency has passed. Communication concerning this control will be through Interceptor or Region Command headquarters. When the barrage commander cannot comply with distressed aircraft control because of mechanical failures at one or more balloon sites, or other causes, he will immediately inform the interceptor or regional commander, stating the exact location of these balloons.

■ 78. GENERAL PRECAUTIONS.—In operating these controls, the number of balloons lowered in the daytime and during weather conditions favorable to surprise attacks should be held to a minimum, particularly in barrages protecting vital points. By night, orders for the close-hauling of balloons may be given more freely, particularly when the balloons are defending large areas where indiscriminate bombing from considerable height is possible. When the balloons are defending smaller areas, where enemy aircraft must descend to lower heights to carry out precision attack, the close-haul should be used more sparingly.





# PART FOUR

# TECHNIQUE

## CHAPTER 1

## RECONNAISSANCE, SELECTION, AND OCCUPATION OF POSITIONS


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### SECTION I

### GENERAL

■ 79. GENERAL.—Barrage balloon defense requires that the locations of all elements forming a barrage be coordinated. The entire defense may be planned by the commander of the barrage balloon command and his staff. This plan may be so detailed as to give the location of all balloon sites. Whether the coordinated barrage is planned from a map by the barrage commander and his staff, or by other methods, suitability of sites must be verified by reconnaissance of the ground. In an urban area, it may be necessary to make a detailed study of roof tops and other locations that may require alterations to provide suitable balloon sites.

### SECTION II

### RECONNAISSANCE BY COMMANDER OF BARRAGE BALLOON COMMAND

■ 80. GENERAL.—The reconnaissance made by the commander of a barrage balloon command is usually general in nature, and is normally limited to a map reconnaissance

based on the elements to be protected and the matériel available.

■ 81. PROCEDURE.—*a.* The commander of the barrage balloon command, after deciding the pattern of defense, determines and selects the location of—

(1) Sectors to be assigned to each battalion.

(2) Command posts of the barrage balloon command and of the battalions.

(3) Bivouac or shelter for service elements.

(4) Bivouac or shelter for headquarters battery.

*b.* All command posts and bivouacs are selected and planned from the standpoint of facilitating communication, concealment, and protection.

## SECTION III

## SUBORDINATE UNIT COMMANDER'S RECONNAISSANCE

■ 82. GENERAL.—*a.* Each battalion commander, accompanied by his battery commanders, makes a ground reconnaissance of his sector to verify the suitability of positions selected as a result of the map reconnaissance, or to determine alternate positions in conformity with the tactical plan. He also determines—

(1) Routes to positions if they have not been prescribed.

(2) Materials needed and method of preparing sites for use.

(3) Exact location of unit command post, bivouac or shelter area, maintenance section, and transportation park.

*b.* When actual positions are selected by the subordinate unit commander, the sites chosen are submitted to the barrage commander for approval, and the final choice of sites will be made by the barrage commander to conform with the tactical plan of defense.

*c.* When the reconnaissance has been made by a barrage commander, the subordinate commander or his representative precedes the unit by sufficient time to permit him to determine the details of occupation before the arrival of his unit.





■ 83. SUBORDINATE UNIT COMMAND POST.—The subordinate unit commander will select the command post if the location has not been designated, and will report the position to barrage headquarters. The unit command post should be located at a point which will facilitate command and the establishment, operation, and maintenance of signal communication. It is desirable to select a position from which all balloons of the unit may be seen when flying.

## SECTION IV

## FIELD RECONNAISSANCE

■ 84. GENERAL.—The field reconnaissance may be made wholly or in part by the barrage commander, by members of his staff, by subordinate unit commanders, or by any combination of these.

■ 85. CHECK LIST.—A check on the following items will be found useful in a field reconnaissance:

*a.* Number of balloons in barrage.

*b.* Additional vehicles required.

*c.* Equipment and where obtained.

*d.* Hydrogen.

(1) Method of supply.

(2) Location of hydrogen generating plants.

(3) Method of distribution to gas dumps.

*e.* Command posts.

(1) Barrage (buildings, tentage).

(2) Battalions (buildings, tentage).

(3) Batteries (buildings, tentage).

*f.* Balloon sites and locations.

(1) Names of site owners.

(2) Rental arrangements.

(3) Types of ground.

(4) Surrounding obstructions.

(5) Accommodations.

(6) Water supply.

(7) Sanitation.

*g.* Facilities for balloon fabric, rigging, and winch repairs.

*h.* Motor transport repair facilities.

*i.* Arrangements for messing of personnel.

*j.* Gasoline distribution and supply.

*k.* Medical facilities.

## SECTION V

## BARRAGE BALLOON POSITIONS

■ 86. GENERAL.—Balloon positions should be so located that the balloon cable will not come in contact with overhead obstructions when the cable is inclined 20° from the horizontal. Trees and bushes near a position which do not endanger the fabric of the balloon should be preserved as wind breaks, thereby making the ground maneuvering of the balloon easier. The site selected should be easily drained. It may be necessary to fly some balloons from sites that lack some of the above characteristics and the likelihood of damage by surrounding obstructions may be present.

■ 87. BALLOON SITE.—A balloon site is the area that contains the ascension point, the balloon bed, the winch position, and maneuvering area. It is desirable that a site have an area at least 100 yards in diameter, level (not exceeding 5 percent in slope), and clear of all obstructions above the ground level which might damage the balloon. Minimum dimensions of a balloon site are approximately 140 by 50 feet.

■ 88. WINCH SITES.—Winches should preferably be located in prolongation of the principal axis of the balloon bed. If a fixed winch is used, the site should permit anchorage by burying deadmen at each end of the winch and securing them to the ends of the skids by cables.

■ 89. GAS DUMP.—Gas cylinders should be stacked about 75 feet from the balloon bed, preferably on ground that is





dry and in natural or artificial shade so as to protect the cylinders from the direct rays of the sun. Circumstances may at times dictate the use of nurse bags, such as a 5,000-cubic-foot storage balloon. Small beds for such bags must be prepared and maintained, to insure against damage to fabric. Nurse bags should be suitably moored. As the gas in such a bag is consumed, the envelope should be rolled up tightly.

■ 90. MOTOR PARK.—Motor vehicles should be parked at least 150 feet from the balloon bed. Except for trucks hauling gas cylinders and winch trucks, no motor vehicles should be permitted to come within 150 feet of any hydrogen inflated balloon.

