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ARMY AIR FORCES HISTORICAL STUDI[ES]

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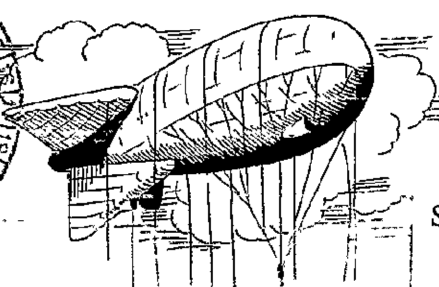
BARRAGE BALLOON DEVELOPMENT

— IN THE —

UNITED STATES ARMY AIR CORPS

1923 to 1942



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PREPARED BY
ASSISTANT CHIEF OF AIR STAFF
INTELLIGENCE
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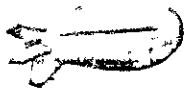
Army Air Forces Historical Studies: No. 3

BARRAGE BALLOON DEVELOPMENT IN THE UNITED STATES ARMY AIR CORPS 1923 to 1942

Prepared by
Assistant Chief of Air Staff, Intelligence
Historical Division
December 1943



BARRAGE BALLOON, HIGH ALTITUDE,
DILATABLE, IN FLIGHT

Manufacturer
GOODYEAR TIRE & RUBBER CO.

Furnished By:
MATERIEL COMMAND, AAF

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BARRAGE BALLOON DEVELOPMENT IN THE UNITED STATES ARMY AIR CORPS, 1923-1942

Chapter I

BARRAGE BALLOON DEVELOPMENTS, 1914-1937

Barrage Balloons During World War I. The development of balloon barrages as one means of antiaircraft defense was a natural outgrowth of the use of the airplane for bombing and for low-flying attacks upon military objectives during World War I. The Germans tried a form of balloon or kite barrage as early as the winter of 1914-1915.[1] By 1917 balloon barrages were being used for the defense of limited areas with considerable success by all the leading European powers. In Paris they were used to protect such important buildings as the Chamber of Deputies. At Nancy three steel plants were protected by balloon barrages. French Army Headquarters in the suburbs of Chalons-sur-Seine was effectively protected in spite of severe bombing of the city itself. A railroad viaduct between Chantilly and Paris was defended with success and other critical areas were similarly protected. The Italians used barrage balloons to guard Venice and its shipping.[2]

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1. Barrage Balloon Organization, Tactics and Technique, Barrage Balloon School, Coast Artillery Corps, Camp Tyson, Tenn., Dec. 1, 1942 revision, iii.
2. 2nd Indorsement (basic unknown), Maj. A. W. Barry, Air Service, to Commanding Officer, Scott Field, Ill., Jan. 31, 1923, in AAG 452.3 A; cf., copy of translation of an article by G. Fontaine, Chef d'Escadron d'Artillerie, France, Nov. 1, 1922, in ibid.

From early 1917 England operated several balloon aprons. Each consisted of four balloons and was about a mile long. A cable was suspended horizontally between balloons anchored about four hundred yards apart. From this cable at intervals of from 60 to 90 feet were hung piano wires about 300 feet long, each with a plumb-bob (lead weight) on the end to keep it hanging straight. Any plane trying to fly in an area thus protected was in danger of running into the wires, and when one of them fell across a wing it frequently went through it like a whipsaw. Since the balloon aprons were movable, the enemy never knew where they would be on any given day or night. Consequently, the area of effective coverage was almost unlimited.[3]

The balloons of that day could only carry their apron up to a height of about four thousand feet, but this proved sufficient to relieve the British of the fear of low-level strafing attacks and permitted a helpful concentration of artillery and fighter defenses. By early 1918 the Germans had evidently concluded that raids on London by low-flying airplanes no longer yielded results commensurate with the risk involved, and such forays became infrequent.

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3. "The Balloon Barrage," extract from "The Air Minister's Answer," in The Aeroplane, Nov. 25, 1936, pp. 678-79.

The balloons used by the different countries varied widely in volume and type, the Italian balloons being almost spherical with fins, while those used by the French and English were more of the "sausage" type.[4] During the World War the United States used balloons solely for observation, utilizing the Caquot French balloon.[5]

United States Interest in Barrage Balloons. After the war the United States Army General Staff decided to make a study of antiaircraft defense devices.[6] In a memorandum dated January 16, 1923 the chiefs of the various services were asked to state their views as to the value of small captive balloons in the defense of limited areas, "and in particular, as to the advisability and practicability of employing such means in connection with the defense of the Panama Canal Locks, the Gatun Spillway, and the Drydock at Pearl Harbor."[7]

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4. Ibid.; cf., "Balloon Barrages" in Encyclopedia Brittanica (14th ed.), II, 1011; "Prospectus for Barrage Balloons," Goodyear-Zeppelin Corp., June 22, 1939, in Barrage Balloon files, Wright Field.
5. Arthur Sweetser, The American Air Service. A Record of Its Problems, Its Difficulties, Its Failures, and Its Final Achievements, 291-95.
6. Office, Director of Air Service to Inventions Section, Operations Division, WD General Staff, March 27, 1920, in AAG 452.3 A; Chief, Engineering Division, Air Service, to Chief of the Air Service, Aug. 23, 1921, in ibid.; U. S. Military Attaché, London, England, to Assistant Chief of Staff, G-2 (for Chief of Air Service), April 10, 1922, in ibid.
7. Memo for Chief of Air Service from Assistant Chief of Staff, War Plans Division, WD General Staff, Jan. 16, 1923, in ibid.

Major General Mason M. Patrick, Chief of the Air Service, replied that he believed barrage balloons would provide an effective and comparatively inexpensive method of increasing the protection of such places as the Panama Canal, the Capitol and White House in Washington, and important bridges, viaducts, dry docks, and wharves, where it would be necessary for bombers to fly at altitudes of less than 15,000 feet in order to bomb such targets accurately. It was his belief that even large cities would be afforded considerable protection by balloons since enemy bombers would not feel so free to fly at the lower altitudes that insure accurate bombing. Moreover, in many cases, the moral effect of a balloon barrage might be such as to keep the enemy away. In conclusion, General Patrick recommended that the responsibility for the development and use of barrage balloons be given to the Air Service, and in that event he planned to undertake early experiments to determine specifications for standard types of equipment.[8]

Air Service Given Responsibility for Barrage Balloon Development. On March 1, 1923 a War Department directive was issued placing the responsibility for the development and use of barrage balloons upon the Air Service.[9] This action brought a protest

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8. General Patrick's reply to Chief of Staff given in full in Appendix 1 (Memo for Assistant Chief of Staff, WPD by Chief of Air Service, Feb. 19, 1923, in AAG 452.3 A).
9. 1st Indorsement (basic unknown), AGO to Chief of Air Service, March 1, 1923, in ibid.

from the Chief of the Coast Artillery Corps who contended that the use of barrage balloons was a legitimate function of the Coast Artillery Corps, which was charged with the operation of antiaircraft artillery, searchlights, and other auxiliaries required for antiaircraft defense from the ground. He maintained that barrage balloons were auxiliary to antiaircraft gun and machine gun defense, and that when balloons were used, their location and that of the guns would be so closely related as to form one problem. The Chief of the Coast Artillery Corps, therefore, while agreeing to the development of barrage balloons by the Air Service, recommended that their operation be charged to the Coast Artillery antiaircraft units.[10] The Chief of Air Service having agreed to this change,[11] it was officially sanctioned on April 13, 1923.[12] This separation of the functions of development and operation between two branches of the Army was to prove a source of some dissension in the years that followed.

General Patrick lost no time in directing his Engineering Division at McCook Field, Dayton, Ohio, to take steps to develop a type of barrage balloon for the protection of limited areas which would be capable of attaining an altitude of 15,000 feet.[13] Preliminary work was conducted to determine the size of balloon needed,

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10. Chief of Coast Artillery to AG, March 30, 1923, in ibid.
11. Memo for G-3 Section, WPD by Chief of Air Service, April 6, 1923, in ibid.
12. AGO to Chief of Coast Artillery, April 13, 1923, in ibid,
13. Memo for Chief, Engineering Division, Air Service, by Chief of Air Service, March 3, 1923, in ibid.

the material best suited, and the number of balloons to be provided for each cable (whether one balloon, or two in tandem as used in Europe). The balloon itself was only one of three items to be considered. The size and type of cable to be employed and the type of winch most suitable for the great length of cable required (12,000 to 15,000 feet) had to be determined also.[14]

As a result of various experimental and model tests, a balloon (Type A-1) was designed with an envelope capacity of about 24,000 cubic feet and with dilatable lobes of 13,000 cubic feet capacity to provide for expansion at altitude. A winch for use with this balloon was designed consisting of a Ford engine mounted on a two-wheel trailer, and a drum with spooling arrangements for 1/8-inch diameter cable.[15]

There were further tests and changes in design[16] so that it was not until June 26, 1926 that a contract was entered into with the Goodyear Tire & Rubber Company for the construction of three Type D-2 barrage balloons at a total cost of $11,850.[17] The balloons were to have the following general characteristics:

1. Volume of envelope, contracted, cu. ft.	15,000
2. Volume of envelope, fully expanded, cu. ft.	23,700

14. Chief of Air Service to AGO, Oct. 4, 1923, in ibid.
15. Chief of Air Service to AGO, June 2, 1924, in ibid.
16. Memo for Chief of Air Service by Chief, Engineering Division, Air Service, Nov. 5, 1925, in ibid.; memo for Chief of Air Service by Chief, Engineering Division, Air Service, April 6, 1926, in ibid.
17. Memo for Chief, Engineering Division, Air Service, by Office, Chief of Air Service, June 26, 1926, in ibid.

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3. Volume of lobes (three), cu. ft.	2,330
4. Fabric weight oz/sq. yd. (single ply)	6
5. Envelope shape, when expanded (length 49.5', dia. 31.8')	A-P[18]
6. Suspension	Catenary type
7. Winch cable	1/8 (7 x 19)
8. Designed altitude ft. (maximum)	15,000[19]

Three barrage balloons, three winches, and three reels of cable were delivered to Fort Monroe, Virginia, early in 1927, along with other minor accessory equipment. However, a number of difficulties were found to stand in the way of conducting service tests at Fort Monroe. The 60,000 cubic feet of hydrogen necessary for the tests was not readily available. Nor were the required instruments or the facilities for inflation and for bedding down the balloons available at this post. Moreover, personnel lacked the experience necessary for inflating and handling balloons and winches. Langley Field, Virginia, had facilities to overcome all of these difficulties.[20] Arrangements were accordingly made to conduct the tests there with personnel furnished by the 61st Coast Artillery Battalion and under the guidance of the officers of the Balloon Company at Langley Field.[21]

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18. Shape was to be similar to that of the standard A-P (Avorio-Prassone) observation balloon.
19. Chief, Lighter-than-Air to General Inspector of Naval Aircraft, McCook Field, Dayton, Ohio, May 3, 1927, in Barrage Balloon files, Wright Field.
20. Coast Artillery Board, Ft. Monroe, Va., to Chief of Coast Artillery, Feb. 17, 1927, in AAG 452.3 A.
21. OCAC to Chief of Coast Artillery, March 1, 1927, in ibid.; OCAC to Chief of Coast Artillery, March 19, 1927, in ibid.

Type D-2

Furnished by:
Materiel Command, AAF

Barrage Balloon Field Tests, 1927-1929. In the tests conducted at Langley Field, Virginia, during the spring of 1927, one balloon broke loose and drifted out to sea. The torn fabric of this balloon was picked up by a commercial vessel and turned over to the military authorities at Fort Jay, Governor's Island, New York.[22] The tests revealed certain weaknesses of design. After modifications, further tests were held during which a second balloon was destroyed.[23]

The third balloon was still further modified in an attempt to overcome the faults which had become apparent. The dilatable gores were removed and shifted. The grommets were relocated and the length of the elastic cords changed to permit a more even expansion and contraction throughout the length of the balloon. The lobes were shifted and tilted in order to produce a kiting effect that would permit the balloon to ride over the winch, as was not the case with the original design. It was hoped by this new arrangement to increase the stability of the balloon.[24] Preliminary tests in the autumn of 1928 revealed the need for still further changes.[25]

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22. Telegram, OCAC to Commanding Officer, Langley Field, Va., March 24, 1927, in ibid.
23. OCAC to Chief, Materiel Division, Feb. 24, 1928, in Barrage Balloon files, Wright Field; Coast Artillery Board to Chief of Coast Artillery, March 12, 1928, in AAG 452.3 A; Chief, Experimental Engineering Section, Air Corps, to Chief, Materiel Liaison Section, March 26, 1928, in ibid.
24. Chief, Materiel Division to Chief of Air Corps, Sept. 24, 1928, in AAG 452.3 A.
25. Office, Chief of Coast Artillery to Chief of Air Corps, Nov. 6, 1928, in ibid.

The original balloon winch, Type A-4, which had been patterned after a French design, while satisfactory for the operation of balloons not in excess of 5,000 to 7,000 cubic feet capacity, did not have sufficient horsepower available for the operation of larger balloons. A more powerful winch, Type A-7, was accordingly developed. It consisted of a Fordson Tractor equipped with an improved Continental winch having a drum capacity of 20,000 feet of 1/8-inch cable. The tractor, equipped with solid tires, front and rear, high-compression head, special gear ratio on intermediate speed, White two-speed power take off, and a Continental winch, was obtained from the Dayton & Troy Auto Company of Dayton, Ohio, at a cost of $1,222.30. Tests of the new winch in the summer and autumn of 1928 showed the need for some sort of cable-spooling device and a more effective breaking arrangement. These and other minor modifications having been made, the A-7 winch was regarded as generally satisfactory.[26]

Additional flight tests of the modified D-2 balloon were held during 1929-1930, but by that time the balloon was too old to be of much service.[27] Funds for the procurement of additional barrage

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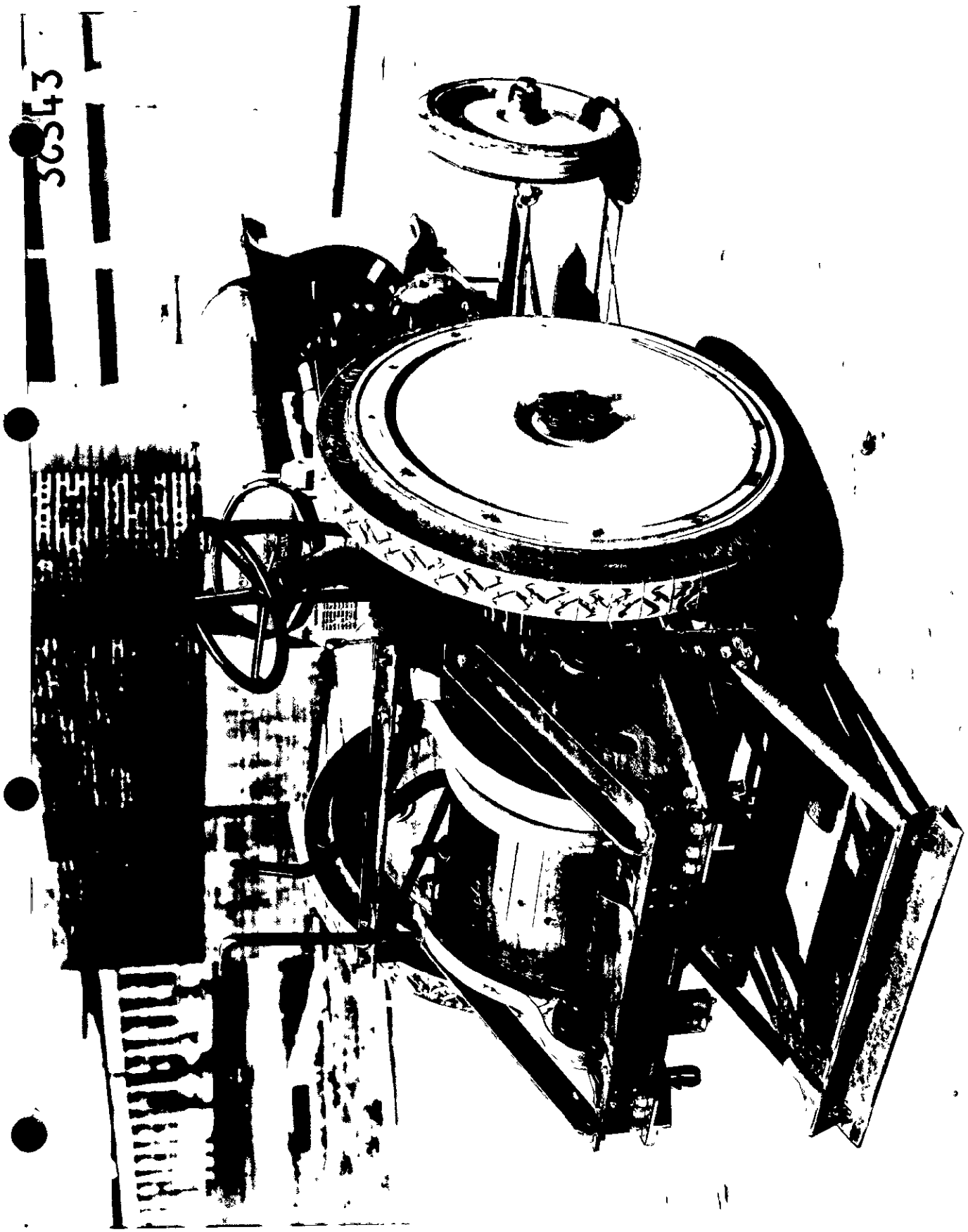
26. Chief, Materiel Division to Chief of Air Corps, Sept. 24, 1928, in ibid.
27. "Service Test Requirements and Manual on Barrage Balloon, Type D-2," along with data on flight test conducted on Aug. 7, 1930, given in Appendix 2 ("Service Test Requirements and Manual on Barrage Balloon, Type D-2," Aug. 15, 1929, in Barrage Balloon files, Wright field).



balloons were not forthcoming,[28] and for almost a decade lack of funds and doubt as to the tactical value of barrage balloons prevented further experimentation with them.

Revival of Interest in Barrage Balloons, 1935-1937. As war clouds began to gather in Europe during the thirties, military men commenced to manifest mild interest in barrage balloons once more. In May 1935 General H. J. Brees, Commandant of the Command and General Staff School, Fort Leavenworth, Kansas, wrote The Adjutant General recommending that a study be made of the feasibility and tactical value of using small barrage balloons to protect marching columns. He explained that the subject of protection of marching columns, during both daylight and dark, against hostile, low-flying attack aviation, had been under discussion at the school for the past two years. In his opinion, this problem would be of the greatest importance to ground troops in any future war.

The suggestion had been made that some form of small barrage balloon and winch be developed for this purpose and a suitable unit be organized to operate it. It was believed that the balloons should be of such size that they could carry small flexible cables to an

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28. Chief, Materiel Division to Chief of Air Corps, June 13, 1929, in AAG 452.3 A; OCAC to AGO, May 9, 1934, in ibid.

altitude of 800 or 1,000 feet, and that the units should be readily portable and susceptible of being mounted on various types of motor vehicles. These units could then be furnished in such number that three or four would be available for assignment to each regiment or similar unit in the infantry or cavalry division.[29]

The subject was made the basis for a study by the Air Corps Board. After a careful analysis of the problem, the Board concluded that the employment of barrage balloons for such a purpose was not advisable. The designing of light, mobile barrage balloons capable of being flown at altitudes up to 1,000 feet over marching columns would not be difficult. But the use of balloons in this way would give notice to the enemy of the movement of ground troops, thus sacrificing the last vestige of secrecy and practically advising a hostile commander of the plan of action. While a balloon barrage would undoubtedly decrease the likelihood of direct assault by air upon marching columns, it would not confer immunity from such assault. It would not, for example, halt the use of chemicals. Moreover, the infantry division as organized was already too large and unwieldy. The use of barrage balloons would inevitably add to operating difficulties and further complicate already difficult

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29. General H. J. Brees, Commandant, Command and General Staff School, to AG, May 28, 1935, in ibid.

logistical problems without materially increasing the ability of the ground forces to move as required to accomplish their general mission.[30] In view of these findings the subject was pursued no further.

The use of barrage balloons for antiaircraft defense was brought to the forefront once more in the summer of 1936 by the Air Corps Tactical School, Maxwell Field, Alabama. The Commandant, writing to the Chief of the Air Corps, recommended the delivery of a barrage balloon and necessary equipment to Maxwell Field for use in the development of an effective defense for flying fields in event of attack by enemy aircraft. He pointed out that it would also be useful in developing tactics to be used by American low-flying craft in attacking areas defended by barrage balloons. Still another important use for the balloon would be as a carrier of meteorological instruments, thus economizing on the use of airplanes.[31]

The Chief of the Air Corps in turn recommended to The Adjutant General that the project be made a subject of study by the General Staff with a view to receiving funds for experimental developments

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30. "Barrage Balloons for Marching Columns," report of the Air Corps Board, Study No. 7, Sept. 19, 1935, in ibid.
31. Maj. William E. Kepner, AC, to Commandant, Air Corps Tactical School, June 26, 1936, in AAG 452.3 A; Commandant, Air Corps Tactical School, to Chief of Air Corps, June 28, 1936, in ibid.

and operations. Eventual development would then depend upon the results obtained by such experiments.[32]

The Adjutant General's reply on December 22, 1936 abruptly terminated this barrage balloon project:

> It is appreciated that the development of barrage balloons and experimentation with them is desirable. However, it is necessary to consider the relative importance of this project and it is believed that such funds as are available for aircraft development should be expended on other and more important projects.
>
> Recommendation that funds be set up for the development of barrage balloons is therefore not favorably considered at this time.[33]

Despite the finality of this statement, it was not many months before the barrage balloon question was revived and pushed to a more successful conclusion.

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32. OCAC to AG, Aug. 1, 1936, in ibid.
33. AGO to Chief of Air Corps, Dec. 22, 1936, in ibid.

[redacted]

Chapter II

INITIATION OF EXTENSIVE BARRAGE BALLOON PROGRAM, 1937-1940

Barrage Balloon Conference Called by General Arnold, 1937.