■ 91. URBAN SITES.—Tactical situations will often require the siting of barrage balloons in urban districts. Urban sites may be placed in three general classes: residential, industrial, and commercial. In residential districts, sites may be found in vacant lots, public parks (including playgrounds and golf courses), school grounds, and athletic fields. In industrial areas, buildings may be sufficiently scattered to permit selection of ground sites. When this is not possible, roof tops must be used. Frequently, flat roofs may be found with sufficient area to provide roof sites without serious difficulty, even though the roof surface may be broken at places by chimneys, etc. In commercial areas, ground siting might be impossible, due to the danger of fouling the cable on adjacent buildings, and it might also be impossible to find available ground. In many cases, the use of available large, flat roofs, such as will be found over large stores, warehouses, etc., may be restricted by adjacent taller buildings. Frequently these roofs will have tar and gravel surfaces. Additional covering, made of lumber or sheets of fiberboard may be laid under the ground cloth. Anchorages can generally be accomplished by the usual commercial methods, but may involve damage to the waterproof covering of the roof. This can be repaired, but due to surging strains may often break loose, and should be checked frequently to avoid damage to property through roof leakage. As a rule, the roof slab will carry

the load of the winch and other heavy equipment if the loads are placed over a beam near a column. If no other sites are available, an irregular roof would require the erection of a platform on scaffolding high enough to clear the obstructions or ridges encountered. Here waterproofing of disturbed roof areas must be given consideration, and engineering and architectural advice should be obtained regarding loads and stresses.

## Section VI

## OCCUPYING POSITIONS

■ 92. General.—*a*. Prior to the arrival of the balloon matériel at the balloon site, the balloon chief will cause the following stakes to be located at the site under his direction:

(1) Such stakes as may be necessary to mark off the location of the balloon bed.

(2) A stake marking the position of the winch.

(3) A stake marking the location of the gas dump.

*b*. The balloon chief will further select positions for the motor park, for bivouac shelters, and for latrines.

*c*. Upon receiving the order to occupy a position, the balloon chief will move his squad to the balloon site, cause the matériel and equipment to be moved to the proper location at the site, and will issue the necessary instruction to accomplish the following:

(1) Clear the site.

(2) Construct the type of balloon bed to be used.

(3) Install the central anchorage if one is to be used.

(4) Fill a sufficient number of sandbags (usually 40 to 60).

(5) Anchor and ground the winch.

(6) Place the gas cylinders in stacks of not more than 6 tiers high with a maximum of 150 cylinders per stack. Cylinders must be so stacked that all outlets are on one side and point in the same direction, preferably down, to keep out dust and dirt. The stack of cylinders is grounded.





*d*. Air raid shelters and other installations for storage of equipment are constructed when time and facilities are available.

■ 93 Command Posts.—*a*. Since normally the command post of a balloon barrage command or battalion is a semipermanent installation, the furniture and fixtures may be of semipermanent nature. The following suggestions as to furniture and fixtures needed in a barrage headquarters may be used as a guide, although it is recognized that variations may be necessary in different installations: two desks for officers, table for use of clerks, filing cabinet, large table for telephones, and about seven chairs.

*b*. The following maps and boards should be displayed on the walls and be visible from the telephone table, showing at a glance the operational and supply status of the barrage:

(1) A site map (scale 1:10,000 is preferable) showing the position and number of each balloon site, the position of the command post of each subordinate unit, the sector boundaries of each subordinate unit, and the sources of hydrogen.

(2) A balloon break-away map showing balloon sites, electrical transmission lines, and railways, and the telephone numbers of the officials of these installations that should be notified in case of a break-away balloon with trailing cable. An arrow indicating the direction of the wind should be fixed to the map for use in determining those installations likely to be damaged by falling cable.

(3) A local area map showing important installations, routes of travel, the headquarters of nearby units, and other similar items.

(4) A general road and rail map.

(5) A blackboard showing an outline of the United States or department and the principal cities, upon which the meteorologist can plot the latest weather chart in chalk.

(6) A board displaying the wind and lightning risks, the operational height of the balloons, and class flying.

(7) An equipment status board which shows the following data: types of balloons and winches at sites, the number and type in reserve, and the number and type awaiting repair and salvage, and the amount and location of all hydrogen immediately available within the barrage.

*c.* A plotting board with a grid map of the interceptor or region command in which the barrage is operating should be placed in barrage headquarters for the purpose of plotting the course of hostile aircraft as the information is received from the information center.

*d.* An observation tower in the immediate vicinity should be provided.





## CHAPTER 2

## TACTICAL COMMUNICATION SYSTEM

■ 94. GENERAL.—Tactical signal communication for barrage balloons comprises several means employed to transmit orders, intelligence information, and commands between barrage balloon units and for liaison with other arms and services. The means employed are wire, radio, teletype, visual signaling, and messengers.

■ 95. RESPONSIBILITY OF COMMANDERS.—The responsibility of tactical unit commanders in establishing and maintaining signal communication within their units is set forth in FM 24-5. This responsibility also applies to commanders of barrage balloon units.

■ 96. ORGANIZATION.—In determining the organization of a barrage balloon communication system, consideration must be given to the characteristics of a barrage balloon unit. It is not a highly mobile unit. However, it is deployed over a large area, and its formation is not subject to change. Therefore, a flexible and simple communication system is necessary. Because of the sudden appearance of enemy targets and their short stay over a given area, the system must be so organized that any orders or intelligence information may be transmitted instantaneously. Telephones are the principal means of communication used, and radio may be used in emergency. Commercial telephone facilities should be utilized to the utmost when available.

■ 97. EMPLOYMENT OF SIGNAL AGENCIES.—Detailed description of communication matériel, together with instructions for the installation, maintenance, and operation of signal communication is contained in FM 24-5.

■ 98. BARRAGE BALLOON BATTALION.—*a. Telephone.*—The barrage balloon battalion establishes communication with its batteries, service elements, and such other units as are designated by higher commanders concerned. When the

situation permits, the battalion communication officer will begin the installation of the battalion telephone net before the arrival of the batteries. A battalion telephone net, including lines laid by batteries and platoons, is shown in figure 13.

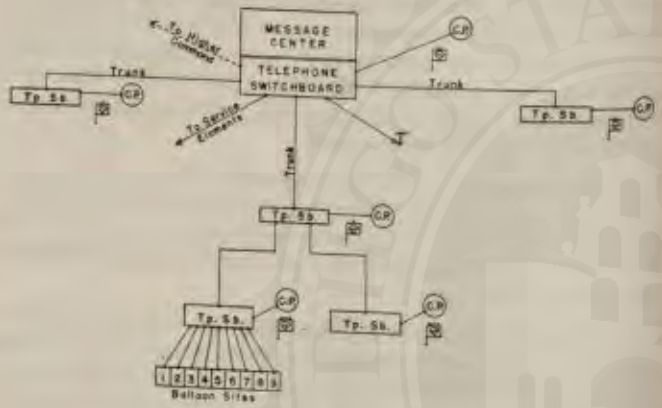


Figure 13.—Battalion telephone net.

*b. Radio.*—Radio is also used in the barrage balloon battalion for communication with higher units or other arms and services. Radio communication can be readily intercepted by hostile stations, making necessary the encoding of messages transmitted by this means. Insofar as practicable, telephone communication should be used for flash messages.

*c. Teletype.*—Orders from the interceptor or regional commander and communication between adjacent air defense units must be transmitted swiftly and reliably, and therefore the teletype may be desirable as the medium of communication between the interceptor or regional commander and the barrage commander. The teletype is used by the weather section.





## CHAPTER 3

## ESTIMATES, PLANS, AND ORDERS

■ 99. FACTORS CONSIDERED.—Preliminary to the preparation of his plan to defend an area against bombing attack, the barrage commander should make an estimate of the situation. In this estimate he should consider his mission, the conditions, and the means available to him and to the enemy. A form for a commander's estimate of the situation is given in FM 4-105. With suitable modifications, that form may be used by a barrage commander in forming his estimate of the situation and arriving at a decision. Among the factors peculiar to barrage balloon defense that must be considered are—

*a.* Objectives of vital importance.

*b.* Number and types of balloons available.

*c.* Available balloon sites.

*d.* Climatic conditions of locale affecting balloon operations.

*e.* Tactical doctrines of hostile air force.

■ 100. COMMANDER'S PLAN.—Having arrived at a decision, the barrage commander must next express it in terms applicable to his own command. He must decide how he is going to use the various subdivisions of his unit to the best advantage in carrying out his decision. This constitutes the commander's plans. The plan includes such details as are necessary to the issuance of a proper order at the proper time.

■ 101. FIELD ORDERS.—For general information on orders and annexes, as well as for the technique of preparation of a field order, see FM 101-5. Field orders are not ordinarily used to any extent by barrage balloon units. When time is available for a barrage commander to make a complete reconnaissance and draw up complete plans before the

movement of the unit into position, field orders may be used. In this event, the following suggestions may be helpful.

■ 102. BARRAGE COMMANDER'S CHECK LIST.—A check list is given below which may be used as a reminder in the preparation of barrage balloon field orders. It is not to be inferred that all items listed must necessarily be included, nor that other items are unnecessary. A trained commander or staff officer prepares an order to fit the situation, not a form.

*a. Enemy situation.*—Information of hostile aerial activity to include types of airplanes, character and method of attack, location of airdromes, landing fields, and probable routes of approach.

*b. Decision of barrage commander.*—To provide barrage balloon protection for certain areas, units, or establishments; detachment of units or reversion to battalion control of detached units; assignment of sectors to battalions or batteries; movements or routes; and assignment of routes to positions.

*c. Administrative matters.*—Location of service elements, instructions relative to supply of barrage matériel, method of distribution of class I supplies, instructions as to ammunition supply, location of aid station, and instructions covering evacuation.

*d. Signal communication.*—Special instructions; locations of command posts of barrage, battalions, or batteries; emergency methods.





## CHAPTER 4

## SUPPLY AND REPAIR

■ 103. GENERAL.—*a.* For general provisions covering supply and evacuation, see FM 100-10. Officers detailed on supply duty should refer to that manual for definitions and basic supply procedure.

*b.* The barrage balloon command, when combined with two or more battalions to operate a single barrage, and the barrage balloon battalion, when acting separately, are both tactical and administrative units. For general supply, they have the facilities for drawing and delivering supplies to subordinate units. With appropriate modifications, the instructions in FM 4-105 applying to antiaircraft units also apply to barrage balloon units.

■ 104. SUPPLY BARRAGE MATÉRIEL.—*a.* For the present, the Air Corps is charged with the research, development, and procurement of barrage balloon matériel. All equipment pertaining to barrage balloons such as balloons, repair kits, rigging parts, winches, winch parts, ground cloths, sandbags, screw pickets, gas generators, gas purifiers, gas generating material, gas cylinders, manifolds, inflation tubes, blowers, balloon cables, and lethal devices are procured by this agency.

*b.* The Coast Artillery Corps is the storage, testing, and supply agency for barrage balloon matériel. Barrage balloon matériel is received by the Coast Artillery Corps at certain general depots. From these depots the delivery of barrage balloon matériel to barrage balloon units is a function of the Coast Artillery Corps. The flow of initial supply to units will be automatic. Replacement supply is by requisition.

*c.* A reserve supply of balloons and winches is kept on hand by the battalion supply officer and by the batteries.

The total reserve of balloons on hand within a battalion is 27, and the total reserve of winches is 8.

■ 105. REPAIRS.—*a.* Ordinary repairs to barrage balloon matériel are normally made in the field by the balloon squad with the assistance of the platoon rigger. Ordinary repairs consist of repairs to scuffed fabric, pinholes, small tears of less than 8 inches, frayed ropes, and rip panels. Major repairs are made by the matériel repair section of the service platoon of the barrage balloon command, or of the barrage balloon battalion when operating alone. Examples of major repairs are: the replacement of a whole panel, gore, or lobe; or replacement of a major part of, or the entire inner or outer rigging.

*b.* Ordinary adjustments or first echelon repairs to winches may be made by the balloon squad. Ordinary adjustments or first echelon repairs consist of any adjustments or repairs which could be done more rapidly and just as effectively, in the field than by the higher echelon. Major repairs, comparable to third echelon maintenance of motor transportation, are made by the matériel repair section of the service platoon. The battery engineer officer determines whether a balloon or winch must be sent to the service platoon for repairs.

*c.* When two or more battalions function under a command, the service platoon of the command is augmented by the service platoons of the battalions constituting the barrage, forming a service unit for the entire barrage. This service unit makes major repairs to both balloons and winches.





## TABLE OF LOGISTICAL DATA ON BARRAGE BALLOONS

| Item | Type | Inches of space Required | Length (inches) | Width (inches) | Height (inches) | Diameter (inches) | Weight (pounds) | Weight (pounds W/O ballast) | Cu. ft. Displacement | Quantity on 2½-ton truck | Flatcar or boxcar | Men to load |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Balloon (crated) | Single ply D 3 | | 96 | 36 | 42 | | | 1,296 (two cases) | 126 | 1 complete | 11 | 12 to 14 (approximate) |
| | D4 A. C. | | 96 | 36 | 42 | | | 1,019 (three cases) | 96 | 1 complete | 14 | 12 to 14 (approximate) |
| | D4 G. T. and R. Co. | | 96 | 36 | 42 | | | 1,364 (two cases) | 110 | 1 complete | 14 | 12 to 14 (approximate) |
| | D4 U. S. R. Co. | | 96 | 36 | 42 | | | | | | | |
| | D5 Goodyear | | 96 | 36 | 42 | | | 1,430 | 120.5 | 1 complete | 14 | 12 to 14 (approximate) |
| | D6 A. C. | | 96 | 36 | 42 | | | | | | | |
| | D6 Firestone | | 96 | 36 | 42 | | | 1,425 | 124 | 1 complete | 11 | 12 to 14 (approximate) |