The study of the employment of balloon barrages underwent a vigorous revival in the summer of 1937 under the direction of General H. H. Arnold, Assistant Chief of the Air Corps. On May 22 a directive was sent to the Air Corps Board, Maxwell Field, Alabama, requesting that body to initiate a study on the employment of balloon barrages at once. This study was to cover their size, cost, method of installation, most advantageous uses, and similar problems.[1]

Acting for the Chief of the Air Corps, General Arnold issued a call for an informal conference to meet on August 30, relative to the use of balloon barrages in the air defense of the United States. Believing that the subject might be of interest to them, General Arnold asked the following groups to have representatives present at the conference: Assistant Chief of Staff, War Plans Division; Chief Signal Officer; Chief of the Coast Artillery Corps; Chief of Chemical Warfare Service; Commanding General,

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1. General H. H. Arnold, Assistant Chief of Air Corps, to President, Air Corps Board, Maxwell Field, Montgomery, Ala., May 22, 1937, in AAG 452.3 A.

[redacted]

General Headquarters Air Force; Chief, Training and Operations Division, Office of the Chief of Air Corps; and Chief, Plans Section, Office of the Chief of Air Corps.[2]

On Monday, August 30, at 2:00 p. m., representatives of all the interested groups assembled in the Munitions Building, Washington, D. C.[3] General Oscar Westover, Chief of the Air Corps, stated that the meeting was for the purpose of considering the problem of setting up a program for barrage balloons. The inauguration of substantial barrage balloon programs by the British and the French raised the question as to whether a similar program should not be set up in this country. Up to that time, explained General Westover, no attempt had been made by the United States to determine either the desirability or the requirements for a barrage balloon program. Some of the questions which he believed worthy of consideration were:

a. Do we need barrage balloons?
b. If so, what type should they be?
c. Should they be used to protect areas? If so, what size?

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2. General H. H. Arnold, Assistant Chief of Air Corps, to Assistant Chief of Staff, WPD; Chief Signal Officer; Chief of Coast Artillery; Chief of Chemical Warfare Service; Commanding General, GHQ Air Force; Chief, Training and Operations Division, OCAC; and Chief, Plans Section, OCAC, Aug. 24, 1937, in ibid.
3. The Air Corps was represented by General Oscar Westover, Chief of the Air Corps; General Arnold, Assistant Chief of the Air Corps; Colonel Rush B. Lincoln, Plans Section; Colonel H. H. C. Richards, Information Division; Major Robert Kauch, Operations Section; and Major Charles Banfill, War Plans and Training Division. The GHQ Air Force was represented by Major Westside T. Larson. Lieutenant Colonel E. C. Wallington represented the Chemical Warfare Service; Major T. T. Handy, the War Plans Division, General Staff; Major H. B. Holmes, Jr., the Coast Artillery Corps; and Major W. S. Rumbough and Captain B. J. Sherry, the Signal Corps.

d. Who should be charged with handling them?
e. What type of personnel would be necessary for their manipulation? What percentage of trained supervisory personnel would be required?

After some preliminary discussion the meeting was adjourned with the understanding that the members present would study the questions involved and submit their advice at a second meeting.[4]

When the representatives reassembled on September 2 they expressed little enthusiasm for a barrage balloon project. The Coast Artillery Corps took the view that its available funds could be better used on active antiaircraft defense projects. The attitude of the War Department General Staff was that while there might be some merit in barrage balloons, there were other projects of greater importance which would require all the available funds. The representative of the GHQ Air Force stated that the usefulness of barrage balloons had not been sufficiently established to warrant further expenditure of funds. Only the Air Corps representatives were in favor of further barrage balloon experiments at this time. The representatives of all groups were willing, however, to see barrage balloon development carried on by the Air Corps with Air

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4. Memorandum Record of Meeting on the Subject of Barrage Balloons, Aug. 30, 1937, in ibid.

Corps funds. It was agreed that $5,000 available in the Air Corps expenditure program for 1938 should be devoted to the purchase of one balloon for experimentation, "and that the results thereof, together with subsequent developments in Europe, [should] form the basis for determination of recommendation for funds to be made available for barrage balloons in 1940."[5] The launching of this one-balloon program could hardly have been regarded with enthusiasm by barrage balloon advocates, but at least it was a beginning.

Report of the Air Corps Board, July 1938.

A further stimulant to barrage balloon development was the report of the Air Corps Board, Study No. 40, "Employment of Balloon Barrages," in July 1938. This study presented a strong case for the further development of balloon barrages. After a careful examination of the various aspects of the subject, the Board reached the following conclusions:

1. It is technically feasible to design a barrage balloon that can be operated satisfactorily at altitudes up to 20,000 feet.
2. Further experimental development is necessary in order to determine the best type of balloon for barrage use.
3. Barrage balloons should be designed for the use of helium as the lifting agent.
4. Barrage balloons should be flown singly, each from a separate winch.
5. Balloon barrages are capable of providing protection against air attacks and are of tactical value as a means of antiaircraft defense.

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5. Memorandum Record of Second Meeting on the Subject of Barrage Balloons, Sept. 2, 1937, in ibid.

6. In time of war there will be urgent need for the antiaircraft protection of many objectives which cannot be specifically defended by the available number of active antiaircraft defense units.
7. Balloon barrages are best suited for the local defense of single objectives or small areas such as airdromes. They are most useful at night and under weather conditions which render active means of antiaircraft defense least effective.
8. Field or scatter siting, with the outer balloons just beyond the probable bomb release line, facilitates the most effective utilization of a limited number of balloons per objective defended.
9. Protection against air attacks at both high and low altitudes is necessary, and it is desirable that two sizes of balloons, both capable of utilizing the same type of winch and auxiliary equipment, be developed. The high altitude balloon should be designed for operation at altitudes from 6,000 to 20,000 feet and the low altitude balloon for altitudes up to 6,000 feet.
10. A barrage balloon capable of being flown at 6,000 feet altitude will be useful for protecting airdromes, aircraft on the ground, and other objectives most subject to air attack at low altitudes.
11. Tactical units intended for handling barrage balloons can, in time of war, be composed mostly of men too old or otherwise incapacitated for full field duty.
12. The peacetime training of barrage balloon crews should qualify each member for duty as chief of such a crew in the event of mobilization for war.
13. The local antiaircraft protection of individual objectives and small areas can be provided for at less cost by the use of balloon barrages than by the use of active means of antiaircraft defense.

In view of the above facts the Board recommended: (1) that an experimental development program be initiated to determine the best type of balloon, winch, and other equipment for use in the employment of balloon barrages; (2) that two sizes of balloons be developed, one capable of satisfactory operation at a maximum

altitude of at least 20,000 feet and the other for operation at a maximum altitude of approximately 6,000 feet; and (3) that at least one barrage balloon squadron be organized for the service test of barrage balloons, the training of a nucleus of qualified crew chiefs, and development of tactical doctrine for the most effective employment of balloon barrages.[6]

In the spring of 1939 the D-2a barrage balloon, which had been constructed with funds provided under the Air Corps expenditure program for 1938, was delivered to Fort Sill, Oklahoma. It was the dilatable type and had been constructed to meet the following specifications: (1) a capacity of 15,000 cubic feet of hydrogen; (2) an ability to rise to a minimum height of 15,000 feet in still air; (3) a rate of ascent of 1,500 feet per minute; (4) a rate of descent of 1,000 feet per minute; and (5) operative with a 1/8-inch flexible steel cable.[7]

Tests were conducted by the personnel of the 1st Balloon Squadron from March 9 to March 23. These tests were for the purpose of obtaining engineering data relative to the rigging arrangement, operating characteristics of the expanding gores, behavior of the

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6. "Employment of Balloon Barrages," Report of the Air Corps Board, Study No. 40, July 15, 1938, in files of Historical Division, AC/AS, Intelligence.
7. R&R, OCAC to Chief, Materiel Division, Sept. 29, 1938, in AAG 452.3 A; OCAC to AG, Dec. 14, 1938, in files of WPD, WDGS, file no. 1098, Barrage Balloons.

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stabilizers in various wind speeds, and related data. Changes were made with a view to improving the balloon's stability, and additional tests were conducted.[8] While much valuable operating experience and data were obtained, it was obvious that little could be accomplished without a more liberal allotment of funds for barrage balloon development.

Sufficient performance data having been obtained, the balloon was shipped to the Panama Canal Zone for storage tests to obtain data on deterioration in storage.[9]

Interest in Barrage Balloon Accelerated by War in Europe, 1939. The outbreak of war in Europe in the autumn of 1939, and reports indicating the extensive employment of balloon barrages by the belligerent powers,[10] brought a request from the War Department General Staff for a re-examination of the barrage balloon question.[11] A subcommittee of the Air Corps Technical Committee, having restudied and reviewed the entire question in the light of all available data,

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8. Memorandum Report on D-2a Barrage Balloon, Engineering Section, Materiel Division, April 4, 1939, in Barrage Balloon files, Wright Field.
9. Chief, Experimental Engineering Section, Materiel Division, to Chief, Field Service Section, Materiel Division, July 14, 1939, in ibid.
10. Office, Chief of Coast Artillery to Chief of Air Corps, Dec. 19, 1939, in AAG 452.3 A; cf., extensive materials in files of Assistant Chief of Staff, G-2, WDGS.
11. OCAC to Chief of Coast Artillery, Jan. 11, 1940, in AAG 452.3 A.

recommended the procurement of a limited number of both low altitude (6,000 feet) and high altitude (15,000 to 20,000 feet) barrage balloons to permit a service test of this equipment.[12]

The desirable military characteristics for both high and low altitude balloons, as well as for a balloon winch, were drawn up by the Air Corps and promptly approved by the War Department.[13] Type specifications and procurement data were also provided. Further development of the project, however, was contingent upon availability of funds, inasmuch as no specific allocation of funds had been made in the Air Corps fiscal program for 1940.[14]

Extensive Barrage Balloon Program Initiated, 1940. In the summer of 1940, $50,000 was made available by the Air Corps out of its research and development funds for the fiscal year 1941 to purchase barrage balloon equipment.[15] Bids were opened, and on June 27, the Assistant Secretary of War signed a contract with the Goodyear Zeppelin Corporation, Akron, Ohio, covering the procurement of six low altitude (6,000 feet) barrage balloons for service tests.

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12. Memorandum Record of Meeting in OCAC of the Air Corps Technical Subcommittee, Aug. 3, 1939, in ibid.
13. The approved military characteristics for these items are given in Appendix 3. (OCAC to AG, Oct. 2, 1939, in AAG 452.3 A; OCAC to AG, April 5, 1940, in ibid.).
14. OCAC to Chief of Coast Artillery, Jan. 11, 1940, in ibid.
15. Note for Record, WPD, June 10, 1940, in files of WPD, file no. 1098.

Deliveries were to start on September 27 and were to be completed by the following April. The Air Corps 1st Barrage Balloon Squadron was authorized to service-test the balloons, with the Chief of Air Corps responsible for personnel, organization, and training.[16]

In the autumn of 1940 General Arnold, Chief of the Air Corps, took steps to implement an extensive barrage balloon program. On Sentember 13 he called upon Colonel C. B. Lober to undertake immediately complete studies and the preparation of plans on the subject of barrage balloons. Colonel Lober's investigations and reports were to be based upon the following directive:

> a. Make a study of all foreign intelligence on this subject, digest it, and place it in usable form drawing conclusions as to the method of operation, organizations employed, and materiel phases.
> b. Prepare a suggested step by step plan for development of a barrage balloon system in this country insofar as the army is concerned, including in this plan the recommended fiscal setup for procurement of the necessary balloons and equipment; a recommended organization for the operation of the equipment to include Tables of Organization and Tables of Basic Allowances.
> c. Prepare a report to the Chief of the Air Corps including the foregoing as inclosures and setting forth in brief terms any pertinent recommendations as a result of your studies.[17]

At this time Colonel Lober was on temporary duty as a student at the Army Industrial College, Washington, D. C. As an officer in

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16. Acting Chief of Air Corps to AG, July 12, 1940, in AAG 452.3 A; Acting Chief of Air Corps to AG, July 17, 1940, in ibid.
17. General H. H. Arnold, Chief of Air Corps, to Lt. Col. C. B. Lober, Sept. 13, 1940, in ibid.

the Air Corps, Regular Army, he had been associated with balloon and airship operation for over twenty years. Graduating from Massachusetts Institute of Technology in 1925 as an aeronautical engineer, he served in various capacities until his appointment as engineering representative of the Air Corps' Materiel Division at the plant of the Goodyear Zeppelin Corporation at Akron, Ohio, where, among other duties, he supervised the design of the largest nonrigid airship (TC-13) which had been built in the United States up to that time (1933).[18]

As the first step toward the accomplishment of his new task, Colonel Lober prepared three papers on barrage balloons. The first described the role of barrage balloons in the current European war. The second dealt with the capabilities and limitations of the various means of antiaircraft defense, while the third discussed the employment of barrage balloons. These studies made it clear that while barrage balloons provided no substitute for other means of antiaircraft defense, they could be made an important auxiliary means of defense.[19]

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18. Biographical data secured from AG 201, C. B. Lober.
19. These three papers are given in full in Appendix 4 (Lt. Col. C. B. Lober, AC, to Chief of Air Corps, "Barrage Balloons in the Present European War," "The Role of Barrage Balloons in Antiaircraft Defense," and "Employment of Barrage Balloons" [n.d., but evidence indicates that these studies were prepared and presented to General Arnold in late September or early October 1940], in Barrage Balloon files, Corps of Engineers, Washington, D. C.).

Several specific uses were advanced. For example, they might be employed to advantage in the defense of important industrial or military installations, so dispersed as to require precision bombing on each individual objective for their destruction. Barrage balloons could be employed along coastal frontiers to force the enemy planes to approach at higher altitudes so that the range of aircraft-detecting apparatus could be extended far enough to sea to permit the use of ground-based pursuit defense of important objectives. They could be employed to erect mobile barrages to block an easily navigated route to an objective, and to deflect the enemy craft from an area or route difficult to defend to one offering greater natural adaptability for antiaircraft defense. Barrage balloons could also be employed to reduce the air space to be defended by pursuit and to force enemy aircraft to altitudes more easily defended by antiaircraft artillery. They could be flown from barges or floats in defending water areas against enemy aerial mine-laying operations, or in deflecting the enemy from following a river to an objective. In regions where poor visibility or overcast clouds prevailed, barrage balloons were believed to offer the best known means of defense.[20]

On the basis of Colonel Lober's studies a comprehensive program for a barrage balloon system was submitted by him and promptly

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20. Ibid.

approved by General Arnold.[21] On October 5, 1940 the Chief of the Air Corps, in turn, recommended to The Adjutant General the adoption of such a program.[22] It called for the procurement of 4,400 balloons to be distributed ultimately as follows:

Northeast Air District (Industrial United States)	2,200
Southeast Air District	400
Southwest Air District	500
Northwest Air District	300
Trinidad	100
Newfoundland	300
Puerto Rico	200
Panama	200
Hawaii	200
Total	4,400[23]

Of these, 1,000 were to be of the high altitude type (12,000 to 15,000 feet) provided it proved possible to develop a satisfactory balloon for this service.[24]

In his report to The Adjutant General, the Chief of the Air Corps pointed out that the number of balloons needed to assist in the defense of a single objective depended upon a variety of factors. If,

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21. Lt. Col. C. B. Lober to Chief of Air Corps, Sept. 30, 1940, in ibid.
22. Chief of Air Corps to AG, Oct. 5, 1940, in ibid.
23. In the course of a detailed study by the War Department General Staff the opinions of General Chaney, General Yount, and Captain Saville were solicited. Each of these officers had spent considerable time in England, and all agreed that approximately 4,000 balloons would be required and that they should be obtained as rapidly as possible. This figure referred to the number of operating balloons and did not include spares and replacements. General J. E. Chaney to General B. K. Yount, Nov. 27, 1940, in WPD File No. 1098; Capt. G. P. Saville to General B. K. Yount, Nov. 27, 1940, in ibid.; General B. K. Yount to Chief of Air Corps, Nov. 27, 1940 in ibid.; General H. H. Arnold, Acting Deputy Chief of Staff for Air, to Chief of Staff, Nov. 28, 1940, in ibid.
24. Chief of Air Corps to AG, Oct. 5, 1940, in Barrage Balloon files, Corps of Engineers.

for example, a dimensionless point objective were to be defended by barrage balloons extending one mile beyond the bomb release line and placed at one-half mile intervals on circles varying by one-half mile in radius, 100 balloons would be needed to defend against attack at 5,000 feet and 200 against attack at 15,000 feet. On the other hand, if the objective were two miles in diameter under the conditions just described, it would require 150 balloons to defend it against attack at 5,000 feet and 300 against attack at 15,000 feet. It was estimated that a group of three squadrons would be required to defend a small objective satisfactorily against bombing at 5,000 feet, and four or five squadrons for a larger objective.

A survey of the industry indicated that the most critical item in the barrage balloon program would be the balloons themselves. The production of winches, cables, and other equipment could easily keep pace with any balloon program attainable. A production program which would provide the 4,400 balloons desired, along with necessary spares, by January 1, 1943 was believed to be attainable as shown in the following schedule:

January 1, 1941	12 balloons
April 1, 1941	40 additional balloons
July 1, 1941	250 additional balloons
January 1, 1942	1,000 additional balloons
July 1, 1942	2,000 additional balloons
January 1, 1943	2,000 additional balloons
Total	5,302

The Chief of the Air Corps' report stressed the fact that piecemeal placing of orders would not permit orderly expansion of plant facilities and would thus jeopardize the program.[25]

Helium was to be used to inflate the balloons. Since existing plant facilities at Amarillo, Texas, had a maximum capacity of only 24,000,000 cubic feet per year, an immediate quadrupling of production capacity would be needed to meet requirements under the projected barrage balloon program and at the same time to provide sufficient helium for man-carrying lighter-than-air craft operated by the Navy.[26]

The report of the Chief of the Air Corps also included a carefully prepared step-by-step program. The first proposed step called for the immediate establishment of an initial barrage balloon training center at Brownwood, Texas, and the ordering of the 3rd Balloon Squadron thereto. This unit was to conduct a service test of both equipment and organization and to assist in developing necessary operating technique and suitable training publications. Five million dollars were requested for the immediate purchase of 250 low altitude balloons and equipment for delivery prior to July 1, 1941, $1,500,000

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25. Ibid.
26. It soon became apparent that it was impracticable to meet both demands. Hydrogen was accordingly substituted for helium in the barrage balloon program, and the use of helium was limited to not more than one battalion for training purposes.

for the construction of additional helium production capacity to the extent of 75,000,000 cubic feet per year, and $250,000 for the purchase of the entire helium production of the existing plant.

The second step called for the transfer of the 1st and 2nd Balloon Squadrons to Brownwood, Texas, by May 1, 1941. These squadrons along with the 3rd Balloon Squadron were to be expanded to five squadrons by June 30, 1941. Each squadron was to consist of 10 officers and 264 enlisted men in times of peace and 11 officers and 277 enlisted men under war conditions. A squadron would be prepared to handle 36 balloons, and in time of war would have 9 additional balloons for replacement.

A third step called for the sending of one squadron to Panama and one to the Northeast Air District by July 1, 1941. The remaining three squadrons were to be used to train ten Regular Army squadrons and five Reserve (trainee) squadrons which were to be equipped by October 30, 1941.[27]

It was further recommended by the Chief of the Air Corps:

(1) That $45,000,000 be included in the estimate for the fiscal year 1942 for the purchase of 3,000 balloons and related equipment, $1,250,000 for the purchase of helium, and $1,000,000 for research and development.

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27. Chief of Air Corps to AG, Oct. 5, 1940, in Barrage Balloon files, Corps of Engineers.

(2) That provision be made for expansion from three balloon squadrons to five Regular Army balloon squadrons and two Group Headquarters squadrons during the fiscal year 1941.

(3) That provision be made for an expansion to thirty-eight Regular Army squadrons with twelve Group Headquarters squadrons during the fiscal year 1942.

(4) That provision be made to organize trainee squadrons as follows:

May 1, 1941 - - - 5 Squadrons - - 2 Group Headquarters
October 30, 1941- 6 Squadrons - - 2 Group Headquarters
March 1, 1942 - - 5 Squadrons - - 1 Group Headquarters

(5) That provision be made to call to active duty 100 Reserve Officers during the fiscal year 1941 and 525 additional Reserve Officers during the fiscal year 1942.

(6) That one complete set of barrage balloon equipment, including training publications and operating instructions, be purchased at once from England for study by the Materiel Division and the 1st Barrage Balloon Squadron.

(7) That a development project be started to determine the practicability of a combined balloon and kite barrage.

(8) That the development of high altitude equipment be continued.[28]

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28. Ibid.

As the barrage balloon program got under way, it became apparent that closer coordination of the activities of the various divisions of the Office of the Chief of Air Corps would be necessary, at least during the period of planning and organization, if the best results were to be obtained. On December 20, 1940 Colonel Lober sent to the Chief of the Air Corps a memorandum suggesting that the desired coordination could be achieved most effectively by having one officer charged with the development of the entire barrage balloon project. This officer, it was believed, should be a special assistant to the Acting Chief of the Air Corps so that he could work with all divisions of that office, as well as with outside agencies such as the War Department General Staff and the National Defense Advisory Commission. It would be his duty to acquire suitable assistants and gradually build up an organization which, after the development period was over, could be used at Brownwood, Texas, as the nucleus for a Barrage Balloon Training Center.[29]

Colonel C. B. Lober Appointed Chief of Barrage Balloon Section. These views were favorably received by General Arnold, and Colonel Lober was appointed Chief of the Barrage Balloon Section, Materiel

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29. Lt. Col. C. B. Lober to Chief of Air Corps, Dec. 20, 1940, in AAG 452.3 A.

Division, Army Air Corps, and charged with liaison with other agencies both within and without the Air Corps regarding barrage balloon matters. Coordination within the Air Corps having been achieved, the materiel procurement program now moved ahead. By February 1941 four balloons--two at Fort Sill, Oklahoma, and two at Fort Lewis, Washington--were in use, while eighty-four were on order and scheduled for completion by August.[30] In March 1941, $6,500,000 were released for current use, and it was expected that an additional $37,000,000 would be available about July 1.[31]

The rest of the program, however, encountered various administrative delays, and progress was disappointing. One of the outstanding causes of difficulty dated back to the directive of April 13, 1923, which had charged the Air Service with the development and procurement of barrage balloon equipment, and the antiaircraft units of the Coast Artillery with its operation.[32] General Arnold and a majority of the Air Corps staff regarded such an arrangement as tactically unsound and out of date.