## TABLE OF LOGISTICAL DATA ON BARRAGE BALLOONS—Continued

| Item | Type | Inches of space Required | Length (inches) | Width (inches) | Height (inches) | Diameter (inches) | Weight (pounds) | Weight (pounds W/O ballast) | Cu. ft. Displacement | Quantity on 2½-ton truck | Flatcar or boxcar | Men to load |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Balloon (inflated) | D3 | | | | | | | 863 | 24,950 | | | |
| | D4 A. C. | | | | | | | 720 | 27,950 | | | |
| | D4 G. T. and R. Co. | | | | | | | 874 | 30,600 | | | |
| | D4 U. S. R. Co. | | | | | | | 694 | 28,000 | | | |
| | D5 Goodyear | | | | | | | 920 | 30,500 | | | |
| | D6 A. C. | | | | | | | 845 | 27,285 | | | |
| | D6 Firestone | | | | | | | 920 | 28,350 | | | |
| Cable 7/32-inch, spool | | | | | 20 | 24 | 810 | | | 6 | | |
| Caustic soda (drum) | | | | | 30 | 24 | 100 | | | 45 | | |



| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chest, field packing, large. | | | 66 | 20 | 25 | | 400 | | | 12 | | |
| Cylinders (approximate) for initial inflation | D3 | | | | | | 130 | | 131 | 40 Maximum pay load 40 less 20 percent 32 for long hauls | 635 | 4 |
| | D4 A. C. | | | | | | 130 | | 147 | | | 4 |
| | D4 G. T. and R. Co. | | | | | | 130 | | 151 | | | 4 |
| | D4 U. S. R. Co. | | | | | | | | | | | |
| | D5 Goodyear | | | | | | 130 | | 160 | | | 4 |
| | D6 A. C. | | | | | | | | | | | |
| | D6 Firestone | | | | | | 130 | | 150 | | | |
| Equipment field lighting, power plant flood lamps. | C-7 | | | | | | 180 | | 9.2 | 26 | | 3 |
| Ferrosilicon (drums) | | | | | 30 | 24 | 125 | | | 45 | | |

## TABLE OF LOGISTICAL DATA ON BARRAGE BALLOONS—Continued

| Item | Type | Inches of space Required | Length (inches) | Width (inches) | Height (inches) | Diameter (inches) | Weight (pounds) | Weight (pounds W/O ballast) | Cu. ft. Displacement | Quantity on 2½-ton truck | Flatcar or boxcar | Men to load |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground cloths (2 in box) | | | 36 | 14 | 14 | | 100 | | | 45 | 560 | |
| Helium purification plant. | A-3 | 420 | | | | | | | | | 1 | |
| Hydrogen generator. | | 192 | | | | | | | | | ½ | |
| Inflation manifold. | | | 72 | 18 | 18 | | | | | | | |
| Kits (blower) | | | 36 | 36 | 36 | | 113 | | | | | 3 |
| Kits (rigging balloon maintenance). | | | 48 | 36 | 36 | | | | | | | 4 |



| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kits (welding). | | | 24 | 24 | 24 | | 45 | | | 123 | | 2 |
| Sandbags (box of 400). | | | 36 | 36 | 60 | | 350 | | | 25 | | |
| Screw pickets (box of 50). | | | 36 | 24 | 24 | | 450 | | | 10 | | |
| Truck, balloon tender. | | 258 | 258 | | | | | | | | | |
| Truck, Ford ¼-ton command and reconnaissance. | | 128 | 128 | | | | | | | | | |
| Winch (crated) | A-9 | | 143.5 | 48 | 55.5 | | 4,400 | | | 1 | 6 | |

## APPENDIX II

## GLOSSARY OF TERMS

*AAAIS.*—Antiaircraft Artillery Intelligence Service established for the surveillance of the air by the commander of the antiaircraft artillery units operating within an area, zone, or theater of operations.

*Adjusting block.*—*See* Cinch block.

*Aerostatics.*—That branch of pneumatics that treats of the equilibrium, pressure, and mechanical properties of air and gases not in motion.

*Air current.*—Motion of air having a vertical component.

*Airfoil.*—Any surface designed to be projected through the air in order to produce a useful dynamic reaction, for example, a stabilizer fin.

*Air mass.*—A term applied by meteorologists to an extensive body of air within which the conditions of temperature and moisture in a horizontal plane are essentially uniform. Air masses are classified as warm or cold; maritime or continental.

*Air raid warning.*—A notice of the imminence or termination of an air raid. Air raid warnings for barrage balloons are classified by the color designations: WHITE, YELLOW, and RED.

*Air raid warning RED.*—A designation that enemy aircraft are approaching a defended area, and that an air raid is imminent.

*Air raid Warning WHITE.*—A designation that hostile aircraft have not been observed in the vicinity of a defended area; or that an air raid is over, and enemy aircraft have departed.

*Air raid warning YELLOW.*—A designation that an air raid is possible.

*Terms and definitions applying only to barrage balloons are designated (BB).





*Air scoop (BB).*—A scoop-shaped protrusion of metal or fabric or an orifice in a ballonet or fin of a balloon, which is exposed to the wind for the purpose of admitting air into and maintaining pressure within the ballonet or fin.

*Air speed (BB).*—Speed of the air relative to the balloon. Symbol: V.

*Air support command.*—An air support command consists of a commander and his staff, which includes officers of the ground combatant arms, and observation, reconnaissance, light bombardment, and dive bombardment aviation. It is organized and trained specially for the direct support of ground forces.

*Air valve (BB).*—*See* Valve.

*Altitude (BB).*—The vertical distance to a point in space from a horizontal reference plane, usually the plane containing the balloon bed. Symbol: H. The balloon altitude is approximately equal to the product of the length of cable paid out and the cosine of the angle of drift.

*Angle of dive.*—The vertical angle between the course of an attacking aircraft and the horizontal, measured in the vertical plane containing the course of the aircraft. Reckoned positive if the craft is descending, and negative if ascending. A negative angle of dive is also known as the angle of zoom.

*Angle of drift (BB).*—The angle between the vertical and a line joining the junction assembly and the ascension point of a balloon. Symbol: D.

*Angle of trim (BB).*—Acute angle between the longitudinal axis of the balloon and the horizontal when the balloon is flying in still air. It is usually about 12° to 14°. Symbol: O.

*Angle of wind attack (BB).*—Acute angle between the longitudinal axis of the balloon and the direction of motion of the air when the balloon is flying. Symbol: A.

*Appendix (BB).*—A short fabric tube directly connected to a gas or air compartment of a balloon and used for inflation and deflation. It can also be used as a manhole.

*Ascension point* (*BB*).—The point on the ground from which a balloon cable extends upward to the balloon.