On February 3, 1941 a memorandum was sent to the Army General Staff requesting that the entire program be placed under Air Corps

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30. Maj. C. K. Gailey, WPD, to General L. T. Gerow, Feb. 5, 1941, in WPD File No. 1098; Col. George E. Stratemeyer to General G. H. Brett, March 12, 1941, in AAG 452.3 A.
31. Executive, Materiel Division to Assistant Chief, Materiel Division, March 31, 1941, in AAG 452.3 A; Office, Chief, Materiel Division, to Technical Executive, Materiel Division, April 15, 1941, in ibid.
32. AGO to Chief of Coast Artillery, April 13, 1923, in ibid.

control. General Arnold argued that the Air Corps was the logical body to operate barrage balloons. He pointed out that their tactical employment was based primarily on existing weather conditions, the operation of friendly bombardment and pursuit units, and the operation of hostile aircraft. War experience had shown that the operation of a fixed barrage would be dangerous to friendly aircraft unless closely controlled and coordinated with the operation of those aircraft. All previous experience in experimentation, supply, training, and operation of lighter-than-air equipment had been in the Air Corps. Then, too, the obtaining of information pertaining to the operation of enemy aircraft was a function of the Air Defense Command. Furthermore, the operation of the Army Weather Service was charged to the Air Corps. For these reasons it was believed that Coast Artillery control would not be as effective as Air Corps control. In fact, control of the barrage balloon program by the Coast Artillery might even result disastrously due to a lack of essential coordination and cooperation with friendly air units.[33]

Generals J. E. Chaney and B. K. Yount and Captain G. P. Saville, all of whom had just returned from studying the situation at first hand in the Battle of Britain, heartily endorsed the recommendations

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33. General Arnold's memorandum is given in full in Appendix 5 (General H. H. Arnold, Acting Deputy Chief of Staff for Air to Chief of Staff, Feb. 3, 1941, in AAG 452.3 A).

of the Air Corps Chief.[34] In support of his views, General Chaney pointed out that the Air Corps had been charged with all lighter-than-air development, procurement, and organization for many years, during which a vast fund of technical, organizational, and tactical information had been accumulated; that the technical development of balloons involved an exhaustive knowledge of aerodynamics and aerostatics--possessed only by Air Corps personnel; that the setting up of technical agencies in the Coast Artillery to handle barrage balloons would involve an undue expense to the government by causing considerable duplication of existing Air Corps agencies and facilities; and that every major nation in the world--except the United States--charged its air arm with all responsibilities for barrage balloons. General Chaney concluded his case by pointing out that regardless of which arm or service was charged with responsibility for barrage balloon development, procurement, and organization, there could be no reasonable doubt that barrage balloon units should be under the tactical command and control of the Air Corps commander charged with the air defense of the area in which the barrage balloons were sited. Experience in England had shown the absolute necessity for such control.[35]

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34. General J. E. Chaney to General B. K. Yount, Nov. 27, 1940, in WPD File No. 1098; Capt. G. P. Saville to General B. K. Yount, Nov. 27, 1940, in ibid.; General B. K. Yount to Chief of Air Corps, Nov. 27, 1940, in ibid.; General H. H. Arnold, Acting Deputy Chief of Staff, to Chief of Staff, Nov. 28, 1940, in ibid.
35. General J. E. Chaney to General B. K. Yount, Nov. 27, 1940, in ibid.

The Coast Artillery apparently was just as firmly convinced that it was the logical arm to operate barrage balloons. Major General J. A. Green, Chief of Coast Artillery, presented the case for his organization. He pointed out that military attaché reports disclosed the need of antiaircraft fire to protect barrage balloons from attack by enemy planes; that balloons and antiaircraft artillery served a common purpose since both were used for the defense of limited objectives; that neither the one nor the other was likely to be used exclusively if both were available; that a sound conception of the tactical employment of antiaircraft defenses required such a disposition of balloons and antiaircraft artillery that the one would complement the other; and that this result could best be obtained if the two functions were under the control of the same commander. Furthermore, explained General Green, since antiaircraft and balloon units normally would be in close juxtaposition, a real economy in the employment of administrative, supply, and operational personnel would result if they were elements of the same command. A more effective system of antiaircraft defense would result if the tactical employment of antiaircraft artillery and of balloons were taught at the same schools and training centers. Should it become necessary in the immediate future to organize balloon batteries or battalions, the Coast Artillery Corps, declared General Green, was in a position to furnish the necessary personnel. Officers could be drawn either from the sixteen harbor-

defense reserve regiments which were neither in use nor required for harbor-defense purposes, or from the sixty-two antiaircraft reserve regiments. Enlisted cadres could be obtained from active antiaircraft regiments and the remaining enlisted personnel from replacement centers.[36]

The Air Corps and Coast Artillery, having presented their cases, awaited the decision of the General Staff. The evidence--especially the practice in the leading European countries--seemed to favor the Air Corps. However, Brigadier General L. T. Gerow, Acting Assistant Chief of Staff, War Plans Division, who had been delegated to study the problem, after reviewing the facts bearing upon it, recommended that the Coast Artillery "be charged with the development, procurement, and operation of barrage balloons." His recommendation was based upon the following points:

> a. Pursuit aviation is the basic defense weapon, due to its mobility and effective fire power. A.A. [antiaircraft artillery] and barrage balloons complement pursuit aviation. This must necessarily continue to be so, due to their relative immobility. All three should operate as distinct type units in the air defense command. These three elements must be so closely coordinated that they will operate virtually as a single unit. . . .
> b. Barrage balloons and A.A. are as a rule employed to protect the same limited objectives and areas. Elements are interspersed and mutually supporting. Since

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36. General Green's views are given in full in Appendix 6 (memo for Chief of Staff by General J. A. Green, Jan. 31, 1941, in AAG 452.3 A).

barrage balloons must be protected by A.A., must be shifted frequently, and have approximately the same mobility, more efficient and economical administration should be attained if A.A. and barrage balloons were under the same commander.

c. The tactical employment of balloons and A.A. constitutes an integrated problem for which A.A. and barrage balloon commanders should be thoroughly trained. Since training of crews is neither complicated nor arduous, the maintenance of any considerable number with barrage balloon units is uneconomical and unnecessary, until an emergency arises. The question of trained officer personnel will be the bottleneck. The Air Corps trained officer and specialist situation is acute, due to the tremendous expansion it is experiencing. The Coast Artillery states that it can provide both officer and enlisted cadres from the 16 harbor defense reserve regiments that are not now and will not be required for harbor defense purposes, or from the 62 reserve A.A. regiments. . . . existing and projected training facilities favor assignment of barrage balloons to the Coast Artillery.

d. Barrage balloons are a comparatively new weapon and facilities and supply organizations lack development. For speedy development and efficient operation, unified control is essential.[37]

General Gerow's report sealed the fate of the barrage balloon project. It was clear that a unified program under Air Corps control could not be expected.

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37. General Gerow's memorandum is given in full in Appendix 7 (memo for Chief of Staff by General L. T. Gerow, Acting Assistant Chief of Staff, WPD, Feb. 11, 1941, in WPD File No. 1098).

Chapter III

JOINT CONTROL OF BARRAGE BALLOON PROGRAM BY AIR CORPS AND COAST ARTILLERY CORPS, 1941

Operation of Barrage Balloons Assigned to Coast Artillery. The barrage balloon decision finally handed down by the General Staff represented a compromise between the views of the Air Corps and the Coast Artillery. On March 14, 1941 a memorandum was issued designating the Coast Artillery as the "using arm" and the Air Corps, "for the time being," as responsible for the experimentation, development, and procurement of barrage balloons.[1] This decision left things just about the way they had been in 1923.

In the months that followed, every effort was made by the Chief of the Air Corps and the Chief of the Coast Artillery to coordinate their operations. Boards and committees were set up on which both branches of the service were represented. A board consisting of two Coast Artillery officers, one Air Corps officer, and one Quartermaster officer was charged with the duty of locating a site for a barrage balloon training center, "to be so selected as not to interfere

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1. General Arnold's instructions for putting this decision into effect are given in full in Appendix 8. (memo for Assistant Chief of Staff, G-3; Assistant Chief of Staff, G-4; Assistant Chief of Staff, WPD; Assistant Chief of Staff, G-1; Chief of Coast Artillery; and General G. H. Brett, OCAC, by General H. H. Arnold, Acting Deputy Chief of Staff for Air, March 14, 1941, in AAG 452.3 A).

with scheduled commercial air line operations or military and naval activities.[2] The board considered the permanent use of Camp Davis, North Carolina, which had been selected as a temporary barrage balloon training center, but rejected it as not conforming with the terms of its directive. Ultimately, the choice narrowed down to two sites, one near Paris, Tennessee, the other at Danville, Kentucky. The latter was the better location from nearly every standpoint except one--cost. Land for the Kentucky site was priced at $300 to $500 per acre, while that in Tennessee could be had for $50 per acre. Accordingly, the site near Paris was selected and ultimately became known as Camp Tyson.[3]

The temporary barrage balloon training center which was to be operated by the Coast Artillery Corps was formally opened by the Chief of Coast Artillery at Camp Davis, North Carolina, on June 1, 1941, and the first balloon was shipped to it on June 6. To provide a nucleus of partially trained personnel to assist in developing barrage balloon operating technique and for training instructors, the Air Corps ordered the 3rd Balloon Squadron from Fort Lewis,

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2. Ibid.; Assistant Chief of Air Corps to Assistant Chief of Staff, G-3, March 21, 1941, in AAG 452.3 B.
3. Office, Chief, Materiel Division to Technical Executive, Materiel Division, April 15, 1941, in AAG 452.3 A; AG to Commanding Generals, Fourth, Eighth, and Ninth Corps Areas, Chief of Coast Artillery, and Chief of Air Corps, April 28, 1941, in ibid.; Office, Chief, Materiel Division to Technical Executive, Materiel Division, May 5, 1941, in ibid.; AG to Quartermaster General, July 29, 1941, in AAG 686 C, Air Bases; interview with and dictated by Col. C. B. Lober, Feb. 12, 1943, in AFIHD files.

Washington, to Camp Davis, together with 50 per cent of the enlisted personnel of both the 1st and 2nd Balloon Squadrons then located at Fort Bragg, North Carolina, and Fort Sill, Oklahoma, respectively. As a component of the training center, a barrage balloon school was inaugurated with an initial student body of 80 officers and 750 enlisted men. The barrage balloon school was to be conducted at Camp Davis until completion of the permanent center at Camp Tyson, Tennessee, in November.[4]

To coordinate operational activities within the Coast Artillery Corps, a Barrage Balloon Board was set up at the Training Center. Meetings were held regularly at which representatives of the Chief of Coast Artillery and of the Training Center came together to study barrage balloon problems and to formulate policy.[5]

Plans were approved for organizing a total of five barrage balloon battalions by about November 1. Each battalion was to consist of three lettered batteries and one battalion headquarters battery. Each of the lettered batteries was to operate thirty-six balloons and to have available for emergencies nine replacements. The battalion headquarters battery was to operate no balloons, but was to

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4. Interview with and memo dictated by Col. C. B. Lober, Feb. 12, 1943, in AFIHD files. Since the training of barrage balloon squadrons was entirely a function of the Coast Artillery, it is not discussed here.
5. Office, Chief of Coast Artillery, to Chief of Air Corps, June 14, 1941, in AAG 452.3 B; interview with and memo dictated by Col. C. B. Lober, Feb. 12, 1943, in AFIHD files.

provide the lettered batteries with supplies and handle all the administrative functions. Three battalions were to be transferred to foreign service stations at the earliest practicable date. The Department commanders concerned were to be prepared to expand these three battalions to eight whenever the need arose. The remaining two battalions were to be held at the Barrage Balloon Training Center. They were to be prepared for immediate threefold expansion on demand, followed in not more than three months by a further and similar expansion.[6] The Chief of Air Corps was requested to make delivery on barrage balloon materiel so as to permit the equipping of five battalions by January 15, 1942, and a total of fourteen battalions by April 15, 1942.[7]

The memorandum of March 14, 1941, which had designated the Air Corps as responsible "for the time being" for the experimentation, development, and procurement of barrage balloons, had not fixed the responsibility for the storage and distribution of balloons and related equipment.[8] The Air Corps had performed these functions without question so long as it had sufficient storage space. In the

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6. Office, Chief of Coast Artillery to Chief of Air Corps (through Assistant Chief of Staff, G-4), July 31, 1941, in Barrage Balloon files, Corps of Engineers.
7. Items of equipment to be supplied and the quantities required are given in Appendix 9 (memo for Chief, Experimental Engineering Section, Materiel Division, by Chief, Aircraft Laboratory, Materiel Division, Sept. 2, 1941, in Barrage Balloon files, Wright Field).
8. Memo for Assistant Chief of Staff, G-3, and others, from General H. H. Arnold, Acting Deputy Chief of Staff for Air, March 14, 1941, in AAG 452.3 A.

autumn of 1941, however, storage space was becoming overcrowded and additional warehouse construction was required.

On September 29 the Chief of Air Corps sent a memorandum to the Chief of Coast Artillery suggesting that since the Air Corps was procuring barrage balloon equipment only "for the time being," it was evident that the Coast Artillery was expected at some future time to take over the experimentation, development, and procurement of barrage balloons. Warehouse construction being required for the storage of the growing quantities of barrage balloon equipment, the question arose as to whether such storage should be provided at Air Corps depots, or at some point or points designated by the Coast Artillery. If the Coast Artillery desired to take over responsibility for the storage and issue of balloon equipment, as seemed logical under the circumstances, then the Air Corps would take no further action to provide additional storage space.[9] In reply, the Coast Artillery agreed to accept responsibility for the storage and issue of balloon equipment, and the transfer was officially sanctioned on November 22. A Coast Artillery section of the Columbus General Depot, Columbus, Ohio, was activated, and in December the functions of storage and issue were transferred to the Coast Artillery.[10]

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9. OCAC to Chief of Coast Artillery, Sept. 29, 1941, in ibid.
10. AG to Chief of Coast Artillery, Nov. 22, 1941, in ibid.

In spite of sincere efforts to coordinate the activities of the Coast Artillery and the Air Corps, the results were not entirely satisfactory. As might have been expected, when one service had undertaken the original development and another service was attempting to develop operating practice, there were many differences of opinion as to the proper characteristics for the different equipment items.

In the summer of 1941 the Coast Artillery Corps sent Lieutenant Colonel R. E. Turley to England as a special military observer for the study of barrage balloon activities there. He spent approximately one month visiting RAF stations where barrage balloon units were in operation, and in collecting information relating to British barrage balloon equipment and its operation. By the time of his return to the United States in August, he had become an enthusiastic convert to British equipment and British barrage balloon practices. In his final report, he recommended:

> That the United States go in without delay for quantity procurement of relatively small and cheap balloons, with auxiliary equipment, similar to that used by the British, and establish barrage balloon units at critical areas such as Panama, Hawaii and the Philippines, for the purpose of learning as quickly as practicable the local conditions in these areas as [they] affect barrage balloon operations. For the present, large, costly and high altitude balloons should be operated only on an experimental basis.[11]

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11. Lt. Col. R. E. Turley, Jr., Coast Artillery Corps, to Assistant Chief of Staff, G-2, Aug. 11, 1941, in AAG 452.3 B.

The Materiel Division, Army Air Corps, regarded Colonel Turley's recommendations as premature and stated that no intelligent action could be taken until the Coast Artillery should set forth clearly the characteristics of the barrage balloon equipment desired and the changes which should be made in the type of equipment then being supplied. The Materiel Division pointed out that any attempt by American manufacturers to duplicate the British equipment would cost more money than the type of equipment already being supplied.

The picture was especially confused in respect to the use of high altitude balloons. A preliminary recommendation from the Commanding General, Air Force Combat Command to the War Plans Division, General Staff, had requested the development of balloons capable of reaching 20,000 feet. The comment of the Office, Chief of Coast Artillery to the War Plans Division on this had been that one high altitude balloon should be provided for every two low altitude balloons. Such a view was completely at variance with the recommendation of Colonel Turley.[12]

A British squadron leader, Michael Bellhouse, paid several visits to this country to give the Coast Artillery the benefit of

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12. Assistant Executive, Materiel Division, for Chief of Air Corps, to Chief of Coast Artillery, Sept. 11, 1941, in ibid.

his advice.[13] There was, undoubtedly, much to be learned from British practice, but the Air Corps objected to absolute adherence to it, believing that American practice was in some respects better adapted to conditions in the United States.

Criticism has been leveled at the Air Corps for not having made greater use of British experience in the development of barrage balloon equipment. A careful examination of the circumstances surrounding the development of barrage balloons by the Air Corps during the winter of 1940 and the spring and summer of 1941 shows that full advantage was taken of all available information concerning British materiel and operating practice. In October 1940 the Air Corps requested the purchase from England of a complete set of barrage balloon equipment, along with training publications and operating instructions.[14] The British government had advised that delivery could be made in about ten days.[15] Due to a shortage of equipment in England and to administrative delays both there and in the United States Army G-2, it required almost eight

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13. Chief of Coast Artillery to Chief of Air Corps, March 6, 1942, in AAG 452.3A.
14. Memo for Assistant Chief of Staff, G-2, by OCAC, Oct. 4, 1940, in G-2 file no. 452.3, Great Britain.
15. U. S. Military Attache, London, to G-2, WDGS, Oct. 18, 1940, in ibid.

months to get delivery.[16] Had the Air Corps delayed its developmental program until after the arrival of the English equipment in May 1941, the barrage balloon program would not have gotten under way before the close of 1941; and few, if any, balloons would have been ready for use in the tense days following Japan's attack on Pearl Harbor.

As a result of Air Corps initiative, nearly 300 D-3, D-4, D-5, and D-6 balloons were available for use when war came, and orders had been placed for about 2,400 more. On the strength of these orders American factories were operating at a production rate of 2,200 units per year. About 150 winches were on hand, and orders had been given for an additional 1,500. Production facilities were available for turning out winches at the rate of approximately 70 per week. Some 30,000 hydrogen cylinders were available, and orders had been placed for an additional 241,750. The existing rate of production was about 8,000 cylinders per month; arrangements had been made for increasing it to 12,000 per month by February 1942,

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16. Memo for Assistant Chief of Staff, G-2, by General H. H. Arnold, Chief of Air Corps, Oct. 25, 1940, in ibid.; memo for Foreign Liaison Officer, G-2, by Chief of Air Corps, Nov. 15, 1940, in ibid.; cablegram, Assistant Chief of Staff, G-2 to U. S. Military Attaché, London, Nov. 22, 1940, in ibid.; cablegram, U. S. Military Attaché, London, to Assistant Chief of Staff, G-2, Feb. 4, 1941, in ibid.; U. S. Military Attaché, London, to Assistant Chief of Staff, G-2, March 14, 1941, in ibid.; Assistant Chief of Staff, G-2, to Commissioner of Customs, May 6, 1941, in ibid.; Commissioner of Customs to Assistant Chief of Staff, G-2, May 14, 1941, in ibid.

and to 18,000 per month by May. Similar arrangements had been made for other items.[17]

The Air Corps was also criticized because of the high cost of American barrage balloon equipment when compared with similar British equipment. A breakdown in comparative costs shows the reason for the disparity:

	British	American
Fabric		
1100 yds 2 ply @ $1.41 1100 yds 2 ply @ $2.50	$ 1,554	$ 2,750
Labor		
1000 hrs @ 20 cents 2000 hrs @ $1.00	200	2,000
Miscellaneous fittings	141	300
Overhead		
22% 18 1/2%	526	1,150
Totals	$ 2,421	$ 6,200

The British balloon was of 20,000 cubic feet capacity and of the ballonet type, while the American balloon was of 27,000 cubic feet and the dilatable type. The amount of labor involved in the

17. The monthly report for December 1941 on barrage balloon equipment is given in Appendix 10 (Chief, Materiel Division, Air Corps, to Chief, Statistics Branch, WDGS, Jan. 5, 1942, in AAG 452.3 B); cf., 1st Indorsement (basic unknown), Hq., AAF to AG, Nov. 14, 1941, in ibid.

American type was greater for two reasons: (1) much more internal rigging was required in the dilatable type; and (2) the British had been up to peak production for some time. When the United States should reach a production rate of 4,000 balloons per year, asserted the Air Corps, it was likely that the labor cost per balloon could be reduced by as much as $500 or $1,000 per balloon.

The chief factor in the higher cost of the American product was the unit cost of American labor, which was five times that of the British. Methods of reducing cost were discussed, such as taping only the inside seams of the balloon, a reduction in the amount of internal rigging, and the use of a simpler packing box. So long as American labor costs remained so much higher, however, there was little likelihood of producing balloons at the British price.[18]

Legitimate criticism was made of the quality of the equipment furnished by some of the contractors during the early stages of the barrage balloon program. The neoprene-coated fabric of which the balloons were constructed was sometimes faulty, allowing the passage of air into the balloon and so causing the hydrogen gas to lose its purity rapidly. The action of heat and sunlight caused

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18. Memo for Foreign Liaison Officer, G-2, from OCAC, Nov. 15, 1940, in G-2 file no. 452.3, Great Britain; U. S. Military Attaché, London, to Assistant Chief of Staff, G-2, Nov. 25, 1940, in ibid.; R&R, Chief, Materiel Division to Executive, OCAC, Dec. 16, 1940, in AAG 452.3 A.

a decomposition of the neoprene, resulting in the liberation of chlorine gas which combined with the hydrogen and water vapor to produce hydrochloric acid. The acid then attacked the cotton fabric and so weakened it as to destroy the balloon's usefulness. There were numerous instances in which the fabric tore, even when under no particular strain, making rents varying from a few feet to half the length of the balloon. Occasionally, when the balloons were gas inflated, the seams at the panels came apart because of poor cementing. Sometimes winches, after relatively short hours of service, required major repairs. Clutches became unserviceable by the burning out of friction plates, sticky valves developed, and engine lubrication systems showed a very high percentage of water.[19] Such faults, however, are natural concomitants of any project in its early stages.