*AWS.*—Aircraft Warning Service. The service operated directly under the control of an interceptor or regional commander to furnish warning of the approach of hostile aircraft. Warnings are sent to commanders of friendly aviation, balloon barrages, and antiaircraft; and to local civilian agencies and local military and naval commanders. It is operated largely by civilian observers organized to cover a specific area, supplemented by instrument spotting devices organic in the interceptor command.

*Ballast* (*BB*).—Any weighty substance, usually sand, used for weighing down a balloon, and for maintaining the angle of trim.

*Ballast pocket* (*BB*).—Pocket attached to the envelope of a balloon for containing small sandbags for ballast.

*Ballast pouch* (*BB*).—A small sandbag used for ballast.

*Ballonet* (*BB*).—An air or gas compartment of variable volume, constructed of fabric or portioned off within the interior of a balloon. An air ballonet is inflated from an air scoop when in ascension, and by a blower when bedded down.

*Ballonet balloon* (*BB*).—A balloon designed so that the envelope shape will remain substantially constant as the gas pressure changes. It contains a gas chamber and an air chamber, separated by a fabric diaphragm. As the gas expands it exerts a downward force on the diaphragm, and air is forced out of the air chamber. As the gas contracts the reverse is true, and the air chamber is filled with air through an air scoop.

*Balloon barrage* (*BB*).—A balloon barrage is the barrier presented to hostile aircraft by a number of barrage balloons sited according to a plan and operating to defend a given point or area.

*Balloon bed* (*BB*).—A cleared space upon which a balloon may be inspected and inflated, and which is equipped for mooring the balloon.





*Balloon cable* (*BB*).—A wire cable used to anchor a barrage balloon. The cable, together with any attached lethal devices, constitutes the principal weapon for destroying hostile aircraft.

*Balloon fabric* (*BB*).—A silk, cotton, or linen textile which has been treated to render it impermeable to gas. Barrage balloon fabric is commonly cotton, treated with natural or synthetic rubber. It may be composed of one or more plies.

*Balloon interval* (*BB*).—The horizontal distance between ascension points of adjacent balloons in a barrage. Symbol: I.

*Balloon position* (*BB*).—The point on the ground over which a captive balloon flies; that is, the vertical projection on the ground of the center of the balloon when in flight. *See* Drift; Ascension point.

*Balloon site* (*BB*).—Area which contains a balloon bed, maneuvering area, and auxiliary installations necessary for inflating and flying a balloon.

*Barrage balloon* (*BB*).—A captive balloon used to support metal cables and lethal devices for destroying enemy aircraft.

*Barrage balloon defense.*—The class of defense provided by barrage balloons against attack by hostile aircraft on important military and industrial establishments.

*Batonette* (*BB*).—A cylindrical piece of wood inserted in the rigging band of a ballonet balloon (held in place by the safety cord) to which the balloon rigging is fastened.

*Bed* (*BB*).—*See* Balloon bed.

*Bed down* (*BB*).—To moor a balloon on its bed.

*Block.*—A sheave, or a set of sheaves in a frame or shell.

*Blower* (*BB*).—A power-driven apparatus used to inflate a balloon or ballonet with air, or for removing air rapidly by suction.

*Bomber command.*—That offensive element of the Army Air Forces which conducts bombardment action.

*Chafing patch (BB).*—A patch on an envelope to protect fabric against wear by ropes.

*Cinch block.*—A device for adjusting the length of a bight on a rope. Sometimes called slip block or adjusting block.

*Class (BB).*—A term signifying the number of balloons in a barrage that are to be flown under different weather conditions. Particular balloons are assigned to different classes.

*Clevis assembly (BB).*—A link for attaching the cable terminal assembly to the shear link assembly or to another connecting device.

*Close-hauled (BB).*—Status of a balloon which is flying at an altitude of approximately 500 feet or less.

*Coating (BB).*—A covering of pigment or other material applied to a balloon to reflect the rays of the sun and to protect the balloon.

*Concentration rig (BB).*—Consists of the junction assembly, strops, toggles, and grommets.

*Crew (BB).*—A crew contains the men necessary to handle a balloon at a balloon site.

*Cumuliform clouds.*—Type of clouds that are heaped and form as the result of instability in the atmosphere.

*Cumulonimbus cloud.*—A cloud formation associated with thunderstorms. Prominent features are: heavy masses, great vertical development, summits resembling mountains or towers, and cauliflower appearance often with an anvil-shaped top.

*Deadman.*—Log, rail, or similar object buried in the ground horizontally with cables attached and used for mooring purposes. Should be buried at a right angle to the pull.

*Dead weight (BB).*—The combined weight of the balloon, rigging, and ballast. Cable weight is not included.

*Deflate (BB).*—To remove air or gas from a balloon.

*Deflation ports (BB).*—Openings, usually in the form of small appendixes, in the stabilizer fins to permit air or gas to escape during deflation.





*Bridle (BB).*—A rope vee which connects two points on the rigging to a rope or cable so that the two arms of the vee absorb approximately equal tension. A bridle is the basic integral part of balloon rigging. The bridles in the tier nearest the balloon are called the "first bridles," those in the next tier, "second bridles," etc. *See* Foot ropes.

*Broken clouds.*—Clouds covering more than five-tenths but not more than nine-tenths of the sky.

*Buoyancy (BB).*—Upward air force exerted on a balloon equal to the weight of air displaced by the balloon.

*Cable meter (BB).*—A device for indicating the length of cable payed out from the winch.

*Cable terminal assembly (BB).*—The element of the junction assembly to which the balloon cable is attached.

*Capacity (BB).*—Gross volume of the gas-containing chamber of a balloon.

*Captive balloon (BB).*—A balloon flown from the ground by means of a cable.

*Catenary curtain (BB).*—A skirt of fabric cemented to a dilatable balloon envelope, the bottom part of which has the outline of a series of inverted catenaries. The curtain is fringed with rope to form loops at the points of the catenaries, to which the first bridles of the rigging are attached. *See* Rigging band.

*Ceiling, cloud.*—Distance from the ground to the base of the clouds when the sky is more than half covered with clouds below 10,000 feet. If less than half the sky is covered with clouds, or clouds are above 10,000 feet, the ceiling is unlimited.

*Ceiling, operating (BB).*—The maximum altitude to which the balloon and cable will rise without the aid of the wind. *See* Maximum altitude.

*Central anchorage (BB).*—A snatch block arrangement at the center of the bed, which becomes the ascension point, and which permits the balloon to be flown with the winch offset.

*Diaphragm (BB).*—Fabric separating the air and gas chambers in a ballonet balloon.

*Diffusion.*—The process of one gas mixing spontaneously with another gas, either directly or through a porous membrane.

*Dilatable balloons (BB).*—Balloons which are constructed to expand or contract in accordance with internal pressure changes. Contraction is effected by internal elastic cords.