Sometimes, too, equipment designed for one purpose--and satisfactory when so used--was employed by the Coast Artillery for some other purpose. The A-9 winch, for example, had not been designed

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19. Memo for Chief, Experimental Engineering Section, Materiel Division, Air Corps, from Chief, Engineering Section, Materiel Division, April 14, 1941, in ibid.; Unsatisfactory Report, Barrage Balloon School, Camp Davis, N. C., Sept. 20, 1941, in AAG 452.3 B; notes submitted by Major S. T. Moore, Air Corps, member of the Barrage Balloon Board, to President, Barrage Balloon Board, Sept. 30, 1941, in ibid.; Hq., 304th Coast Artillery Barrage Balloon Battalion, Fort Lewis, Wash., to Commanding General, 39th Coast Artillery Brigade (AA), Ft. Lewis, Wash., March 8, 1942, in Barrage Balloon files, Wright Field.

to accommodate 1/4-inch 6 x 1 cable. When the Coast Artillery attempted to use it with cable of that size, the result was unsatisfactory. The Air Corps pointed out that a new winch would have to be designed, constructed, and tested before a machine suitable for handling 1/4-inch 6 x 1 cable could be obtained in production quantities.[20]

United States Enters World War II. News of the attack on Pearl Harbor on December 7, 1941 galvanized the whole country into action. Air attacks upon other American possessions, or even the mainland, were expected momentarily. A speeding up of the barrage balloon program became imperative. On December 17 both General Joseph A. Green, Chief of the Coast Artillery, and General Mark W. Clark, Chief of Staff, Army Ground Forces, directed that every effort be made to expedite the sending of three barrage balloon battalions to the West Coast. One was to be used at the Bremerton Navy Yard, Bremerton, Washington, the second at the Boeing Aircraft factory at Seattle, and the third at the Naval Air Base, San Diego. The latter was shortly changed to the Mare Island Navy Yard near San Francisco. The Bremerton unit was to be in readiness for use

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20. Chief, Experimental Engineering Section, Materiel Division, to Chief, Field Service Section, Materiel Division, March 12, 1942, in Barrage Balloon files, Wright Field.

by January 1, with the other units following in order at two-week intervals.

The problem of equipping these units on such short notice was a difficult one. Cable production was still slow, and to meet the requirements for the first unit, it was necessary to ship about twenty reels of 1/4-inch observation balloon cable from storage in San Antonio, Texas. Winch requirements were met by shipping twenty-six from Camp Davis, North Carolina. A survey of hydrogen production facilities in the United States had been made only a short time before, and it indicated ample capacity at Tacoma, Washington, and Martinez, California, to meet current needs. Some difficulty was encountered in securing adequate compressor and bottling facilities, but it was promptly overcome. By early January the plants of the Pennsylvania Salt Manufacturing Company and the Hooker Electro-Chemical Company, both of Tacoma, Washington, and the Shell Chemical Company of Martinez, California, were able to supply the necessary gas for maintaining the West Coast barrages.[21]

Many difficulties were encountered throughout in obtaining adequate priority ratings and allocations on certain critical items,

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21. Interview with and memorandum dictated by Col. C. B. Lober, Feb. 12, 1943, in AFIHD files; Assistant Executive, Materiel Division, Air Corps, to Priorities Committee, Army and Navy Munitions Board, Jan. 7, 1942, in AAG 400.174, Priority in Supply; Pennsylvania Salt Mfg. Co., Takoma, Wash., to Col. C. B. Lober, Chief, Barrage Balloon Section, Materiel Division, Air Corps, Jan. 15, 1942, in AAG 463.2 C; Chief, Barrage Balloon Section, Materiel Division, Air Corps, to Independent Engineering Co., O'Fallon, Ill., Feb. 17, 1942, in AAG 679.

the most important being neoprene, rolled sheet steel, and certain parts required for winch construction. The entire program was given an A-1d rating, but it became necessary to procure A-1a ratings for certain items. From December 1941 to February 1942 the delay in obtaining rolled sheet steel almost prevented the obtaining of hydrogen generators in sufficient time to meet tactical requirements. The shortage of high grade solvents used in processing neoprene was another source of difficulty. Many conferences were held with representatives of the War Production Board and with users and producers of this material. As a partial solution of this problem, it finally became necessary for the Vulcan Proofing Company of Brooklyn, New York, to install solvent recovery apparatus at a cost of almost a quarter of a million dollars.[22]

The procurement problem was still further complicated by the fact that the Air Corps was also called upon to supply the Marine Corps with barrage balloons, winches, cables, hydrogen generators, and other minor equipment. Careful planning and ingenuity were required to meet the requirements of both services and still not delay either one.

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22. Interview with and memorandum dictated by Col. C. B. Lober, Feb. 12, 1943, in AFIHD files; Assistant Chief, Materiel Division, to Executive, OCAC, Feb. 18, 1941 (and after), in AAG 452.3 A; Assistant Executive, OCAC to Technical Executive, Materiel Division, Dec. 12, 1941, in AAG 452.3 B; Executive, Air Service Command to Assistant Chief, Air Service Command, Jan. 13, 1942, in AAG 400.174, Priority in Supply; Office, Commanding General, Materiel Command to Chief of Engineers, April 23, 1942, in AAG 452.3 C.

The first Marine Corps balloon squadron which departed from Norfolk, Virginia, in February 1942 was only partially equipped in spite of strenuous efforts. The second squadron which departed from San Diego in early April was fully equipped, including a three months' supply of chemicals. This achievement was accomplished, however, only by taking from the Barrage Balloon School at Camp Tyson, Tennessee, its only hydrogen generator. The Air Corps agreed to replace it within a few weeks with a generator of smaller capacity made from material on hand at the factory.[23]

Joint Barrage Balloon Committee Set Up. In an attempt to secure closer cooperation between the Air Corps and the Coast Artillery Corps, a Joint Barrage Balloon Committee was constituted to determine the desirable military characteristics for the equipment to be developed and to make recommendations as to its standardization. The official committee was to consist of one officer representing the Chief of Coast Artillery, two officers representing the Commanding Officer of the Barrage Balloon Training Center, and three officers representing the Chief of the Air Corps.[24]

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23. Interview with and memorandum dictated by Col. C. B. Lober, Feb. 12, 1943, in AFIHD files; Chief, Bureau of Aeronautics, to Chief of Air Corps, Jan. 28, 1942, in AAG 452.3 A; Chief, Bureau of Aeronautics, to Chief of Air Corps, March 14, 1942, in ibid.
24. Chief, Materiel Division, Air Corps, to AG, Nov. 13, 1941, in AAG 452.3 A; AG to Chief, Army Air Forces, Nov. 22, 1941, in ibid.

The first meeting of the Joint Barrage Balloon Committee was held on January 2, 1942.[25] General J. A. Green, Chief of Coast Artillery, addressed the committee on the barrage balloon equipment supply situation. He explained that while the equipment being supplied at that time was not entirely satisfactory, it was far better than none. The developmental work that had been going on had given the Coast Artillery a tremendous start with its barrage balloon program, explained General Green, and as time went on the kind of balloon equipment that would fill the needs of the Coast Artillery could be determined. He urged the committee to take no action which might cause any delay in the production and delivery of balloons and related equipment. The committee was asked to set up desirable military characteristics for the various barrage balloon items so that the Chief of the Air Corps might know definitely the objective with respect to such equipment. Critical items in the barrage balloon category were to be discussed with a view to taking special action to implement their procurement.

A list of desirable military characteristics for the various barrage balloon items, which had been drawn up by the Barrage Balloon

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25. Present as members of this committee were: Colonel Robert Arthur, Commanding Officer, Barrage Balloon Training Center; Colonel C. B. Lober, Air Corps, Office of the Chief of Air Corps; Colonel P. P. Lowry, Coast Artillery Corps, President, Barrage Balloon Board; Lieutenant Colonel W. H. Dunham, Jr., Coast Artillery Corps, Office of the Chief of Coast Artillery; Major C. F. Danberg, Air Corps, Materiel Division, Wright Field; and Lieutenant Fred Thomas, Jr., Air Corps, Materiel Division, Wright Field.

Board for discussion, was then taken up. Each item was discussed by the committee in detail, and changes were made to meet limitations imposed by design or procurement. The amended list, which represented a compromise between the views of the Air Corps and of the Coast Artillery, was approved by the committee and then transmitted to the Chiefs of the Air Corps and Coast Artillery with a recommendation for favorable consideration.[26]

The desirable military characteristics for a low altitude barrage balloon as fimally agreed upon were as follows:

1. A non-pressure closed ballonet balloon with a gas valve, which operates only when the balloon has reached the ballonet ceiling. Fins to be air-inflated.
2. An operational height of approximately 5000 feet at sea-level under the following conditions:
   a. Air temperature at ground: 60° F.
   b. Air pressure at ground: 29.92 in. mercury.
   c. No wind.
   d. Weight of balloon cable: Not over 90 pounds per 1000 feet.
   e. A free lift of 35 pounds at operating altitude.
   f. Cable armed with a lethal device weighing not over 50 pounds.
   g. Inflation with hydrogen of 92% purity.
   h. To be rigged for mechanical handling designed to reduce the operating personnel to a minimum.
3. The ballonet ceiling shall be 8000 feet under the conditions set forth in Paragraph 2-a-b-c.
4. Balloon to valve gas when the internal pressure becomes dangerous to the fabric. Valve setting or point of operation should be easily adjusted.

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26. Report of Joint Barrage Balloon Committee to Chief of Coast Artillery, Jan. 3, 1942, in ibid.

5. Design of balloon to be such as to allow rate of haul down of not less than 300 feet per minute in a 20 mi. per hour wind, with a haul down rate of 1,000 feet per minute desired.
6. Topping-up to be possible from a close-haul position of balloon.
7. Fabric.
   a. A known fabric with the least permeability obtainable, consistent with other requirements, particularly long life and low weight.
   b. Fabric deterioration under storage or use not to limit the life of the balloon to less than 9 months.
   c. Fabric to be treated to prevent excessive superheat.
8. Flying behavior.
   a. Capable of flying in a 50 m.p.h. wind without loss of or damage to balloon.
   b. Under steady wind conditions balloon not to pitch or yaw or fly off wind to the degree that the balloon becomes unmanageable.
   c. Design and rigging to be such that no ballast is required.
9. Minimum weight and volume consistent with characteristics previously described.
10. Maximum simplicity of design consistent with the above requirements.

Other items of barrage balloon equipment--winches, cables, ground cloths, junction assemblies, lethal devices, air blowers, hydrogen generators, trailers, and minor items--were treated similarly.[27] Intelligent development of barrage balloon equipment was now possible.

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27. The complete list of desirable military characteristics for barrage balloon equipment is given in Appendix 11 (Report of Joint Barrage Balloon Committee to Chief of Coast Artillery, Jan. 3, 1942, in AAG 452.3 A).

War Department Reorganization, March 9, 1942. In the meantime, however, plans had been inaugurated for a reorganization of the entire War Department. On March 2, 1942, Circular No. 59 was issued announcing a reorganization to become effective March 9. Extensive changes in every branch of the service resulted.[28]

The functions of the Coast Artillery with respect to storage and issue of barrage balloon equipment, which had been handed over to it by the Air Corps several months earlier, were transferred to the Corps of Engineers. In the interest of efficiency, it was believed that all functions pertaining to this equipment, that is, development, procurement, storage, and issue, should be placed under one operating division.[29] With this end in view, conferences were held by representatives of the Army Air Forces, the Corps of Engineers, and the Coast Artillery Corps. Representatives of the Army Air Forces agreed that there was little point in having the Air Forces retain the functions of development and procurement of barrage balloons if their operation was to be a function of the Coast Artillery. Under the circumstances, Headquarters, Army Air Forces, indicated its willingness to have the functions of development and procurement transferred to the Corps of Engineers.[30] Such a transfer

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28. W. D. Circular No. 59, March 2, 1942.
29. Lt. Gen. Brehon Somervell, Commanding, Services of Supply, to Commanding General, AAF, March 24, 1942, in AAG 452.3 A.
30. Hq., AAF, to Commanding General, Services of Supply, March 28, 1942, in ibid.

was duly authorized by a War Department directive dated March 27. The details were to be arranged by direct action between the Army Air Forces and the Corps of Engineers.[31]

. Development and Procurement of Barrage Balloons Transferred to Corps of Engineers. Arrangements were completed as rapidly as possible for the transfer of existing Air Force contracts to the Chief Engineer, United States Army, for future administration, and contractors were notified of the transfer. While the Engineers were training replacement personnel, inspection on contracts in effect was to be continued by the Air Forces. The Navy Department was requested to pay the amounts due the Air Forces for barrage balloon equipment which had been furnished the Marines. Arrangements were concluded for the transfer of all unexpended barrage balloon funds. By the summer of 1942 the transfer was virtually complete, and Air Forces participation in the barrage balloon program was terminated. The Barrage Balloon Section, Materiel Command, was then discontinued.[32]

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31. AG to Commanding General, AAF, March 27, 1942, in ibid.
32. Chief, Materiel Division to Technical Executive, Materiel Division, April 1, 1942, in AAG 452.3 C; Chief, Barrage Balloon Section to Chief, Materiel Division, March 28, 1942, in AAG 452.3 A; Chief, Barrage Balloon Section to Chief, Materiel Division, April 22, 1942; Assistant Technical Executive, AAF to Commanding General, Materiel Command, May 15, 1942, in AAG 452.3 C.

[redacted]

Chapter IV

PROGRESS IN DETERMINATION, DEVELOPMENT, AND PROCUREMENT OF BARRAGE BALLOONS UNDER THE ARMY AIR CORPS, 1940-1942

Review of Barrage Balloon Program under the Air Corps. Substantial progress was achieved by the Army Air Corps in the development and procurement of barrage balloon equipment during the fifteen months between September 1940, when the program really got underway in earnest, and April 1942, when Air Corps participation with the program was terminated. During this period, research and experimentation with barrage balloon equipment never ceased. Every item was worked on critically and efforts were made to improve its performance. A brief review of Army Air Corps achievements in respect to the development and procurement of the principal items of barrage balloon equipment will serve to make clear the nature and extent of the progress made.

Types of Balloons Developed. Durable fire to barrage balloons themselves, the desirable military characteristics for a barrage balloon depended upon whether it was to be used at high altitudes, low altitudes, or for special work. With respect to the general functional design a balloon for any one of these uses could be either of the

[redacted]

ballonet or the dilatable type. The ballonet type is one in which the outer hull retains its shape through provision for the variation in lifting gas volume, due to variation in atmospheric density or temperature, by means of an air chamber within the outer hull to which is connected an air scoop. Wind velocity is employed to generate pressure within the balloon causing it to hold its shape. The dilatable type has no air chamber, being entirely filled with gas. Elastic cords placed internally or externally are depended upon to retain the balloon's shape during expansion and contraction of the gas.[1] The available evidence as to the respective merits of the two types being inconclusive, both ballonet (D-4, D-7, and D-8) and dilatable (D-3, D-5, and D-6) low altitude balloons were purchased for field testing.[2]

In addition to the ballonet and dilatable balloons, a third type, the positive pressure balloon, was developed, and some experimental tests made with it in an effort to develop a lower cost

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1. "Information Regarding Barrage Balloon Program" by authority of the Commanding General, AAF, n.d. [about March 1942], in Barrage Balloon files, Corps of Engineers; Col. R. E. Turley, Jr., Coast Artillery Corps, "Barrage Balloons," in Coast Artillery Journal, Jan.-Feb., 1942, pp. 20-24; "Prospectus for Barrage Balloons," prepared by Goodyear-Zeppelin Corp., June 22, 1939, in Barrage Balloon files, Corps of Engineers.
2. Contractor's specifications on the D-3, D-4, D-5, and D-6 balloons are given in Appendix 12. Specifications for a particular type of balloon varied slightly depending upon the contractor. (Contractor's specifications, Barrage Balloon, Type D-3, Low Altitude, Dilatable, Goodyear Tire and Rubber Co., June 20, 1941, in Barrage Balloon files, Wright Field; Type D-4, Low Altitude, Ballonet, Air Cruisers, Inc., June 20, 1941, in ibid.; Type D-4, Low Altitude, Ballonet, United States Rubber Co., June 20, 1941, in ibid.; Type D-4, Low Altitude, Ballonet, General Tire and Rubber Co., June 20, 1941, in ibid.; Type D-5, Low Altitude, Dilatable, Goodyear Tire and Rubber Co., June 20, 1941, in ibid.; Type D-6, Low Altitude,

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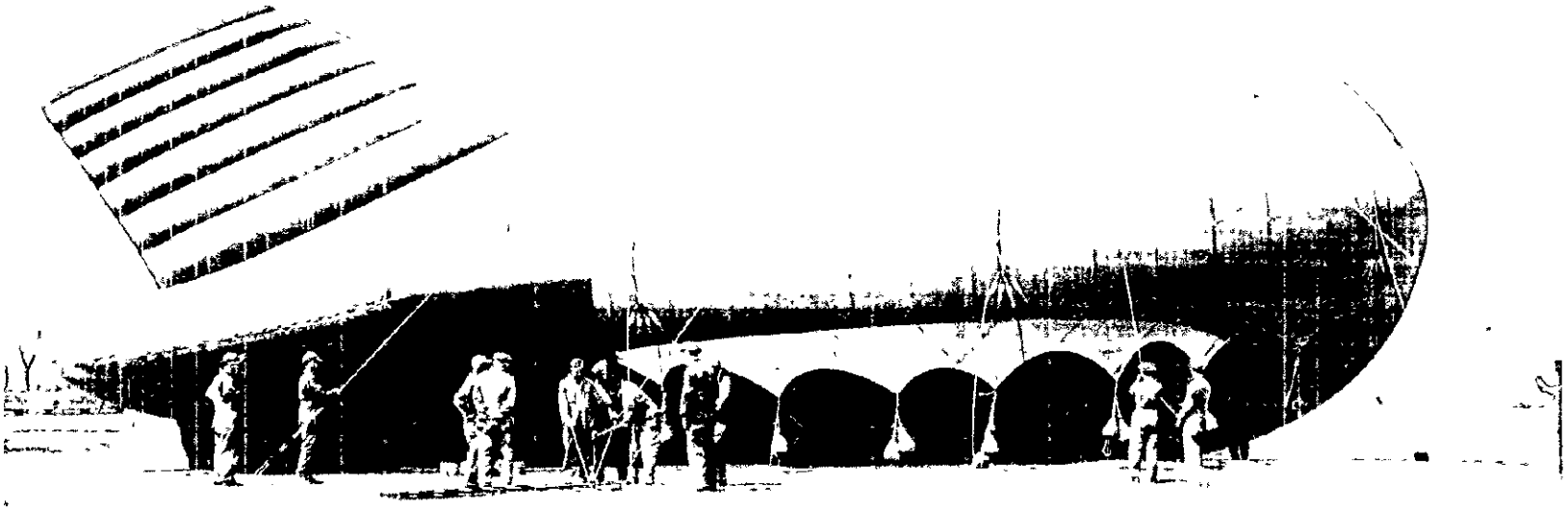


Type B-3, Low Altitude, Dirigible.

Manufacturer:
Goodyear Tire and Rubber Co.

Controlled by:
Materiel Command, AAF

Type L-2, Low Altitude, Ballonet

Manufacturer:
B. F. Goodrich Co.

Furnished by:
Materiel Command, AAF

Type L-3, Low Altitude, Dilatable

Manufacturer:
Firestone Tire and Rubber Co.

Furnished by:
Materiel Command, AAF

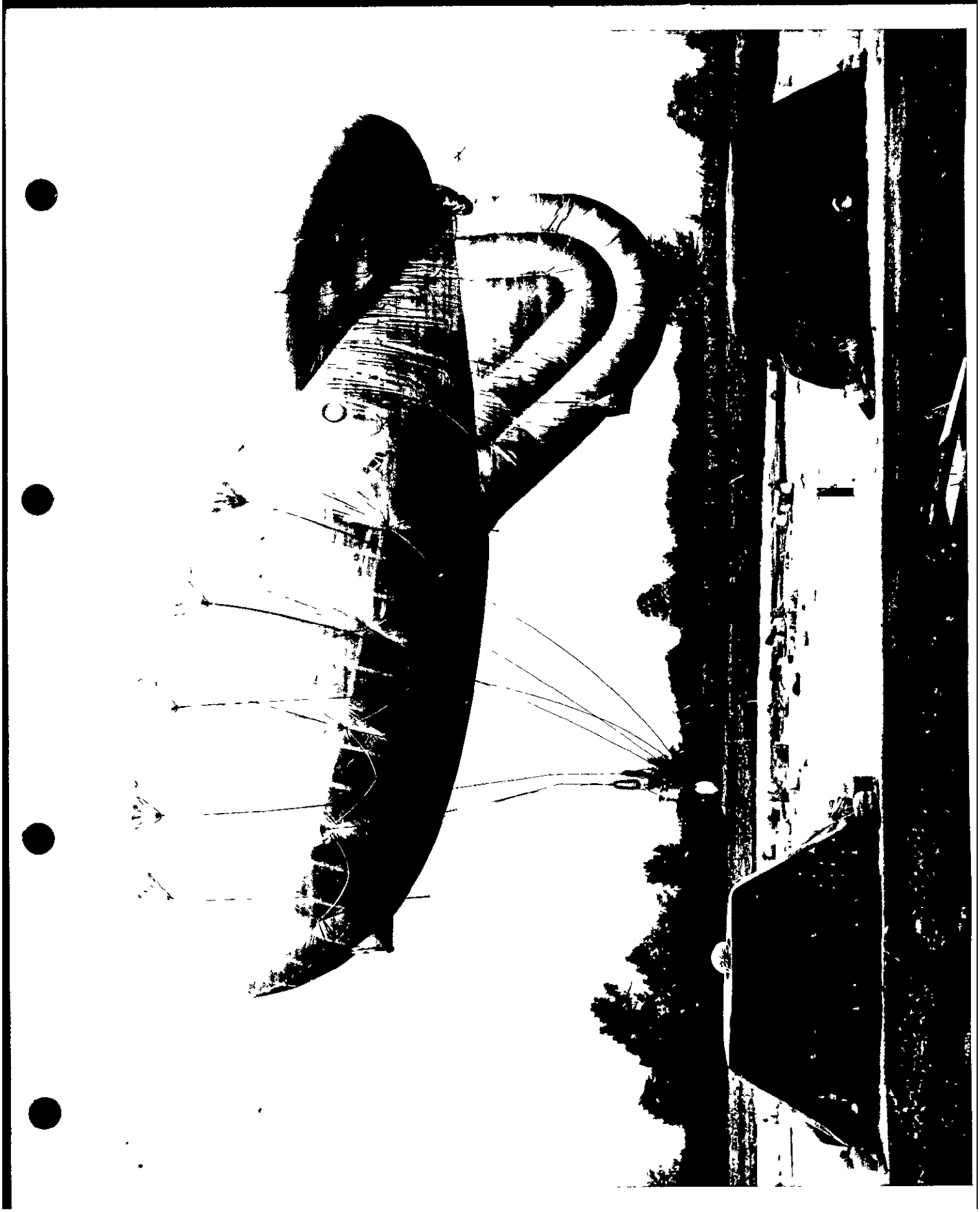
Type L-3, Low Altitude, Ballonet

Furnished by:
Materiel Command, AAF

Type D-6, Low Altitude, All-Metal

Manufacturer: Goodyear Tire and Rubber Co.