*Distressed aircraft control (BB).*—Operational control over barrage balloons exercised by any aircraft commander through the interceptor or regional commander for the safety of friendly aircraft in distress when their safety is seriously endangered by the balloons.

*Drag (BB).*—The component of the total air force on the balloon parallel to the wind direction. Symbol: *d*.

*Drift (BB).*—The product of the sine of the angle of drift and the slant distance from the ascension point to the junction assembly. It is equal to the horizontal distance between the balloon position and the ascension point. Symbol: d.

*Dumping (BB).*—Venting gas from a balloon by pulling the rip cord. To prevent hydrogen fire, dumping should be done only in extreme emergency.

*Effective area (BB).*—Area about the objective in which balloons may be located in order to be effective against dive bombardment attack. The radius of the effective area is the altitude of the balloons multiplied by the cotangent of the angle of dive.

*Effective balloon (BB).*—A balloon located within the air space through which a hostile aircraft must pass in order to successfully bomb its objective.

*Elastic tie-off cord (BB).*—An elastic cord used to secure the inflation tubing to the inflation appendix or to the inflation manifold bell.

*Electric bonding (BB).*—Copper braid encircling the envelope and attached to all metal parts of the balloon. It is attached to the anchoring cable for the purpose of grounding static electricity and lightning.





*Empennage.*—The tail parts of a balloon for the purpose of steadying it in flight. *See* Fin; Stabilizer; Rudder.

*Envelope (BB).*—The outer covering of a balloon. It may be divided by diaphragms into separate gas or air ballonets.

*Expansion cords (BB).*—Elastic cords within a dilatable balloon which permit the shape and volume of the balloon to change as the inflation gas expands or contracts.

*Extension ladder (BB).*—A cantilever ladder used when inspecting the fabric of an inflated balloon.

*Fabric thimble.*—*See* Inflation thimble.

*Fighter night (BB).*—This means that balloons will be flown at ROH and the air space above barrage altitude will be defended by friendly pursuit aircraft.

*Filter center.*—An element of the AWS where information from individual spotting stations concerning hostile aircraft is collected, sifted, and passed on to an information center.

*Flap valve (BB).*—A nonreturn fabric valve at the inner end of an air scoop. It will permit the entrance of air through the valve, but will not permit air to pass out through the valve. It is retained in place by light elastic cords, and is prevented by a grid from bulging out through the air scoop.

*Fin (BB).*—Appendage at the tail of the balloon for the purpose of steadying the balloon in flight. *See* Stabilizer; Rudder.

*Fin lashing (BB).*—A cord or strap for furling a deflated fin.

*Foot ropes (BB).*—Ropes which connect the bridle suspensions with the junction assembly or with the concentration rig.

*Friction drive band (BB).*—A friction band driving the storage drum on the balloon winch. By adjusting the length of the band, the tension on the cable, being spooled onto the storage drum, can be varied.

*Front.*—Boundary between two different air masses. The different types of fronts are cold, warm, and occluded.

*Gage pressure.*—The difference between the pressure within a container and the pressure of the atmosphere.

*Gas cylinder.*—A steel cylinder used for transporting and storing compressed gas.

*Gas cylinder valve.*—The outlet valve of a gas cylinder. It is provided with a threaded nipple for coupling to the inflation nipple of the manifold hose. Threads are left-hand for helium and hydrogen, and right-hand for oxygen.

*Gas valve (BB).*—*See* Valve.

*Gear box (BB).*—The housing on the winch that contains the gears that drive the surge drums and the storage drum friction drive.

*Gland (BB).*—A rubber stopper through which the rip cord passes through the envelope.

*Gore (BB).*—A line of panels extending from nose to tail of a balloon. *See* Ring.

*Grommet.*—A ring made of rope; also a metallic eyelet secured to fabric for reinforcing an opening.

*Ground cable or rope (BB).*—A cable or rope anchored to the ground by means of screw pickets, and to which the ground rigging is attached for the purpose of mooring a balloon on a balloon bed.

*Ground cloth (BB).*—Canvas placed on the balloon bed to protect the balloon fabric from abrasions during the inspection of the envelope, during inflation, and when bedded down.

*Grounding clamp (BB).*—A clamp used to connect a grounding wire to a balloon cable when the balloon is flying.

*Grounding rod (BB).*—A metal rod driven into the ground for the purpose of conducting static electricity or lightning into the ground.

*Grounding wire (BB).*—A wire connecting a balloon cable, winch frame, central anchorage, or gas cylinders to a grounding rod or mat.





*Ground readiness (BB).*—Status of a balloon which is ready to fly or can be put into the air within 2 hours.

*Ground rigging (BB).*—A number of short ropes of adjustable length used to connect the rigging band or catenary curtain of a balloon to the ground cable.

*Gun operational control (BB).*—In order to facilitate the engagement of enemy aircraft by antiaircraft artillery at night or at other times when visibility is limited, the antiaircraft artillery commander may request of the barrage commander that certain balloons which interfere with the gun-laying instruments be grounded, close-hauled, or reduced in height. The control is automatically released if reliable warning is received that hostile aircraft are approaching at or below barrage height.

*Gust.*—A rushing or driving wind, sudden and of short duration.

*Handling line (BB).*—A rope attached to the balloon envelope, and used for hauling down or maneuvering a balloon.

*Inflammable mixture.*—A mixture containing hydrogen and air, either alone or with other gases, which is capable of burning.

*Inflation manifold (BB).*—An apparatus used to conduct gas from a number of cylinders simultaneously to the inflation tube. It is provided with a number of flexible manifold hose for attachment to the gas cylinders, each hose leading to a metal manifold bell which is connected to the inflation tube.

*Inflation manifold hose (BB).*—Flexible hose used to connect a gas cylinder valve with the manifold bell. Each hose is provided with a check valve for preventing escape of gas when the hose is disconnected from a cylinder.

*Inflation nipple (BB).*—Small brass tube and nut used to connect a gas cylinder valve to the inflation manifold hose.

*Inflation site (BB).*—The place where a balloon is inflated.

*Inflation thimble (BB).*—A short, rigid tube used to support the connection between the inflation appendix and the inflation tube. The connection is secured by means of an elastic tie-off cord.

*Inflation tube (BB).*—A fabric tube used to convey the gas from the inflation manifold or air from a blower to the balloon; sometimes known as inflation sleeve.

*Information center.*—Part of an Aircraft Warning Service where information concerning the movements of hostile aircraft is assembled in final form and plotted on a large operations map.

*Inspection window (BB).*—A small window in a balloon envelope which permits inspection of the interior.

*Interceptor command.*—An interceptor command consists of the commander and his staff, and Aircraft Warning Service, pursuit aviation, antiaircraft artillery, barrage balloons, and other defense weapons. It conducts the general air defense of one or more areas and such local defenses as the situation and available forces may indicate. If its area of responsibility is large, it may be divided into regions commanded by the senior pursuit aviation commanders of the regions.