Official Photograph, U.S.



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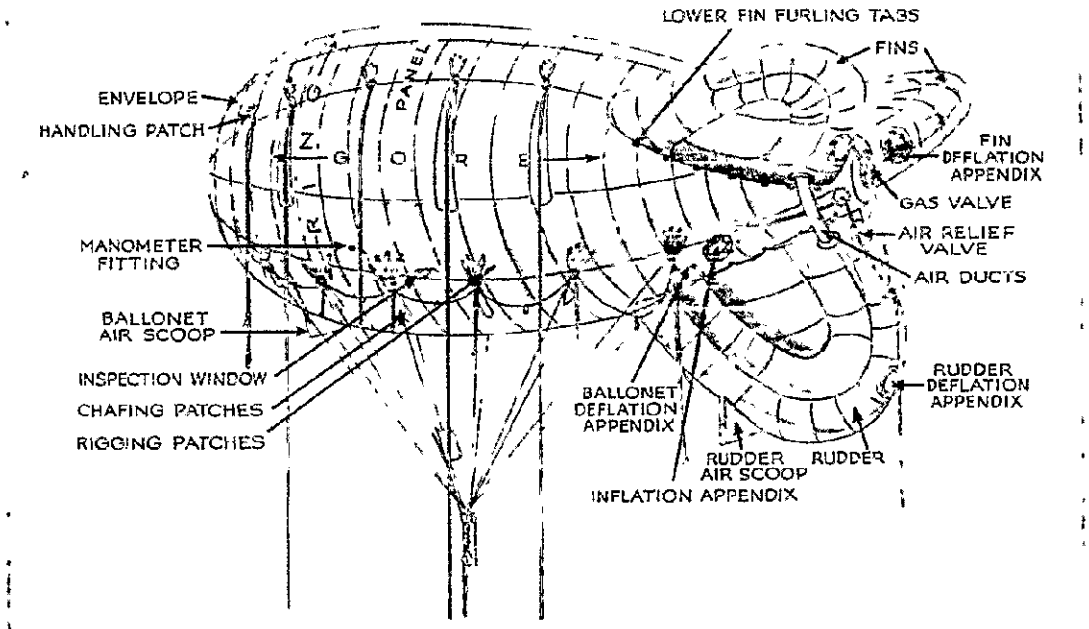
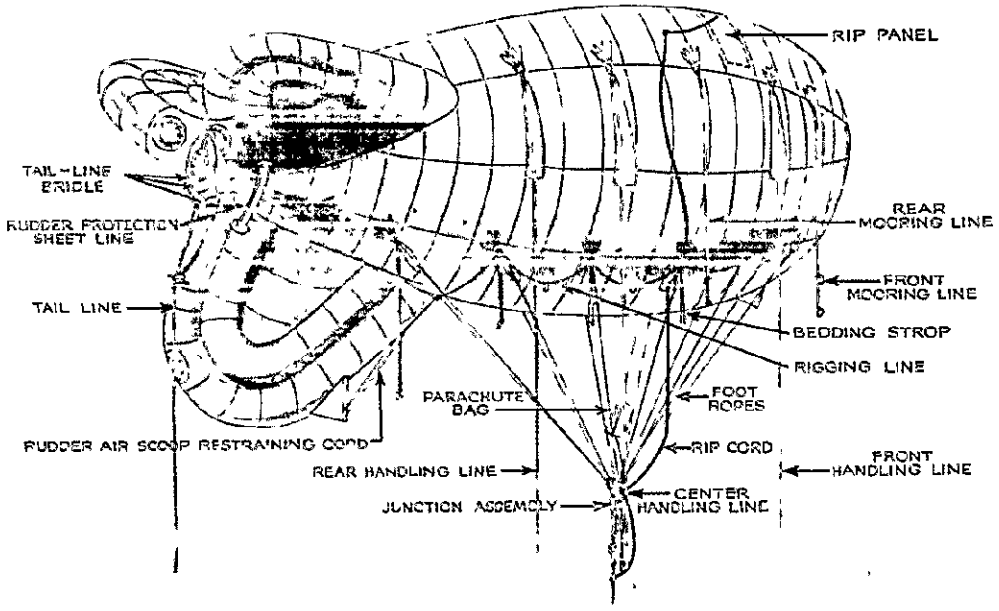
Type D-7, Low Altitude, Ballonet

Furnished by:
Barrage Balloon Board,
Coast Artillery Corps



LEFT SIDE OF D-8 BALLOON



RIGHT SIDE OF D-8 BALLOON

Based on diagram in Barrage Balloon, Service of the Balloon and Balloon Equipment, Low Altitude, Barrage Balloon School, Coast Artillery Corps, February 13, 1943.

balloon. This balloon was essentially a ballonet type which used an electrically driven mechanical blower to force air into the ballonet. The blower was automatic in operation and maintained a fixed internal pressure independent of wind velocity.[3]

The dilatable type had been regarded as superior on the basis of design, but in actual operational tests the ballonet type proved itself the more practical balloon. At the time the Air Corps' participation in the program terminated, production of D-4, D-5, and D-6 models was being converted to the production of D-7 and D-8 ballonet models, these being American versions of the British Mark VII and Mark VIII, respectively.[4]

While the major emphasis was upon the development of satisfactory low altitude balloons, steps were taken to devise a balloon capable of reaching an altitude of 15,000 feet.[5] A contract for the construction of such a high altitude balloon was awarded the Goodyear Tire & Rubber Company. The balloon was to have a basic gas displacement of 49,000 cubic feet and a displacement of 71,000 cubic feet when fully dilated. Rate of ascent was to be between 200 and

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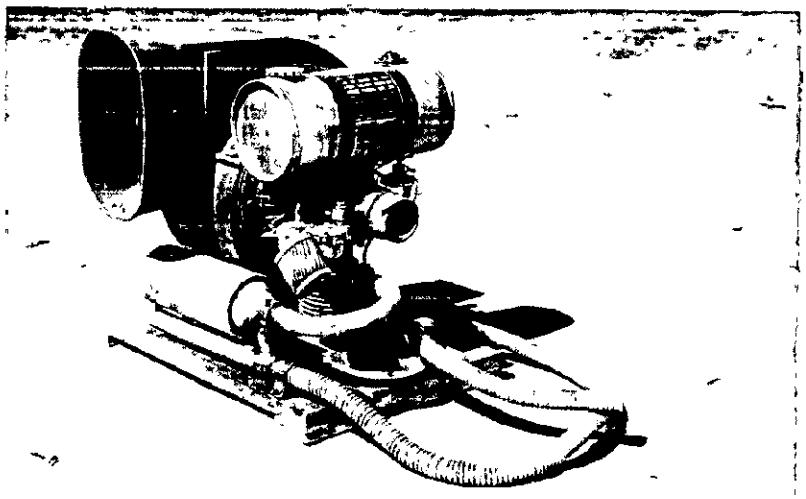
3. "Information Regarding Barrage Balloon Program," by authority of the Commanding General, AAF, n.d. [about March 1942], in Barrage Balloon files, Corps of Engineers.
4. Ibid.; Barrage Balloon. Service of the Balloon and Balloon Equipment, Low Altitude, Barrage Balloon School, Coast Artillery Corps, Camp Tyson, Tenn., Feb. 13, 1943.
5. OCAC to Chief of Coast Artillery, Jan. 11, 1940, in AAG 452.3 A; Chief, Experimental Engineering Section, Materiel Division, to Air Cruisers, Inc., Sept. 24, 1940, in Barrage Balloon files, Wright Field.



1,000 feet per minute depending upon net lift, wind speed at the balloon, and winch pay-out ability. Rate of descent was to be between 125 and 1,000 feet per minute depending upon wind speed at the balloon. A flying cable of 7/32-inch diameter was to be used and the balloon was to be capable of flying in winds up to 50 m.p.h.[6] Only one high altitude balloon had been built at the time of American entrance into the war. From that time on, tactical considerations and a desire to speed up the production of low altitude balloons resulted in an almost complete suspension of high altitude production.[7]

Cable Development. Cable development underwent a similar evolution. Original production was begun on 3/16-inch 7 x 19 preformed steel cable having a rated breaking strength of 5,100 pounds, being furnished in reels of 9,000 feet each. When this cable was found to be of insufficient strength, production was changed to 7/32-inch 7 x 7 preformed cable having a rated breaking strength of 6,800 pounds, and being furnished in 8,000-foot reels.

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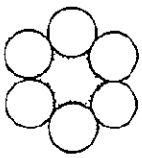
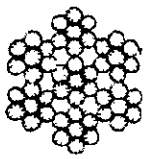
6. Contractor's specifications on the High Altitude Barrage Balloon are given in Appendix 13 (Contractor's Specification, Barrage Balloon, High Altitude, Dilatable, Model No. D-BB-6L, Goodyear Tire and Rubber Co., May 30, 1942, in Barrage Balloon files, Wright Field).
7. Aircraft Laboratory, Materiel Division, Weekly Teletype Report, May 7, 1942, in Barrage Balloon files, Wright Field; AG to Chief of Air Corps, Oct. 24, 1941, in AAG 452.3 B.

CABLE CONSTRUCTION

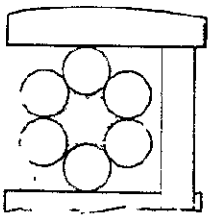


6 x 1
(HEMP CENTER)

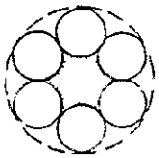


7 x 7

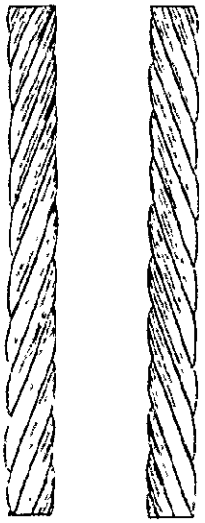
CROSS SECTIONS OF CABLES



METHOD OF MEASUREMENT



THE DIAMETER OF A CABLE IS THAT OF A TRUE CIRCLE



RIGHT LAY

LEFT LAY

Based on diagram in Portable Barrage Balloon Winches and Barrage Balloon Flying Cables, Barrage Balloon School, Camp [illegible], November 10, 1942.

In accordance with the recommendations of the Joint Barrage Balloon Committee, it was decided in February 1942 to change to 1/4-inch 6 x 1 preformed cable having a rated breaking strength of 7,100 pounds, furnished in 7,000-foot reels. This was essentially the same cable as that being used in England. One reason for preferring this cable was its alleged greater destructive power against airplane wings. There was some belief in Air Corps quarters that a 7 x 1 cable with a metallic central strand might be still better, inasmuch as it would be less subject to deformation than one with a hemp core. It was found that all cables needed to be either galvanized or tinned and treated with corrosion-resistant material.[8]

Lethal Devices. If a balloon cable is to damage hostile aircraft, either it must be sufficiently heavy and stiff to prevent further controlled flight of contacting planes, or it must be equipped with some form of lethal device. In order to render cables more dangerous and at the same time to permit the use of lighter and more flexible cables, the development of some form of lethal device was attempted. It was found that the British employed a method which

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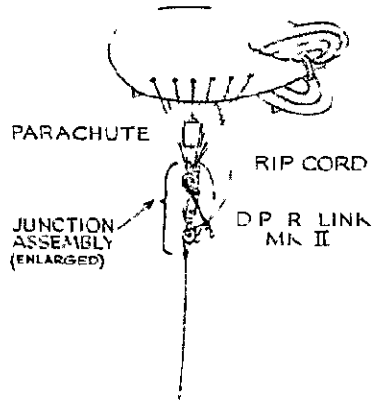
8. "Information Regarding Barrage Balloon Program," by authority of Commanding General, AAF, n.d. [about March 1942], in Barrage Balloon files, Corps of Engineers; Portable Barrage Balloon Winches and Barrage Balloon Flying Cables, Barrage Balloon School, Coast Artillery Corps, Camp Tyson, Tenn., Nov. 10, 1942.

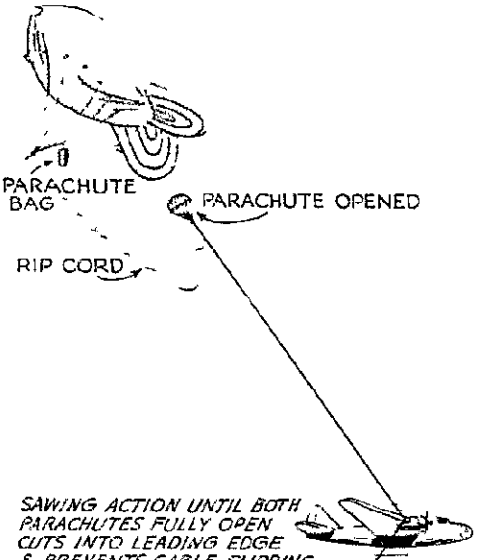
ARMED CABLE
BEFORE & AFTER IMPACT



NOTE THE LOWER DPL UNIT MUST BE HIGHER THAN THE SURROUNDING OBSTRUCTIONS & NOT LESS THAN 200 FT ALONG THE CABLE FROM THE WINCH

D P L MK VI

TO WINCH



NOTE THE CABLE IS ALWAYS RELEASED BY THE LINKS BEFORE THE AIRCRAFT CAN BREAK IT AT POINT OF IMPACT THE TWO PARACHUTES PUT ON A COMBINED LOAD OF 6 TONS SUFFICENT TO CAUSE ANY AIR-CRAFT TO STALL & CRASH EVEN IF THE WING IS NOT ACTUALLY TORN OFF

PARACHUTE DRAWN TOWARDS AIRCRAFT UNTIL FULLY OPENED

PARACHUTE BAG

TO WINCH

NOTE PARACHUTE TAKES 7 SECS TO OPEN AND MAY DIVE TOWARDS THE GROUND IT MUST THEREFORE BE HIGH ENOUGH TO CLEAR ANY POSSIBLE OBSTRUCTION

Based on diagram in Lethal Devices for Low Altitude and Very Low Altitude Balloons, Barrage Balloon School, Coast Artillery Corps, December 5, 1942

consisted of a combined detachable parachute link and ripping link at or near the balloon junction piece and a second detachable parachute link several hundred feet above the ground. Upon being struck by an airplane, the cable was cut at each of the two links. The length of cable thus cut free carried on each end a large strong parachute. This contrivance attached to the wing of the contacting plane introduced so much aerodynamic drag that flying speed could not be maintained. A proposed variation of this procedure was to make the lower parachute smaller than the upper one and place a bomb one hundred feet or so above the lower detachable parachute link. Such an arrangement would cause the cable to be drawn across the airplane wing, ultimately bringing the bomb into contact with the wing. Experimental work along these and similar lines was conducted in cooperation with the Ordnance Department.[9]

Kite Barrages and Other Antiaircraft Defense Devices. During this development other means of interference with low-flying aircraft were considered. One that received considerable attention was the kite barrage. Kites used either independently or in conjunction with barrage balloons were believed to offer interesting

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9. Lt. Col. C. B. Lober to Chief, Experimental Engineering Section, Materiel Division, Dec. 19, 1940, in AAG 452.3 A; OCAC to Chief of Ordnance, Feb. 26, 1941, in ibid.; the Engineer Board, Barrage Balloon Section, Corps of Engineers, to Chief of Engineers, June 27, 1942, in AAG 452.3 C; Lethal Devices for Low Altitude and Very Low Altitude Balloons, Barrage Balloon School, Coast Artillery Corps, Camp Tyson, Tenn., Dec. 5, 1942.

possibilities. Tests of the Manheim-Schwartz kite system were made at St. Petersburg, Florida, in August 1941.[10] A demonstration of the Sauls-Van Grow kites was given at Fort Sill, Oklahoma, in October.[11] Both of these kites demonstrated good stability and were able to attain a maximum height of about 3,500 or 4,000 feet. The conclusion was reached, however, that they would have to attain cable angles of approximately 70° from the horizon if they were to render any efficient protection against dive bombing. Such a result could be achieved only if much higher L/D (Lift/Drag) ratios were developed for individual kites. Multiple kites distributed along the length of the main cable could be used to secure the desired result, but such a system would disclose the position of the cable to enemy aircraft, thus defeating the purpose of the barrage.[12]

A few months later an airfoil kite, developed at the Franklin Institute and using cambered surfaces, was tested at Camp Davis, North Carolina. This kite was so constructed that every lifting surface was an airfoil. It presented the appearance of a biplane. The two wings were joined at the tips by vertical airfoils with

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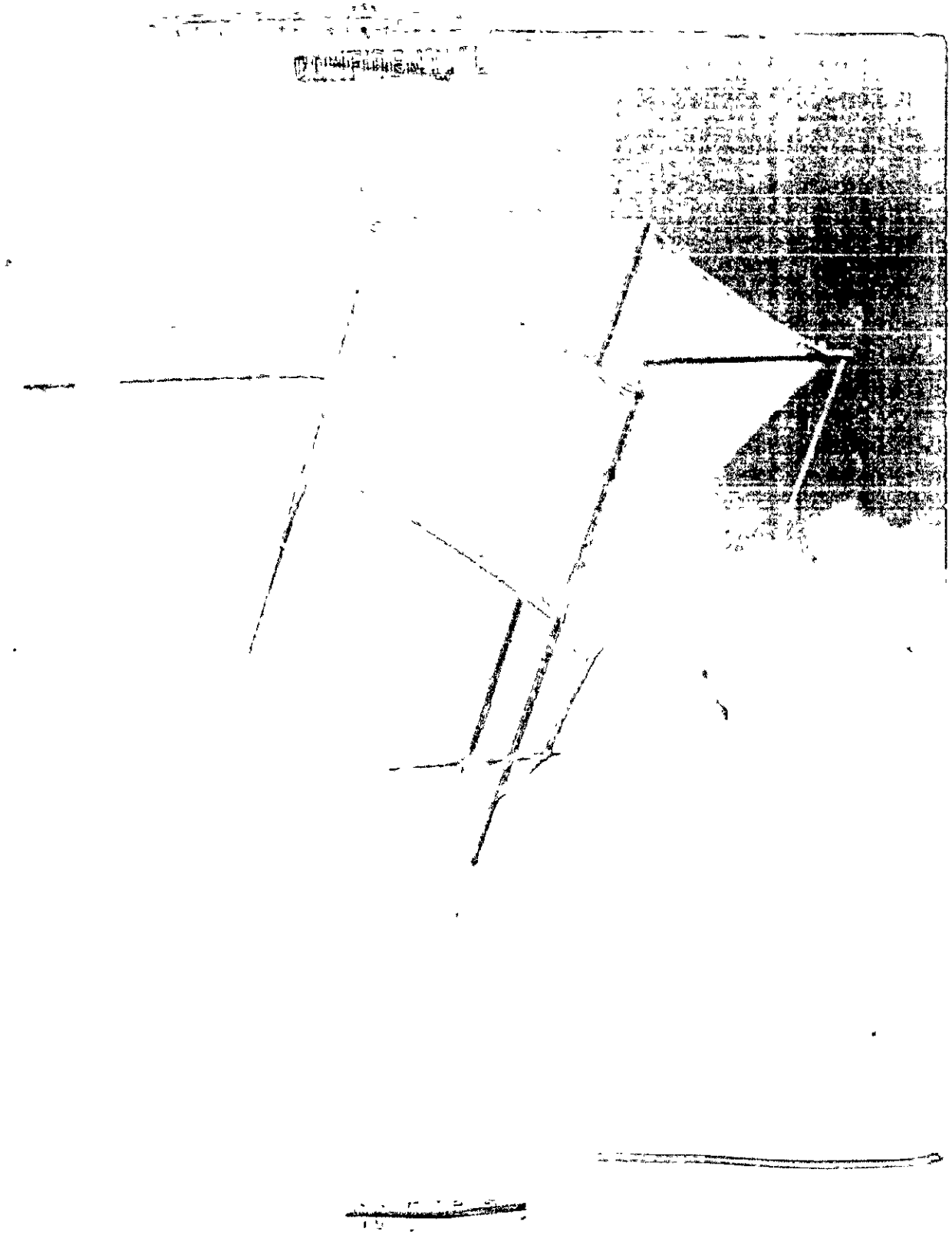
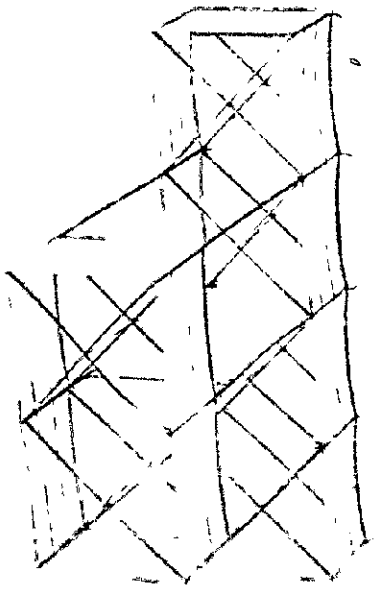
10. "Memorandum Report on Tests of Manheim-Schwartz Kite System Conducted August 23 to 26, 1941," Experimental Engineering Section, Materiel Division, Oct. 4, 1941, in Barrage Balloon files, Corps of Engineers; Lt. Col. C. B. Lober, Air Corps, "Report on Tests of Barrage Kite Equipment Conducted August 23 to 26, 1941," Sept. 22, 1941, in ibid.
11. "Memorandum Report on Demonstration and Tests of the Sauls Kites Conducted on October 25 and 26, 1941," Experimental Engineering Section, Materiel Division, Dec. 16, 1941, in ibid.
12. Ibid.; cf., note 10 above.