*Interceptor control (BB).*—Control over barrage balloons used by the interceptor or regional commander to facilitate active operations by pursuit units against enemy aircraft. Balloons may be ordered flown, close-hauled, or bedded down, and the control remains in effect until canceled by the interceptor or regional commander.

*Internal rigging (BB).*—Rigging located inside a balloon, such as expansion cords, stabilizer rigging, etc.

*Junction assembly (BB).*—An assembly for connecting the foot ropes to the balloon cable. It consists of the concentration rig, shear link assembly (if used), clevis assembly (if used), and cable terminal assembly, together with any intermediate connecting device.

*Junction piece (BB).*—A metal fitting to which the strops leading from the foot ropes are attached.





*Lead-off gear (BB).*—A device mounted on a winch which takes the vertical pull of the cable and allows the cable to swing from the winch in any direction.

*Leak detector (BB).*—An instrument for locating gas leaks.

*Lethal device (BB).*—A device attached to a balloon cable to enhance its ability to destroy aircraft.

*Lift, dynamic (BB).*—Lift due to kiting effect of the balloon produced by the wind.

*Lift, gross (BB).*—Buoyancy less the weight of the buoyant gas. Symbol: L. $L = V (D_a - D_g)$, where $D_a$ is the weight of 1 cubic foot of air, $D_g$ is the weight of 1 cubic foot of buoyant gas, and V is the actual volume in cubic feet of the buoyant gas in the balloon.

*Lift, net (BB).*—The difference between the gross lift and the dead weight.

*Line squall.*—A sudden burst of wind, often accompanied by rain or snow, occurring simultaneously along a line, usually a cold front.

*Lobes (BB).*—The rounded longitudinal sectors of a dilatable type barrage balloon.

*Local safety control (BB).*—Control exercised over barrage balloons by commanders of airdromes adjacent to the barrage for the purpose of close-hauling or bedding down balloons which may interfere with aircraft taking off and landing at the airdromes.

*Maneuvering area (BB).*—That part of a balloon site exclusive of the balloon bed.

*Maneuvering block or sheave (BB).*—A sheave constructed so that it may be placed upon the balloon cable while the balloon is in flight. Usually employed with a maneuvering spider to haul down the balloon when the winch is inoperative.

*Maneuvering ropes or cables (BB).*—Two ropes or cables which are attached to a double hook for maneuvering a balloon over obstacles. The ropes are released alternately in moving the balloon over obstructions.

*Maneuvering spider (BB).*—A number of ropes, usually four, concentrating at a point, to which may be attached a maneuvering block, and by means of which the balloon crew may maneuver or haul down the balloon in emergency.

*Manhole (BB).*—An orifice permitting entrance to the envelope for repairs or inspection; usually the main inflation appendix.

*Manometer (BB).*—An instrument for measuring or indicating gas pressure, graduated in inches of water and indicating gage pressure. (One inch of water equals 0.03614 pound per square inch or 0.07355 inch of mercury.)

*Manometer tube (BB).*—A flexible pressure tube leading from a pressure fitting on the envelope to the manometer.

*Maximum altitude (BB).*—The highest altitude attainable by balloon and cable under actual conditions. It includes the kiting effect of the wind, if any. *See* Ceiling.

*Mooring lines (BB).*—Ropes attached to the balloon for securing the balloon to pickets when the balloon is bedded down. Usually extensions may be connected to the ends of mooring lines.

*Mooring line extension (BB).*—A rope winch may be attached to the end of a mooring line of a balloon for securing it to a picket or other anchorage.

*Mousing.*—Securing the mouth of a hook to prevent it from becoming disengaged.

*Nose heavy (BB).*—Term used to describe the condition of a balloon that is heavy at the nose.

*Nurse bag (BB).*—A bag used as a gas reservoir for supplying a balloon. It is also used to carry helium from a balloon to a helium purification plant. Sometimes known as a supply balloon.

*Operational controls (BB).*—*See* Distressed aircraft control; Fighter night; Gun operational control; Interceptor control; Local safety control.





*Overcast.*—More than nine-tenths of the sky covered by clouds.

*Panels (BB).*—Pieces of balloon fabric seamed together to form the envelope of a balloon.

*Parceling (BB).*—Wrapping placed around ropes and fittings to prevent damage to fabric when a balloon is packed.

*Permeability (BB).*—A measure of the rate at which gas passes through balloon fabric.

*Picket.*—A rod or stake driven into the ground to which lines may be attached. *See also* Screw picket.

*Prepared position (BB).*—A site where the balloon bed is prepared, the maneuvering area is cleared, winch and anchoring gear are installed, the balloon and all equipment are at the site, and a sufficient quantity of inflation gas is at the site to permit inflation for ascension.

*Probability of hitting (BB).*—Probability of an aircraft that flies through a barrage hitting a balloon cable. Symbol: P.

*Region command.*—An area defended by an interceptor command may be divided into regions for purposes of tactical administration. A region command is responsible for the general air defense of a region.

*Reinforcing patch (BB).*—A piece of fabric cemented to an envelope to give added strength.

*Rigger (BB).*—A man who repairs and supervises the repair of cordage, fabric, and accessories of a balloon.

*Rigging band (BB).*—A fold of fabric extending from fin to fin around the bow of a ballonet balloon (secured to the envelope, usually by cementing), to which the first bridles of the rigging are attached. The common type has notches through which batonettes may be introduced to bear against the inside fold of the band to support the bridles.

*Rigging curtain (BB).*—*See* Catenary curtain.

*Ring (BB).*—A series of panels extending around a balloon, normal to the length. *See* Gores.

*Rip cord (BB).*—A cord, usually colored red, for the purpose of pulling out the rip panel.

*Rip panel (BB).*—A strip of reinforced fabric cemented in place over an opening in the envelope, usually at the top, which when pulled away permits the gas to escape rapidly.

*ROH (BB).*—Ruling operational height. The altitude at which barrage balloons are ordered flown.

*Rudder (BB).*—The lower vertical fin of a balloon.

*Rudder lashing (BB).*—*See* Fin lashing.

*Safety cord (BB).*—A cord running along the rigging band, laced through metal grommets in the band, and tied to the batonettes for the purpose of securing the latter in place.

*Safety disk (BB).*—A metal disk clamped to the balloon cable, and which forms a part of an automatic cut-off system to prevent the junction assembly from being pulled into the winch inadvertently. It is attached a short distance below the junction assembly so as to make contact with metallic strips on the lead-off gear, thereby causing a short circuit in the ignition and stopping the winch engine.

*Sandbag (BB).*—A canvas bag for holding sand, usually filled to weigh 33-1/3 pounds.

*Sandbag bridle (BB).*—A rope bridle to which sandbags may be attached.