Wachter-Schwartz Ferrage Kite in Flight

Furnished by:
Material Command, AAF



Double-Tee Crow Barrage Kite in Flight

Furnished by:
Materiel Command, AAF

symmetrically cambered surfaces. The tail was similar in construction, being attached to the wings by a skeleton fuselage of four longérons of wood. The flight performance of the airfoil kite was erratic. It had been in the air only a short time when it winged over and crashed. In spite of this disappointing demonstration, however, certain responsible Air Corps officers believed that the airfoil principle properly applied offered a possible solution to the problem of achieving higher L/D ratios.[13]

Numerous other ideas, both practical and impractical, were submitted by various individuals for consideration. Among them were balloon-carried bombs which would be released to float upward into attacking aircraft, parachute bombs to be dropped from aircraft, and rocket-fired parachute bombs. One individual presented a plan by means of which he claimed he could fly balloons to an altitude of 35,000 feet. At the 25,000-foot level he proposed to suspend a platform which would mount a crew of men with machine guns.[14]

Winches. With the revival of interest in barrage balloons in 1937-1939, a balloon winch was developed in accordance with a directive from General Arnold, who desired a lightweight, compact,

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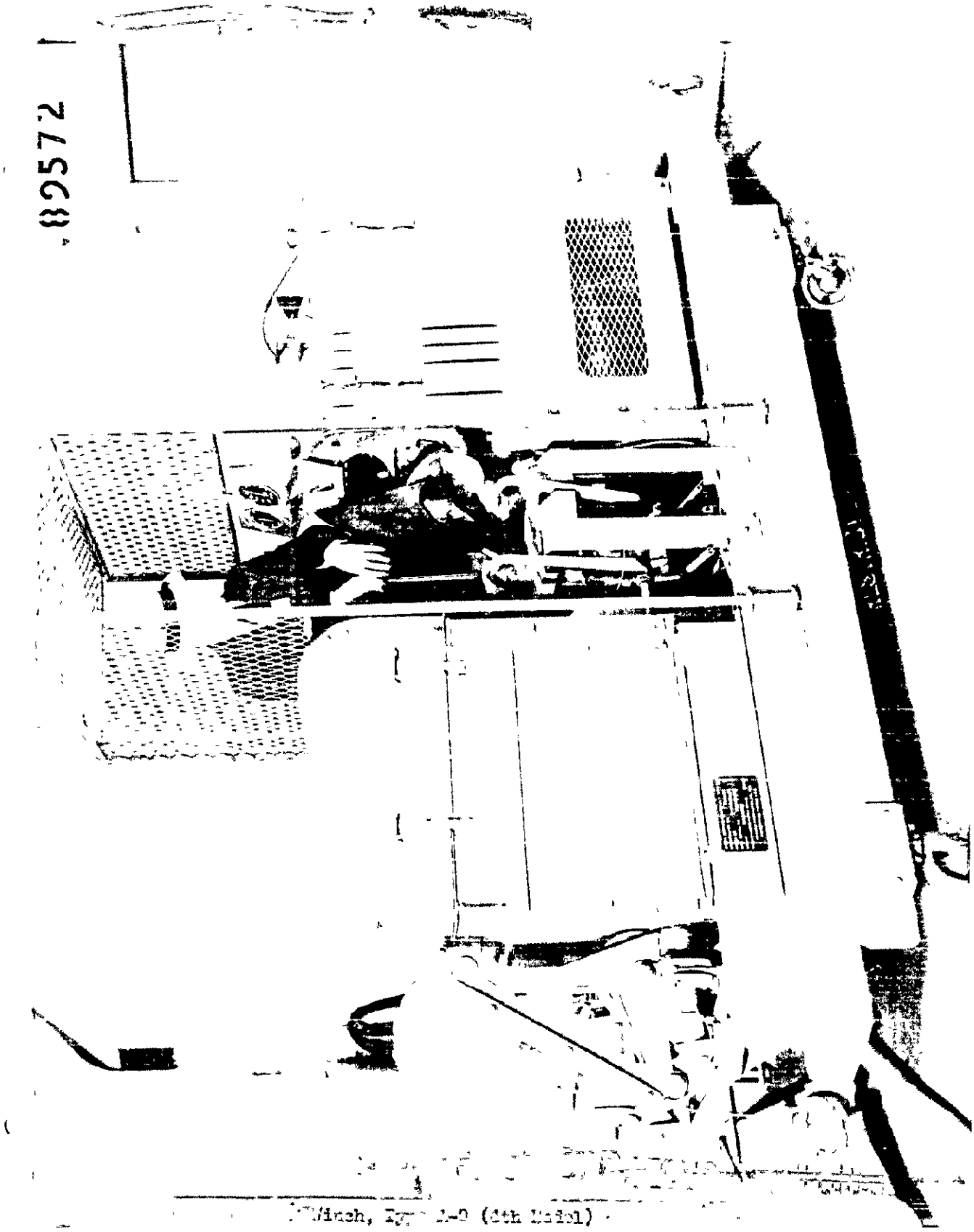
13. Maj. S. M. Skinner, Coast Artillery Corps, "Report on Test of Kites, Camp Davis, N. C., Jan. 19-21, 1942," Jan. 26, 1942, in ibid.; interview with and memorandum dictated by Col. C. B. Lober, Feb. 12, 1943, in AFIHD files.
14. Ibid.

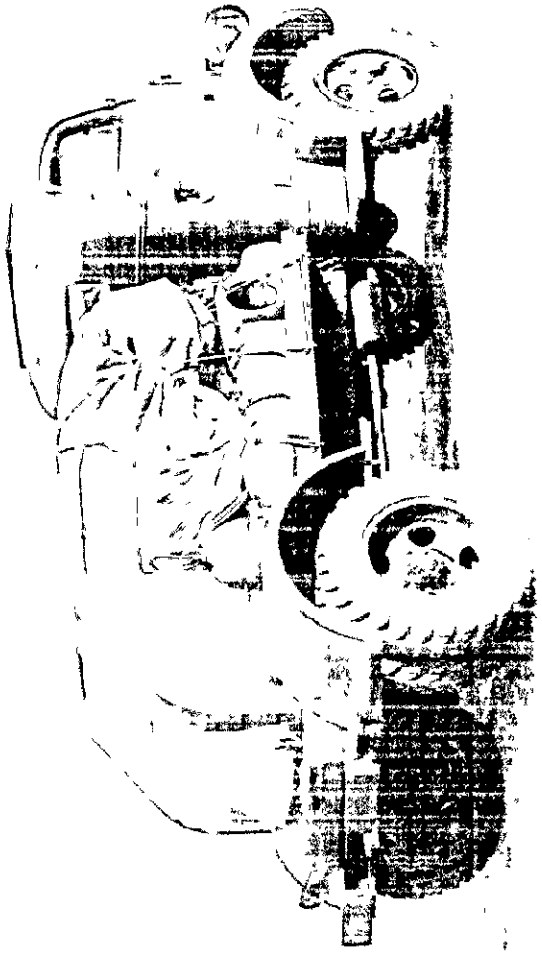


Winch, Type A-9 (4th Model)

Manufacturer:
Herron-Harrington Co.

Furnished by:
Materiel Command, AAF

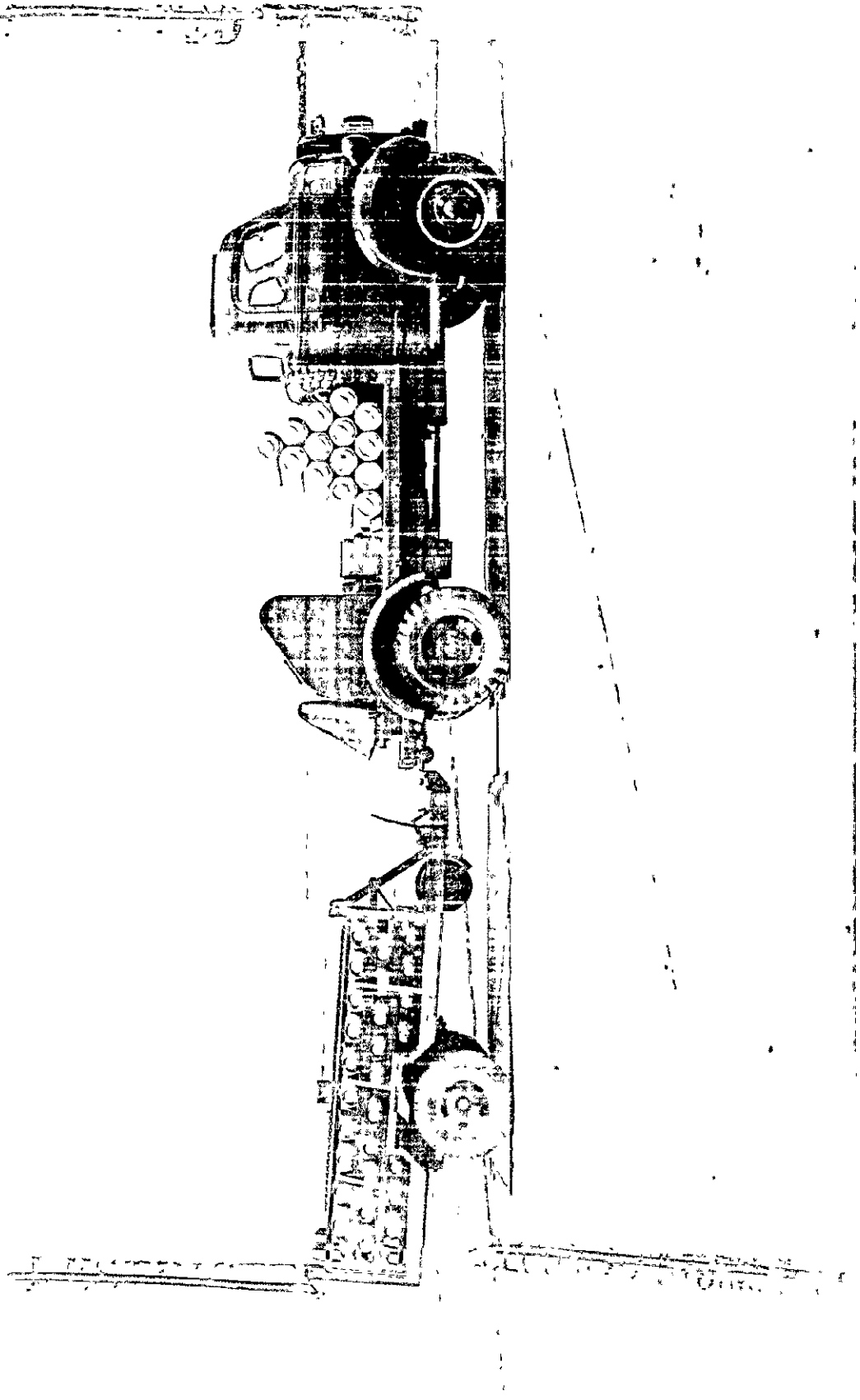
78625

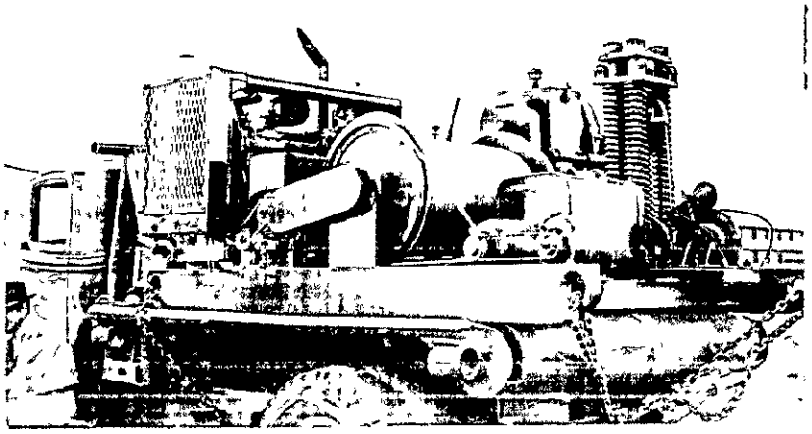


Winch, Type [illegible] Altitude,
Loaded with [illegible]

Manufacturer:
Wrason-Harrington Co.

Furnished by:
[illegible] Co., Inc., LF

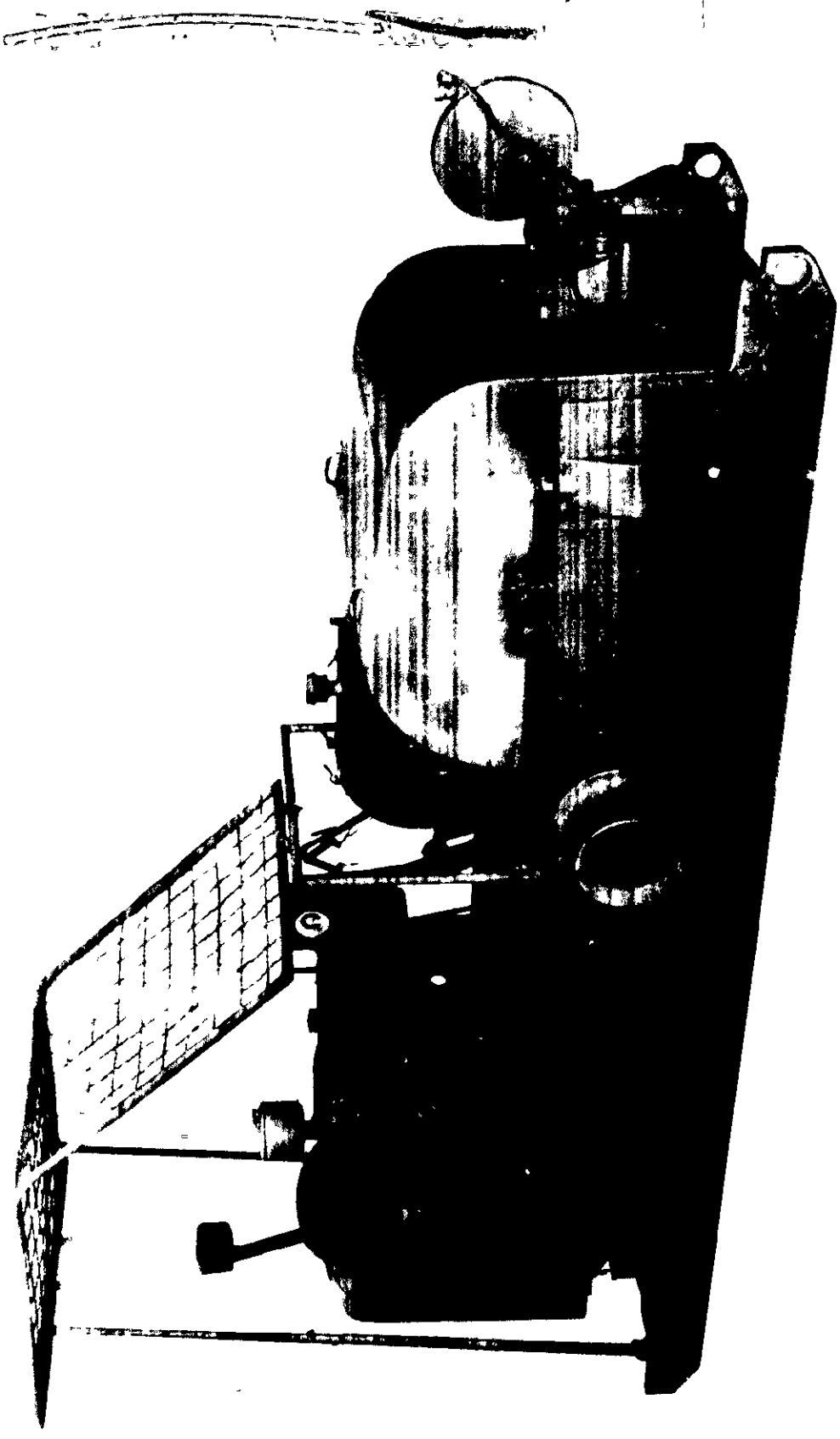




Mach, Type V-1, Portable, Low Altitude

Manufacturer:
Wilson Manufacturing Co.

Official Photograph, AAF



inexpensive mechanism devoid of frills. The result was the A-9 low altitude portable winch.[15] The A-10 high altitude portable winch and the A-11 low altitude mobile winch were also developed. All of these were manufactured by the Marmon-Harrington Company of Indianapolis, Indiana, although much of the fabricating was done by Gar Wood Industries, Inc., Detroit, Michigan, on subcontracts. The A-9 and A-10 winches were self-powered and skid-mounted. The A-11 mobile winch, while employing the same winch mechanism as that used on the A-9, was permanently attached to a truck chassis and used the truck engine as its source of power.[16] None of these winches proved satisfactory to the Coast Artillery, which requested that they be modified to include an improved lead-off gear, a capstan, a protective cage over the operator, a shock absorber, an improved exhaust pipe, an electrical starting system, and the following instruments: a footage-out meter, a rate of pay-out or haul-in indicator, a tensiometer, and an engine-temperature gauge.[17]

The Wilson Manufacturing Company of Wichita Falls, Texas, makers of oil rigs, offered to develop a winch along these lines

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15. Ibid.
16. Contractor's specifications on the A-9, A-10, and A-11 winches are given in Appendix 14 (Contractor's Specifications, Barrage Balloon Winch, Portable, AC, Type A-9, Contractor's Model No. BB-1, Marmon-Harrington Co., Inc., n.d., in Barrage Balloon files, Wright Field; Portable High Altitude, AC Type A-10, Contractor's Model No. BB-3, Marmon-Harrington Co., Inc., n.d., in ibid.; Mobile, Low Altitude, AC Type A-11, Contractor's Model No. BB-2, Marmon-Harrington Co., Inc., n.d., in ibid.).
17. "Information Regarding Barrage Balloon Program" by authority of Commanding General, AAF, n.d. [about March 1942], in Barrage Balloon files, Corps of Engineers.

at company expense and to submit it wherever desired for testing. The first model developed by the company was tested at Wichita Falls in October 1941. It contained several innovations, the principal one being a constant-torque electric drive for the storage drum. This machine was much heavier than was desired; moreover, while the electric drive functioned satisfactorily, it was felt that under conditions existing in the field, dirt and corrosion might cause difficulties with the various electric-control contacts. It was suggested, therefore, that the electric control should be abandoned in favor of either a mechanical or a hydraulic drive. A second model was developed using a mechanical principle for storage drum drive. This type also included (1) a cable shock-absorbing system with a maximum cable travel of 35 inches; two sets of springs were provided, one requiring a 750-pound load for its compression, while the second necessitated a 5,100-pound load for complete compression; (2) a capstan driven by a power take-off from the main power plant through a separate clutch; the capstan rotated about a horizontal axis and was mounted to the left rear of the winch chassis; (3) a relocated engine throttle which brought it nearer the winch driver; (4) a cable tension meter which operated by a push-pull cable attached to the shock absorber spring and was so calibrated that correct readings were registered; (5) a cage of iron-mesh construction to protect the winch driver; (6) a self starter; and (7) a cable footage and pay-out meter to record the actual amount of

cable payed out in feet, and also the rate at which the cable was payed out or hauled in. This modified A-9 winch proved quite satisfactory and, with several minor modifications, was adopted in April 1942.[18]

Hydrogen Supply. Under the original plan, helium was to be used to inflate the barrage balloons. It soon became apparent, however, that helium production facilities were barely sufficient to take care of the needs of the Navy Department for its airship program.[19] A satisfactory substitute for use in barrage balloons was hydrogen, which could be made available in almost unlimited quantities. The various methods by which hydrogen gas may be produced for military purposes can be divided into two broad categories: (1) those methods suitable for field use, (2) those methods suitable for use in large, fixed plants.[20]

During the World War, hydrogen gas generation in the field had been accomplished by use of the ferro-silicon-caustic soda method, the hydrogen being produced at atmospheric pressure. The

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18. Interview with and memorandum dictated by Col. C. B. Lober, Feb. 12, 1943, in AFIHD files; "Information Regarding Barrage Balloon Program," by authority of Commanding General, AAF, n.d. [about March 1942], in Barrage Balloon files, Corps of Engineers; Portable Barrage Balloon Winches and Barrage Balloon Flying Cables, Barrage Balloon School, Coast Artillery Corps, Camp Tyson, Tenn., Nov. 10, 1942.
19. OCAC to Commanding Officer, Barrage Balloon Training Center, Camp Davis, N. C., July 7, 1941, in Barrage Balloon files, Corps of Engineers; "Information Regarding Barrage Balloon Program," by authority of Commanding General, AAF, n.d. [about March 1942], in ibid.
20. Lt. Col. C. B. Lober, Chief, Barrage Balloon Section, "Report on Methods of Producing Hydrogen Gas," Nov. 12, 1941, in ibid.

Air Corps considered it impractical to provide a sufficient number of generators and compressors for such low-pressure operation. A solution for this difficulty was found by the Independent Engineering Company, O'Fallon, Illinois, which developed a high-pressure hydrogen generator capable of producing hydrogen gas at 2,000 pounds pressure. The completed generator was trailer-mounted and weighed approximately 30,000 pounds. An estimate of the weight of chemicals and generating and bottling equipment necessary for the initial inflation of one battalion of barrage balloons and their subsequent maintenance for thirty days indicated a total weight of approximately 1,000 tons.[21]

In an effort to reduce this weight, studies were undertaken looking toward the development of other methods for producing hydrogen in the field. These included (1) the dissociated ammonia method, (2) the use of calcium hydride, and (3) the use of lithium hydride.[22]

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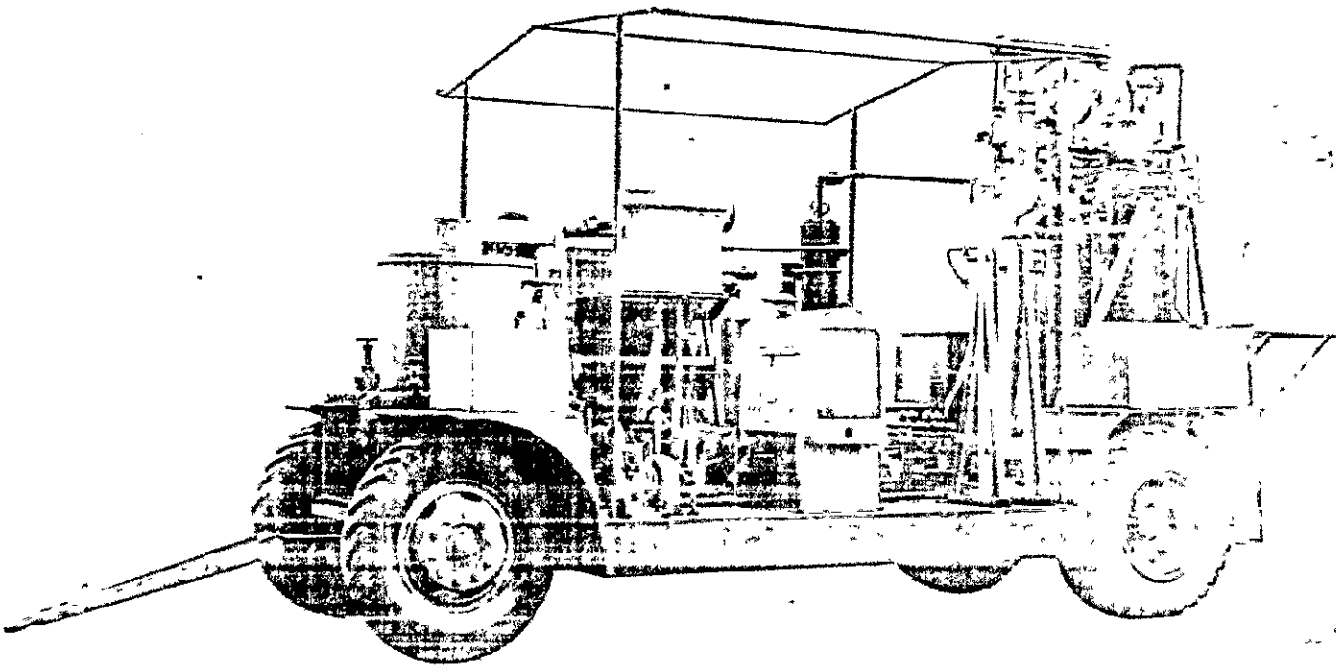
21. Interview with and memorandum dictated by Col. C. B. Lober, Feb. 12, 1943, in AFIHD files; "Information Regarding Barrage Balloon Program," by authority of Commanding General, AAF, n.d. [about March 1942], in Barrage Balloon files, Corps of Engineers; Training and Operations Division to Commanding General, Air Corps Technical Training Command, June 19, 1941, in AAG 679; OCAC to Undersecretary of War, June 28, 1941, in ibid.
22. National Defense Research Committee of the Council of National Defense to Lt. Col. H. W. Dix, May 1, 1941, in AAG 463.2 C; Lt. Col. C. B. Lober, Chief, Barrage Balloon Section, Materiel Division, to Metal Hydrides, Inc., May 28, 1941, in ibid.; also numerous other letters to companies throughout the United States respecting hydrogen supply and methods of producing hydrogen are to be found in this file.

[redacted] SECURITY INFORMATION



The cracking of ammonia to provide a stable mixture of hydrogen and nitrogen offered a simple and economical means of producing gas with a lifting power of somewhere between 50 and 75 per cent that of pure hydrogen. This method was eliminated by the Air Corps because the gas produced did not have sufficient lift.[23]

The calcium hydride process was developed by Metal Hydrides Incorporated of Clifton, Massachusetts. Production of hydrogen by the calcium hydride process is extremely simple. Water is merely added to calcium hydride in a closed container. The evolved hydrogen quickly builds up sufficient pressure to inflate the balloon. The outstanding advantage of this system is its portability and readiness for action at practically a moment's notice. The chief difficulty was cost. It was estimated that the cost of producing 1,000 cubic feet of hydrogen by the calcium hydride method would be approximately $14 while the same amount of gas generated by the ferro-silicon process would cost only $5.73.[24]

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23. Du Pont Ammonia Corp. to Chief of Air Corps, Dec. 8, 1930, in ibid.; Chief of Air Corps to Du Pont Ammonia Corp., Dec. 13, 1930, in ibid.; Metal Hydrides, Inc., to Lt. Col. C. B. Lober, Chief, Barrage Balloon Section, Aug. 8, 1941, in ibid.
24. Metal Hydrides, Inc., to Lt. Col. C. B. Lober, Chief, Barrage Balloon Section, Aug. 8, 1941, in ibid.; Lt. Col. C. B. Lober, Chief, Barrage Balloon Section, to Metal Hydrides, Inc., Sept. 9, 1941, in ibid.; Lt. Col. C. B. Lober, Chief, Barrage Balloon Section, to Metal Hydrides, Inc., Dec. 13, 1941, in ibid.; Col. C. B. Lober to Chief, Experimental Engineering Section, Materiel Division, Dec. 12, 1941, in AAG 679.

Work with lithium hydride was done by Lithalloys Corporation of New York City. It was found that the lithium hydride method required only 50 tons of chemicals and equipment to supply a battalion of barrage balloons for 30 days in contrast to the 1,000 tons required by the old ferro-silicon method. However, the cost per cubic foot of gas by the lithium hydride method was calculated to be approximately ten times that required by the older method. Preliminary studies indicated that with a $5,000,000 plant investment, sufficient lithium hydride could be produced to supply only one battalion.[25] The cost of producing gas by the new methods appeared to limit their use to those places where the weight of equipment handled and the amount of local equipment had to be kept at an absolute minimum.

It is interesting to note some of the novel developments which sprang from these studies of the production of hydrogen by the calcium hydride and lithium hydride methods. A system was devised whereby a small generator using lithium hydride was employed to inflate a meteorological balloon which then carried into the air an antenna for radio signaling when men found themselves adrift on the water. This equipment constitutes the major part of the sea-

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25. Lithalloys Corp. to Col. C. B. Lober, Jan. 14, 1942, in AAG 463.2 C; Lithalloys Corp. to Col. C. B. Lober, Feb. 7, 1942, in ibid.; interview with and memorandum dictated by Col. C. B. Lober, Feb. 12, 1943, in AFIHD files.

[redacted] SECURITY INFORMATION

rescue kit--commonly known among fliers as the "Gibson Girl"--which is rapidly becoming standard equipment in Army Air Forces' medium and heavy bombers and in transport planes. Another development was a water still for producing pure water from sea water. The heat generated by the chemical reaction was used to distill sea water, while the products of combustion were condensed to produce pure water.[26]

More economical than the production of hydrogen gas in the field is its production in large fixed plants. Of course, the latter is frequently not practicable, since the gas produced would have to be transported in cylinders for hundreds of miles. In an area such as the Panama Canal Zone, however, where a large number of balloons are to be located in a relatively small area, fixed plant production is sound practice. Shortly after the entrance of the United States into the war, action was initiated for the construction of two electrolytic hydrogen-oxygen generating plants for use in the Panama Canal Zone, each with a daily capacity of 300,000 cubic feet of hydrogen. The War Department was urged to make similar arrangements for Hawaii. The importance of having ample facilities for the production of hydrogen becomes clear when

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26. This method of producing pure water is not in practical use since more satisfactory methods are available to fliers forced down at sea (interview with and memorandum dictated by Col. C. B. Lober, Feb. 12, 1943, in AFIHD files).

it is realized that the rate of hydrogen consumption for barrage balloons is approximately 250 per cent per month of the original volume employed.[27]

Ground Operations. When the barrage balloon program was first embarked upon, it was natural to attempt operation in the same manner in which observation balloons had been handled in the past; that is, when the balloon was hauled down, it was detached from the cable, placed in the hands of men, and moved under their control to a prepared bedding down position. In strong or gusty winds this procedure required a crew of at least twelve men. With the large number of barrage balloons which were to be flown, the use of that many men at each balloon site was impractical. Colonel Michael McHugo of the Air Corps devised a handling method by which the balloons could be managed with a very limited personnel. Under the McHugo system the winch hauled the balloon down to where an auxiliary strop could be used to hold the balloon while the main flying cable was detached. The balloon was then fastened to an auxiliary rigging which would permit the hauling down of the balloon very

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27. While two generating plants were actually manufactured, neither was shipped either to Panama or Hawaii, other arrangements having been made in the meantime. One generating plant was finally sold to Russia; the other is still in the possession of the War Department. "Information Regarding Barrage Balloon Program," by authority of Commanding General, AAF, n.d. [about March 1942], in Barrage Balloon files, Corps of Engineers; Lt. Col. C. B. Lober to Field Service Section, Materiel Division, March 26, 1941, in AAG 452.3 A.

close to the ground. A "dead man," to which was fastened a swiveling snatch-block, was located in a pit four feet deep. The balloon cable passed through the snatch-block and along a trench from the pit to the winch. Through the use of this arrangement the balloon could be hauled down close enough to the ground so that it could be bedded down easily by a crew of six men.[28]

A study of the various mechanical means of hauling down and bedding a barrage balloon was made by the Barrage Balloon Board late in 1941. Four methods were examined: (1) the British system, (2) the Peters system, (3) the Milmore system, and (4) the McHugo system. The first three systems utilized the balloon handling lines for hauling down and bedding the balloon and hence employed six or eight points of attachment. The McHugo system, on the other hand, made use of one-point pull, from a point in line with the balloon junction piece. After comparing the different systems, the board concluded that the McHugo system required a minimum of personnel and materiel for its operation and recommended that this

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28. "Information Regarding Barrage Balloon Program," by authority of AAF, n.d. [about March 1942], in Barrage Balloon files, Corps of Engineers; Memorandum Report on Barrage Balloon Equipment, Experimental Engineering Section, Materiel Division, Feb. 19, 1942, in AAG 452.3 B.

system be adopted.[29]

Other Improvements and Additions. Field tests suggested further improvements in and additions to the barrage balloon system. The neoprene-coated cotton fabric used in the earlier balloons was found to be unsatisfactory when subjected to extremes of heat or cold. As has already been pointed out, the action of heat and sunlight caused a decomposition of the neoprene. Low temperatures rendered the balloon fabric so porous as to impair the efficient operation of the balloon. As a temporary expedient, various protective paints were used. Later, fabric specifications were changed to include an outer aluminized coating. A ripping link or shear pin was devised to prevent loose balloons from carrying great lengths of cable considerable distances across country, sometimes causing serious damage to power lines.[30]

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29. With the gradual adoption by the Coast Artillery during 1942 of equipment modeled closely after that of the British, this conclusion was revised in favor of the British system. "Balloon Beds and Anchoring Devices," Report of the Barrage Balloon Board, Project No. 24, Dec. 27, 1941, in Barrage Balloon files, Wright Field; interview with and memorandum dictated by Col. C. B. Lober, Feb. 12, 1943, in AFIHD files.
30. Chief, Engineering Section, Materiel Division, to Chief, Experimental Engineering Section, April 14, 1941, in AAG 452.3 A; Chief, Experimental Engineering Section to Chief, Materiel Division, July 14, 1941, in ibid.; "Aluminization of Barrage Balloon Fabrics," Report of the Barrage Balloon Board, Project No. 40, Oct. 17, 1941, in ibid.; Chief of Coast Artillery to Chief of Air Corps, Oct. 10, 1941, in AAG 452.3 B; Hq., 304th Coast Artillery Barrage Balloon Battalion, Ft. Lewis, Wash., to 39th Coast Artillery Brigade (AA), Ft. Lewis, Wash., March 8, 1942, in Barrage Balloon files, Wright Field.

Experiments were conducted and a system devised for flying balloons over water, using barges for anchorages. Commenting on the need for such a system, General Green, Chief of Coast Artillery, declared that many such positions would have to be established throughout the United States in order to give effective protection to certain strategic areas.[31]

The development of means of reducing operational hazards was initiated, and considerable progress was made in devising instruments which would indicate on the ground the following conditions existing at the level of the balloon: temperature, barometric pressure, presence of clouds, wind velocity, and the gas pressure or fullness of the balloon.[32] The provision of some sort of lightning protection as standard balloon equipment was discussed at length and a system was devised by the Air Corps. The Coast Artillery, however, did not consider such protection necessary and the system was not developed.[33]

Sources of Supply. Another valuable service performed by the Air Corps was the preparation of a comprehensive list showing

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31. Report of the Joint Barrage Balloon Committee to the Chief of Coast Artillery, Jan. 3, 1942, in AAG 452.3 A.
32. Lt. Col. C. B. Lober to Experimental Engineering Section, Materiel Division, Oct. 14, 1941, in Barrage Balloon files, Corps of Engineers; "Information Regarding Barrage Balloon Program," by authority of Commanding General, AAF, n.d. [about March 1942], in ibid.
33. "Information Regarding Barrage Balloon Program," by authority of Commanding General, AAF, n.d. [about March 1942], in ibid; interview with and memorandum dictated by Col. C. B. Lober, Feb. 12, 1943, in AFIHD files.

actual and potential sources of supply for barrage balloon equipment. The Big Five--Goodyear Tire & Rubber, B. F. Goodrich, General Tire & Rubber, Firestone Tire & Rubber, U. S. Rubber--and Air Cruisers, Inc., were possible sources for balloons. Marmon-Harrington Company, Gar Wood Industries, James Cunningham Company, the Pacific Car & Foundry Company, and the Wilson Manufacturing Company could be called upon for winches. John A. Roebling Company, American Chain & Cable Company, American Steel & Wire Company, and Bethlehem Steel Company were in a position to supply cables. The Independent Engineering Company, O'Fallon, Illinois, was prepared to supply hydrogen generating and helium purification plants. All other items of barrage balloon equipment had been similarly arranged for, so that when the Corps of Engineers assumed the responsibility for the procurement of equipment, it knew where to get it.[34]

Summary of Equipment Procured and Contracted for. A summary of barrage balloon equipment actually procured or contracted for during the period of Air Corps control is impressive. On April 1, 1942 the Coast Artillery had received 560 and the Navy 103 low altitude barrage balloons, while an additional 2,814 were on order for

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34. "List of Sources for Barrage Balloon Equipment--Balloons and Accessories," statement prepared by Experimental Engineering Section, Materiel Division, March 31, 1941, in AAG 452.3 A.

the Coast Artillery and 47 for the Navy.

Other items delivered to the Coast Artillery included 1,060 reels of low altitude cable; 2 reels of high altitude cable; 3 hydrogen generators; 479 low altitude, Type A-9, portable winches; 12 low altitude, Type A-11, mobile winches; and 10 high altitude, Type A-10, portable winches. Other items delivered to the Navy included 166 reels of low altitude cable; 2 hydrogen generators; and 108 low altitude, Type A-9, portable winches. Orders had been placed for large quantities of additional equipment.[35]

The years of study, discussion, experimentation, and testing of barrage balloon equipment had not been in vain. By early 1942 the Army Air Forces was prepared to supply both the Army and Navy with barrage balloons, cables, winches, hydrogen generators, and minor items of barrage balloon equipment in quantity. In short,

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35. A complete record of equipment received and on order as of April 1, 1942, and cost breakdown on barrage balloon equipment under contract with U. S. Army Air Forces is given in Appendix 15 ("Cost Breakdown and Summary of Barrage Balloon Equipment Procured by Experimental Engineering Section, Materiel Division," prepared April 1, 1942, in Barrage Balloon files, Corps of Engineers); cf., "Status Report, Barrage Balloons and Equipment on Contract with U. S. Army Air Forces," April 30, 1942, in AAG 452.3 A.

the foundations for an extensive barrage balloon program had been firmly laid by the Army Air Forces when the functions of development and procurement were transferred to the Corps of Engineers in the spring of 1942.

BIBLIOGRAPHY

The principal source for the information contained in this monograph is the Army Air Forces files--classified and unclassified. Materials on barrage balloons and accessories are to be found in file no. 452.3, parts A, B, and C. The following AAF files were also consulted: Air Bases, file no. 686; Hydrogen, file no. 463.2; Hydrogen Plants, file no. 679; and Priority in Supply, file no. 400.174.

Other files which yielded valuable information were: Barrage Balloon file of Colonel F. H. Forney, Corps of Engineers (much of the material in this file was turned over to Colonel Forney by Colonel C. B. Lober when the development and procurement functions were transferred from the Army Air Forces to the Corps of Engineers); Barrage Balloon file of the old War Plans Division, General Staff, file no. 1098; G-2 file no. 452.3, Great Britain; and Barrage Balloon files of the old Experimental Engineering Section, Materiel Division, Wright Field, Dayton, Ohio, in the office of Captain J. F. Bolgiano.

The following documents were also made use of:

1. "Aluminization of Barrage Balloon Fabrics," Report of the Barrage Balloon Board, Project No. 40, October 17, 1941.

2. "Balloon Beds and Anchoring Devices," Report of the Barrage Balloon Board, Project No. 24, December 27, 1941.

3. Barrage Balloons for Marching Columns, Report of the Air Corps Board, Study No. 7, September 19, 1935.

4. Employment of Balloon Barrages, Report of the Air Corps Board, Study No. 40, July 15, 1938.

5. WD Circular No. 59, March 2, 1942.

Numerous conversations with and a memorandum dictated by Colonel C. B. Lober on February 12, 1943 were also very helpful. Colonel Falk Harmel, Biographical Branch, Historical Division, AC/AS, Intelligence, furnished biographical material on Colonel C. B. Lober. A trip to Camp Tyson and Wright Field gave the opportunity for numerous conversations with those connected with barrage balloon development. Conversations with members of the Barrage Balloon Board at Camp Tyson and with Captain J. F. Bolgiano at Wright Field were especially helpful.

The following books, magazines, and pamphlets were also used:

1. "The Air Minister's Answer" in The Aeroplane, LI (November 25, 1936), pp. 676-679.

2. "Balloons" in the Encyclopaedia Brittanica, 14th edition, II, 1011.

3. Barrage Balloon Organization, Tactics, and Technique, Barrage Balloon School, Coast Artillery Corps, Camp Tyson, Tennessee, September 1, 1942, Revised December 1, 1942 (Pamphlet).

4. Barrage Balloon. Service of the Balloon and Balloon Equipment, Low Altitude, Barrage Balloon School, Coast Artillery Corps, Camp Tyson, Tennessee, February 13, 1943. (Pamphlet).

5. Lethal Devices for Low Altitude and Very Low Altitude Balloons, Barrage Balloon School, Coast Artillery Corps, Camp Tyson, Tennessee, December 5, 1942.

6. Portable Barrage Balloon Winches and Barrage Balloon Flying Cables, Barrage Balloon School, Coast Artillery Corps, Camp Tyson, Tennessee, November 10, 1942.

7. Prospectus for Barrage Balloons, Goodyear-Zeppelin Corporation, Akron, Ohio, June 22, 1939.

8. Sweetser, Arthur, The American Air Service. A Record of the Problems, Its Difficulties, Its Failures, and Its Final Achievements. D. Appleton & Co., New York, 1919.

9. Turley, Colonel R. E. Jr., Coast Artillery Corps, "Barrage Balloons," in Coast Artillery Journal, January-February, 1942, pp. 20-24.

GLOSSARY

AA	Antiaircraft
AAF	Army Air Forces
AAG	Air Adjutant General
AC	Air Corps
ACTTC	Air Corps Technical Training Command
AFIHD	Historical Division
AG	The Adjutant General
AGO	Adjutant General's Office
cf.	see also
Ibid.	the same, in the same place
n.d.	no date
OCAC	Office, Chief of Air Corps
R&R	Routing and Record Sheet
WD	War Department
WDGS	War Department General Staff
WPD	War Plans Division

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Appendix 1.

February 19, 1923

MEMORANDUM FOR: Assistant Chief of Staff, War Plans Division.

1. Reference attached memorandum from your Division, dated January 16, 1923, requesting the views of this Office as to the value and use of small captive balloons in the anti-aircraft defense of limited areas, the following conclusions have been reached.

2. During the World War the French did not attempt a complete balloon barrage around any city. A number of barrage balloons were used in Paris, but they were placed primarily for the protection of such important buildings as the Chamber of Deputies, etc., and secondarily to influence the morale of the inhabitants. At Nancy, three (3) steel plants were protected by balloon barrages. Although the flames thrown off intermittently from the furnaces in such factories were an excellent target for hostile bombers, yet the protection afforded by the balloons was apparently effective. The city of Nancy was bombed quite frequently. The number of barrage balloons were limited, railroad stations and other similar points were not especially furnished this kind of protection.

3. Barrage balloons were used successfully for the protection of the French Army Headquarters in the suburbs of Chalons-sur-Soine, notwithstanding the fact that the city itself sustained severe damage from air bombardment. The viaduct on the Paris-Troyes railroad, south of Chateau Thierry, was successfully protected by balloon barrage. Similarly, a railroad viaduct between Chantilly and Paris was successfully protected by the same means. Barrage balloons were successfully used to protect iron works and factories near Dunkirk. Other cities and areas were similarly protected with reasonable success.

4. Generally speaking, the balloons were used to protect limited areas and to act as an obstacle over rivers or other well defined lines, known or expected to be used by enemy bombers. The balloons were usually placed in a semi-circle or similar shape so as to surround three (3) sides of a selected area, leaving open the side opposite the one from which the attack was expected. In this manner any plane flying from any direction toward the area covered by the balloons would be compelled to either maintain a very high altitude or to pass through the barrage. Barrage balloons were frequently placed on both sides of long narrow objects,

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such as viaducts, and were also placed so as to close the ends and thus completely encircle the object. I am of the opinion that enemy aviators were timid about approaching areas which were known or were suspected of being protected by barrage balloons or else they would fly so high that there was diminished probability of accurate bombing.

5. I believe that barrage balloons are an effective and comparatively cheap method of increasing the protection of such places as the Panama Canal, the Capitol and White House in Washington, important bridges, viaducts, dry docks, and wharves, etc., where it would be necessary for bombers to fly at altitudes less than 15,000 feet in order to accurately bomb small targets. I do not agree with the statement made in Paragraph 17 of the attached translation of an article on this subject by the Chief of the Bureau of French Anti-Aircraft Defense. It is not believed that it is a complete error to use barrage balloons for the protection of large cities. These balloons would afford considerable protection to otherwise defenseless cities because while it is true that planes could fly above the barrage and drop bombs upon the city, nevertheless, the enemy bombers would not feel so free to fly at the lower altitudes that insure accurate bombing, and the moral effect of the balloon barrage might be such in many cases as to keep the enemy away.

6. So far as Paris is concerned, there was a great mass of anti-aircraft artillery in place for the protection of the city. The great volume of fire from this anti-aircraft artillery did considerable damage to the city itself. Only a few barrage balloons were used, partly because of the presence of the anti-aircraft artillery, and partly because there was a greater need for the balloons elsewhere. If the balloons did little direct good, they at least did no harm, and doubtlessly did much indirect good.

7. The protection of New York City by means of barrage balloons would differ in many respects from that of Paris. It is realized that barrage balloons could not prevent an enemy from bombing New York City, but many of the most important limited areas could be protected to a very considerable extent by the use of balloons. There will always be greater incentive to attack a small area in or adjacent to a large city, than would be the case of a similar object in the country for the reason that, although the bombs may not reach the actual target, they would be very apt to strike buildings of some sort, and at least have a bad effect on the morale of the inhabitants.