*Scattered clouds.*—Clouds covering from one-tenth to five-tenths, inclusive, of the sky.

*Screw picket (BB).*—A metal rod with an eye at one end, and a device for screwing into the ground at the other end. Mooring and handling lines are attached to screw pickets when the balloon is bedded down. Screw pickets are also used to anchor the ground cable.

*Seam (BB).*—A juncture of panels or pieces of fabric forming the balloon envelope.





*Shear link assembly (BB).*—A link in the junction assembly for transmitting cable tension through the shear pin.

*Shear pin (BB).*—A pin in the shear link assembly which is subjected to shearing stress, and which has a shearing strength less than the tensile strength of the balloon cable. Arranged to release the balloon in the event of a stress which is likely to break the cable. The rip cord is attached to the cable below the shear pin, and if the shear pin shears, the rip cord will be pulled, causing the balloon to be deflated and descend.

*Shock cord.*—*See* Expansion cords.

*Snatch block.*—A single block having an opening in one cheek to receive a rope, and usually having a swivel hook.

*Spacer cord (BB).*—*See* Stabilizer rigging.

*Spider (BB).*—*See* Maneuvering spider.

*Spooling mechanism (BB).*—A device for guiding a balloon cable on the storage drum of the winch in even layers.

*Spring turnbuckle (BB).*—A device used to adjust the tension on the friction band of the winch friction drive.

*Squall.*—A sudden burst of wind, usually accompanied by rain or snow.

*Stabilizer (BB).*—A fin, either gas or air inflated, which helps to steady a balloon in flight. The vertical stabilizers render the balloon directionally stable, and the horizontal stabilizers render the balloon vertically stable. *See* Fin; Rudder.

*Stabilizer rigging (BB).*—The rope rigging inside the stabilizers which hold the stabilizers in proper shape. Also known as spacer cords.

*Static band (BB).*—*See* Electric bonding.

*Static electricity.*—A charge of electricity at rest. Static electricity may accumulate on a balloon, and will be discharged if contact is made with the ground.

*Storage drum (BB).*—A drum on the winch upon which the balloon cable is wound for storage.

*Storm.*—A wind force of about 64 to 75 mph, very rarely

experienced, and accompanied by widespread damage. The U. S. Weather Bureau forecasts use the term "whole gale" to designate winds from 55 to 75 mph. The word "storm" is also used to designate any disturbance of the atmosphere, as thunderstorm, snowstorm, rainstorm, duststorm, and sandstorm.

*Strop (BB).*—A short connecting rope constructed with an eye at each end for the purpose of connecting the foot ropes to the junction piece.

*Superheat (BB).*—The difference between the temperature of the gas in the balloon and that of the outside air. Superheat may be either positive or negative, being positive during hours of sunshine, and reaching the negative condition at night.

*Supply balloon (BB).*—*See* Nurse bag.

*Surge drums (BB).*—A pair of power-driven, grooved drums on the winch to which the balloon cable is led directly from the lead-off gear, and which take up the stress in paying out or hauling in cable.

*Surging (BB).*—Movement of the balloon on its cable in the vertical plane.

*Tension, cable (BB).*—The load carried by the cable. It increases from the winch to the balloon. Tension at the winch is equal to net lift, plus wind effects, less cable weight.

*Tension meter (BB).*—An instrument for measuring cable tension.

*Tie-off cord (BB).*—An elastic cord used to tie fabric tubing. For example, it is used for tying the appendix to the inflation tubing.

*Toggle.*—A piece of wood or metal, around which a rope can be spliced. Used to connect two ropes by passing the toggle, around which a rope has been spliced, through a loop in another rope.

*Topping-up (BB).*—Addition of gas to increase purity or pressure in a barrage balloon.





*Valve (BB).*—Apparatus installed in the envelope of a gas or air ballonet of a balloon for the purpose of automatically releasing air or gas from the envelope whenever the interior pressure exceeds the valve setting.

*Weighing-off (BB).*—Determining the net lift of a balloon by adding known weights, normally sandbags, to the junction assembly until the lift of the balloon is equalized by the weights. The sum of the known weights is equal to the net lift.

*Winch (BB).*—A mechanical device for letting up or hauling down a captive balloon on its cable.

*Wind scoop.*—*See* Air scoop.

*Yawing (BB).*—Lateral movement of the balloon on its cable transversely to the direction of the wind.

## APPENDIX III
## BALLOON REQUIREMENTS

(For defense of a single point with low-altitude balloons.)

| Assumptions: | |
|---|---|
| Barrage altitude | 6,000 ft. |
| Minimum balloon spacing | 400 yds. |
| Wing spread, dive bombers | 15 yds. |
| Wing spread, level flight bombers | 20 yds. |
| Plane altitude (level flight) | 6,000 ft. |
| Plane speed (level flight) | 200 mph |

| Dive bombardment only | | | Additional for level flight bombardment | | Best combinations | | | Remarks |
|---|---|---|---|---|---|---|---|---|
| Angle of dive | Maximum possible number of effective balloons | All around hitting probability (incoming and outgoing) (percent) | Probability desired (incoming only) (percent) | Number of balloons required | Total number of balloons required | Probability against level flight (percent) | Probability against dive bombardment (percent) | |
| 80° | 3 | 6.1 | 5 | 30 | 23 | 5 | 6.1 | |
| | | | 10 | 49 | 52 | 10 | 6.1 | |
| | | | 15 | 86 | 89 | 15 | 6.1 | |
| 70° | 12 | 13.3 | 5 | 20 | 32 | 5 | 13.3 | Normal defenses |
| | | | 10 | 49 | 61 | 10 | 13.3 | |
| | | | 15 | 86 | 98 | 15 | 13.3 | |
| 60° | 27 | 19.9 | 5 | 23[1] | 38[2] | 5 | 16.3 | Normal defenses |
| | | | 10 | 54[1] | 67[2] | 10 | 16.3 | |
| | | | 15 | 95[1] | 104[2] | 15 | 16.3 | |
| 50° | 64 | 31.6 | 5 | 0[1] | 38[2] | 5 | 24.5 | Normal defenses |
| | | | 10 | 3[1] | 67[2] | 10 | 31.6 | |
| | | | 15 | 40[1] | 104[2] | 15 | 31.6 | |

[1] Due to interference with dive bombardment protection.

[2] Dive bombardment balloons are also effective against level flight bombardment.

NOTES

1. In multiple defended points, the number of balloons per objective is reduced by mutual support.

2. In ordinary circumstances, ideal sites are not available, and not all balloons in an ideal pattern are usable. Therefore, the actual number of balloons and the actual probability may be somewhat smaller than indicated above.

3. Probability is directly proportional to wing spread of the attacking plane.

4. Probability against level flight bombing attack will be greater against airplanes attacking at lower than 6,000 feet.






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