8. It is recommended that the responsibility for the development and use of barrage balloons be placed on the Air Service. If the charge is so placed, I will request the manufacture of one (1) or two (2) experimental types of barrage balloons. The experimental types could be tested at Scott Field, Belleville, Illinois, and at McCook Field, Dayton, Ohio, in order to secure specifications for a standard type. It is believed that barrage balloons should have a capacity of about 12,000 cubic feet when fully expanded, and capacity of 8,500 to 9,000 cubic feet when contracted by means of the rubber lacings inserted in the sides. They should be designed to attain a height of 15,000 feet. The manufacture of an experimental winch for their operation will also be necessary.

9. The size and number of Barrage Balloon Units would have to be determined from the results of tests noted above. Officers and non-commissioned officers of limited technical training could be, in a very short time, taught to operate these balloons. The balloons could be successfully operated by the National Guard Troops, Reserve, or even by Home Guards of old men. The balloons and other equipment could be produced in quantity without difficulty.

10. The approximate cost of two (2) barrage balloons, which when used in tandem will reach an altitude of 12,000 feet, will be between $3,600 and $4,000. The balloon fabrics stored in the tropics are being subjected to deterioriation tests. Insufficient time has elapsed to definitely determine practical results, but it is believed that such fabrics stored in hermetically sealed packages will remain in good condition for at least five (5) years.

11. It is believed that the allotment in the future of barrage balloon units in the Air Service may best be cared for in the Reserve organization, except for barrage balloon protection in our foreign possessions.

MASON M. PATRICK
Major General, A. S.,
Chief of Air Service

1 att:
Memo, Asst. Chief of Staff,
January 16, 1923

SECURITY INFORMATION

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August 7, 1930

93 29.51 73

Clear

Surface	12	WNW
1000	24	WNW
2000	29	WNW
3000	20	WNW
4000	19	W
5000	18	WNW
6000	17	WNW

1/4

2-1/2 hours

1670 meters or 5500 feet

6860 See Comments.

See Comments.

See 10 above

15

Barrage balloon winch Type A-7

Balloon was very stable.

Yes

43 Lbs. sand in left bag and 48 in right.

Yes

Yes Yes

No

Yes. See attached Sketch SK-249 for length of suspension ropes.

Based on maximum altitude obtainable

Yes

SECURITY INFORMATION

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91

22. Are the attachment bands for elastics satisfactory? Yes

23. Is single ply fabric for envelope and louvre satisfactory? Yes

24. Is the envelope sufficiently gas tight? See comments.

25. Is 3/16 [illegible] satisfactory? 3/16 was used.

26. Attach overleaf [illegible]

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WAR DEPARTMENT
Office of the Chief of Air Corps
Washington

October 2, 1939

SUBJECT: Military Characteristics, High Altitude Barrage Balloons

TO: The Adjutant General

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WAR DEPARTMENT
Office of the Chief of Air Corps
Washington

April 5, 1940

SUBJECT: Military Characteristics - Truck, Low Altitude Barrage Balloon Winch

TO: The Adjutant General

Appendix #3 (1)

October 7, 1939

~~Memorandum from Office Chief of Air Corps to~~ The Adjutant General

Subject: Military Characteristics, Low Altitude Barrage Balloons

1. The following principal characteristics of Low Altitude Barrage Balloons are submitted for approval by the Secretary of War:

Military Characteristics

a. Missions - To serve as anti-aircraft measure against low-flying attacking aircraft for the protection of strategic points by having the flying cable serve as a mental and material hazard to aircraft operation.
b. Employment - Scattered along probable enemy aerial routes and arranged in various patterns around localized enemy objectives. Employed at night.
c. Type - Dilatable or ballonet.
d. Performance (in still air):
   (1) Altitude - 6,000 feet minimum.
   (2) Inflating gas - Helium or Hydrogen
   (3) Cable - 3/16-inch diameter, flexible steel.
   (4) Rate of Ascent - 1,500 feet perminute
   (5) Rate of Descent - 1,000 feet per minute.
e. Armament - none.
f. Crew - ground or handling crew of non-combatant personnel.

2. These characteristics if approved will be effective for experimental development during fiscal year 1940 and will supercede characteristics contained in letter of December 14, 1938, approved by Adjutant General in 1st Indorsement of January 5, 1939.

For and in the absence of the Chief of Air Corps.

B. K. YOUNT
Brig. Gen., Air Corps
Ass't Chief of the Air Corps.

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Memorandum from Office Chief of Air Corps to The Adjutant General

Subject: Military Characteristics - Truck, Low Altitude Barrage Balloon Winch

1. The following principal charateristics of a Low Altitude Barrage Balloon Winch Truck are submitted for approval by the Secretary of War:

Truck, Low Altitude Barrage Balloon Winch

Chassis

a. Purpose - For flying and transporting Barrage Balloons.

b. Requirements -
1. Minimum pay load and body allowance of 3,700 pounds, which includes driver, winch operator, winch mechanic, and cable.
2. Minimum engine horse-power required for operation - 85. The winch will not be operated while the truck is in motion.
3. Power take-off - approximately one to one ratio to in-put shaft speed in both directions of rotation. This power take-off will be located on the transfer case and will be capable of transmitting full engine torque through all speeds of transmission, continuous operation.
4. Cab - cab over engine (window in roof of cab for observing balloon in flight.)

Winch

a. Purpose - For flying Barrage Balloons.

b. Requirements -
1. General -
(a) The winch will be capable of hauling down the balloon at the rate of 1,000 feet per minute against a cable drag of 2,100 pounds.

[redacted]

(b) The winch will be capable of arresting the ascension and hold the balloon against a cable pull of 7,000 pounds.
(c) The winch will be capable of withstanding continuous operation under all climatic conditions.

2. Special -

a. Cable capacity - the storage drum will have a minimum capacity of 18,000 feet of 3/16-inch diameter cable.

b. Balloon cable drive - the direct pull of the balloon cable will be taken through grooved surge drums and guided on the storage drum by a mechanically operated spooling device.

c. Storage drum drive - drive will be friction type with automatic compensating differential action in both directions of rotation.

d. Brakes - payout and snatch brakes will be provided.

e. Speeds - change of speeds will be through chassis transmission with direction of rotation controlled at the power take-off.

f. Controls - control of speed will be through chassis transmission and power take-off lever, clutch pedal and engine throttle.

g. Leading-off gear - swivel-mounted sheave for the balloon cable will be provided at rear of chassis. Gear will include automatic engine ignition cut-out device.

h. Tension meter - tension meter with remote indicator on instrument panel will be provided.

i. Capstan - power-driven capstan or "nigerhead" will be provided.

3. These characteristics are considered as minimum requirements in connection with the procurement of this type of equipment for Service Test purposes only.

For the Chief of the Air Corps

D. K. YOUNT
Brig. Gen., Air Corps
Ass't Chief of the Air Corps

The following three papers - "Barrage Balloons in the Present European War," "The Role of Barrage Balloons in Antiaircraft Defense," and "Employment of Barrage Balloons" - were prepared by Colonel C. B. Lober in response to General H. H. Arnold's directive.

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[redacted]

[October 1940]

MEMORANDUM FOR: The Chief of the Air Corps

SUBJECT: Barrage Balloons in the Present European War.

1. The following facts have been obtained from a study of MID reports from England, Germany and France. Since the British barrage balloon operations have been rather extensive and the MID reports thereon more numerous, most of the information contained herein was obtained from that source.

2. Equipment.

a. Balloons. The British balloons are similar in form to our Caquot balloon except as to displacement, which is given as 20,000 cubic feet. The German balloons are of somewhat different shape as regards appendages and are reported to go to 14,000 feet altitude. Reference is made to balloons to go to 16,000 feet and to the coupling of balloons in tandem to go to higher altitudes. Synthetic rubber is used in the manufacture of the British fabric, as it provides longer life and less loss of gas. Balloons are colored greenish rather than aluminum to reduce visibility.

(See Air Bulletin No. 13, Aug. 2, 1940, and IG No. 9820 file 2083-1500-17 Aug. 27, 1940.)

b. Winches. The winch used by the British is a separate unit powered by a Ford V-8 engine. It may be mounted on a truck or used independently. The truck contains a locker in which a deflated balloon may be carried. Take-in speeds are given as 1800 ft./min. in emergency and 800 ft./min. normal.

(See MID report No. 40816, Jan 24, 1940.)

c. Cable. Two sizes of cable are reported in use by the British, (1) 20,000 feet of cable of 1 ton breaking strength, (2) a shorter length of 3-1/2 tons breaking strength. Mention is made of the use of tapered cable. Reference is frequently made of cable of 3 m.m. diameter. A swivel has been found necessary at the point of balloon attachment. The cable is six strand and is as stiff as is consistent with spooling on a winch.

d. Gas supply. Hydrogen is carried in a trailer, containing bottles weighing 320 lbs. each having a capacity of 600 cu. ft. of gas at atmospheric pressure, stored at 3000 lbs./sq. in. pressure.

e. Cost. The cost of a complete British unit is given as $15,000.

3. Organization.

(See MID report 40816, Jan. 24, 1940)

[redacted]

a. Air Defense System. The Air Defense System of Great Britain consists of:

(1) The Coastal Command - 25 squadrons.

(2) The Observer Corps - 15,000 civilians, operating observations stations 8 miles apart, under control of the Fighter Command.

(3) The Fighter Command - 3 Groups (like our wing) of 40 squadrons total.

(4) The AA Arty. - 7 divisions of AA Arty., totaling 155,000 officers and men.

(5) The Barrage Balloons—44 squadrons.

(6) Air Raid Precautions—Numerous civilians.

b. Barrage balloon squadrons are organized into Centers (corresponding to our group) based on geographical considerations. One such Center, containing 10 squadrons is charged with balloon operations in the London area. This Center operates 500 balloons and employs 120 officers and 5380 men. This does not check with the figures for the total barrage balloon operations in Great Britain which uses 44 squadrons consisting of 33,000 officers and men. Each balloon crew consists of 2 NCOs and 10 men, mostly in the age group of 38 to 50 years.

4. Operations. Balloons are sited in depth and scattered rather than in single or double rows about the perimeter of the defended area. Report No. 6-5-2083-1627 April 26, 1940 says of the London defense, "Almost every little park has one Barrage Balloon, one truck with winch, a few cylinders of gas and ten men. They are operated on days of little wind, when the sky is cloudy or overcast and are not put up on* clear, cloudless days or nights." In one gale 250 balloons were lost before operating as above. At 9000 feet they may be flown as close together as 1200 feet, or at 3500 feet with a 300 foot interval. Air Bulletin No. 6, Dec. 7, 1939 states, "Due to losses from lightning and gales, barrage balloons are flown only when the weather is favorable or when threat of air raid makes operation necessary." Air Bulletin No. 11, May 8, 1940 indicates that kites are undergoing test, being particularly valuable when winds are too high for balloon operations. Balloons are operated from barges or rafts in water areas and from boats for convoy protection. At London balloon headquarters is a map room showing the location of all barrage balloons by a light for each balloon position, the light being illuminated when the balloon is in flight. Food is prepared in squadron messes and distributed to balloon positions by fireless cooker. Lightning protection has been afforded by a metallic band placed about the maximum diameter of the balloon and attached to the cable system.

* In the light of later information the Chief of Air Corps, wrote the Adjutant General on March 5, 1941, requesting the following change: Delete "not put up on" and substitute therefor "from at least operating like it on".

5. Value of Barrage Balloons. The British evidently consider the Balloon barrage of great value since they employ 33,000 officers and men in this service and operate over 1400 balloons. Reports indicate that within the areas and altitudes protected by low altitude balloons they act as a greater deterrent than do fighter aviation or antiaircraft artillery. The high altitude balloons are not so effective, since the cable is so light that usually sufficient damage is not done to the hostile aircraft. The British operations have proven that balloons do prevent aerial mine laying operations. The recent heavy bombing of London (Sept. 1940), in spite of the use of barrage balloons, merely shows that they are not effective in defending a large area against high altitude area bombing. Their greater use is in the defense of small concentrated objectives where precision bombing is necessary for efficient destruction.

/s/ Clarence B. Lober

CLARENCE B. LOBER
Lieut. Col., Air Corps.

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[redacted] [October 1940]

MEMORANDUM FOR: The Chief of the Air Corps.

SUBJECT: The Role of Barrage Balloons in Antiaircraft Defense.

I. The problem presented:

To determine the role of barrage balloons in antiaircraft defense.

II. Facts bearing on the problem.

1. An efficient antiaircraft defense is one which, at minimum cost, employs all known applicable means of preventing hostile aerial operations over the defended area in such a manner as to use the more effective capabilities of one means to supplement the limitations of another, and thus present the strongest combined defense.

2. Capabilities and Limitations of the Various Means.

a. Antiaircraft Artillery.

(1) Capabilities.

(a) It can bring fire power to bear on hostile aircraft entering its radius of action regardless of the speed of flight of such aircraft.

(b) It can detect the approach of aircraft within its radius of action and determine the approximate location of same in space, and the then direction and speed of flight.

(c) It can illuminate and render visible aircraft flying at night within its radius of action.

(2) Limitations.

(a) It is limited to a small unit radius of action, within which its weapons are effective.

(b) This requires a number of units to protect all approaches to an objective, of which, if the objective or area defended is large, only a part can be brought to bear on an enemy making a single raid on the objective in from but one direction.

(c) Its effectiveness is reduced in proportion to the number of hostile aircraft employed in a single raid since one battery can fire on but one airplane at a time.

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(d) An antiaircraft artillery defense of one objective is not materially effective in defending another objective several miles away and outside its radius of action.

(e) Cloud layers below the level of hostile aircraft prevent or interfere with the sighting of the guns and the night illumination of such aircraft.

(f) The equipment of Antiaircraft Artillery units is costly and requires a long time for production. The weapons of an antiaircraft artillery regiment cost approximately $2,000,000. One regiment reinforced by one gun battery is needed for the minimum acceptable defense of a single concentrated objective such as a bridge or canal lock.

(g) The cone of dispersion of fire is large at the higher altitudes, resulting in reduced effectiveness of fire.

(h) It cannot determine the position in space which will be occupied by the target airplane at the time when the projectile fired reaches the altitude of the airplane.

b. Pursuit Aviation.

(1) Capabilities.

(a) It can bring fire power to bear on slower hostile aircraft entering its radius of action.

(b) Its radius of action is relatively large.

(c) A single combat force can be used to defend several or even many objectives.

(d) The effectiveness of its fire power, relative to that of the hostile aircraft encountered, is not adversely affected by increase in the altitude of hostile approach.

(e) It has the ability to select the range and other conditions of combat.

(2) Limitations.

(a) It cannot force combat on aircraft having a speed of flight greater than its own.

[redacted]

(b) It cannot be effectively used at night unless the hostile aircraft is illuminated or its presence and location made known in some other manner.

(c) For its effective employment on ground alert, an aircraft interception net or other warning service is required extending about 120 miles about the object or objects to be defended.

(d) If only a reduced aircraft interception net can be established, the air alert method must be used against hostile approaches at the higher altitudes. This requires three or four times the number of aircraft in commission, takes a similar increase in number of trained personnel and tremendously increases the cost of maintenance due to the much greater number of aircraft hours flown.

(e) If no aircraft interception net can be established, the use of air patrols becomes necessary, with a still greater cost in amount of personnel, equipment and the maintenance thereof, if the same amount of fire power is to be delivered at any time and at any point.

(f) Its effectiveness is reduced as the number of hostile aircraft engaged in a single raid increases, but not, however, as much as is the case with antiaircraft artillery since, due to its larger radius of action, the enemy remains exposed to its fire power for a much longer period of time and hostile aircraft may be successively engaged.

(g) The equipment of Pursuit squadrons is costly and requires a long time for production. The weapons of a pursuit squadron cost approximately $900,000.

(h) Its effectiveness is reduced by weather of poor visibility.

c. Barrage Balloon Defense.

(1) Capabilities.

(a) It can, through threat of destruction deter and practically prevent hostile aerial operations over the area defended, below the altitude at which the balloons are flown.

[redacted]

[redacted]

(b) Its effectiveness is not reduced by the number of hostile aircraft engaged in a single raid on the defended objective.

(c) Its effectiveness is increased by weather of low visibility.

(d) It is effective at all times when in use without need of advance warning of the approach of hostile aircraft.

(e) It can be used above a layer of solid overcast cloud for purposes of deception.

(f) It forces hostile aircraft to higher altitudes thereby reducing the effectiveness of precision bombing of small objectives.

(g) Less time is required for the production of the equipment and much less time is needed for the training of operating personnel.

(2) Limitations.

(a) It is doubtful if it can be used at altitudes higher than 15,000 feet and it is doubtful if the cable which can be carried to altitudes higher than 6,000 is capable of destroying aircraft which strike it.

(b) If used above a layer of overcast cloud, it may disclose the position of the defended objective unless moved therefrom for purposes of deception.

(c) It cannot be used when high winds prevail.

(d) It has no effect on hostile aerial operations conducted at altitudes higher than that at which the balloons are flown, except to reduce the effectiveness of precision bombing of small objectives.

3. The Mission of Barrage Balloons. The mission of barrage balloons is to deter enemy aviation from entering areas protected thereby, thus -

a. Preventing bombing from altitudes below that at which the balloons are flown or reducing the accuracy of bombing conducted from higher altitudes.

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[redacted]

b. Reducing the vertical dimension of the space to be denied the enemy by the operations of pursuit aviation.

c. Preventing low altitude hostile aerial mine laying operations.

d. Deflecting hostile aircraft from natural routes of approach and forcing the use of routes defended by other means or less easily navigated.

e. Forcing the enemy to higher altitudes at which the effective range of aircraft detecting apparatus is greatly increased thus giving earlier warning of a hostile approach which permits the more efficient employment of pursuit aviation at greatly reduced cost.

III. The Role of Barrage Balloons.

The employment of barrage balloons in conjunction with either or both antiaircraft artillery and pursuit aviation is indicated under any or all of the following conditions:

a. When the defended objective is limited in size and precision bombing is required for its efficient destruction.*

b. In regions where ground alert pursuit protection cannot otherwise be efficiently used.

c. In regions where poor visibility or overcast cloud prevail.

d. In regions where high winds do not frequently occur.

IV. Concurrences.

This report was discussed at length with all members of the staff of the Air Defense Commander who are in accord.

/s/ Clarence B. Lober
Clarence B. Lober,
Lieut. Col., A.C.

* In the light of later information the Chief of Air Corps, wrote the Adjutant General on March 5, 1941, requesting the following change:
"a When a number of important objectives are grouped in one geographic location not so scattered therein as to require precision bombing for their efficient destruction." - 5 -

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[October 1940]

EMPLOYMENT OF BARRAGE BALLOONS

1. Where used

Barrage Balloons are best used in -

a. Regions where poor visibility or overcast cloud prevail, and

b. Where high winds do not frequently occur.

2. Mission

The mission of barrage balloons is to deter enemy aviation from entering areas protected thereby, thus -

a. Preventing bombing from altitudes below that at which the balloons are flown or reducing the accuracy of bombing conducted from higher altitudes.

b. Reducing the vertical dimension of the space to be denied the enemy by the operations of pursuit aviation.

c. Preventing low altitude hostile aerial mine laying operations.

d. Deflecting hostile aircraft from natural routes of approach and forcing the use of routes defended by other means or less easily navigated.

e. Forcing the enemy to higher altitudes at which the effective range of aircraft detecting apparatus is greatly increased thus giving earlier warning of a hostile approach which permits the more efficient employment of pursuit aviation at greatly reduced cost.

3. Employment

a. Barrage balloons are employed in the defense of grouping of important industrial or military installations so dispersed as to require precision bombing on each individual objective for their efficient destruction.

b. Barrage balloons are not employed in the defense of a single objective unless its protection is of the utmost importance.

c. Barrage balloons are employed along coastal frontiers where by forcing the enemy airplanes to approach at higher altitudes the range of aircraft detecting apparatus can be extended far enough to sea to permit the use of ground based pursuit defense of important objectives.

d. Barrage balloons are employed to erect mobile barrages intended to block an easily navigated route to an objective and to deflect the enemy aircraft from an area or route difficult to defend to one offering greater natural adaptability for antiaircraft defense.

e. An application of the above is the employment of barrage balloons to reduce the air space to be defended by pursuit and to force enemy aircraft to altitudes easier defended by antiaircraft artillery.

f. Barrage balloons may be flown from barges or floats in defending water areas against enemy aerial mine laying operations or in deflecting the enemy from following a river to an objective.

4. Balloon sites

Balloons should be sited in accordance with the following principles:

a. The area to be occupied by a balloon barrage should extend about one mile beyond the line at which a bomb could reach the defended objective if released from an airplane flying toward the defended objective at the altitude at which the balloons are then being flown. At 300 m.p.h. airplane speed, this would require the boundary of the barrage to extend 2½ miles outside the defended objective when balloons are flown at 5,000 feet and 4 miles when flown at 15,000 feet.

b. The balloons should be distributed throughout the area in an irregular pattern but generally of uniform density. The distribution of suitable operating sites will usually result in the desired irregularity.

c. Sites should not generally be over 1/2 mile apart.

d. Sites should provide sufficient clear space for the launching and bedding observation.

e. Balloon beds should provide reasonable shelter from wind and aerial observation.

f. Shelter should be available for the balloon crew.

g. Roads should be available to each balloon position and should preferably interconnect balloon position and the squadron and group headquarters locations.

h. Pole lines for the erection of telephone lines and availability of electric power are desirable but not essential.

5. Height of flying
   a. In clear, cloudless weather, balloons are flown at full operating height.
   b. When clouds exist either scattered or solid, balloons are flown above the cloud base level but never projecting above the top cloud level, except for purposes of deception.

6. Control
   a. The general tactical control of barrage balloons is vested in the Air Defense Commander of the district in which operating.
   b. The detailed tactical control as to when and at what height balloons will be flown is vested in the senior BB commander on duty in the area defended subject to the orders of the Pursuit Aviation Commander on duty in the same area.

7. Communications
   a. The basic means of communication in the squadron is the field telephone. Telephone communication should be established between squadron operations and each balloon position.
   b. Both telephone and teletype are used in communications between the squadron and group headquarters.
   c. Both teletype and radio are used in communications between group headquarters and higher and adjacent echelons of command, usually the Air Defense Commander, Pursuit Commander and Anti Aircraft Artillery commander.

8. Other Signal Functions
   Radio and visual means of warning friendly aircraft from entering the area protected by barrage balloons should be employed.

9. Group Headquarters Squadron
   a. The group headquarters squadron is responsible for production (hydrogen) and storage of lifting gases. When squadrons act independently they will of necessity take over this and other group functions.

b. It is responsible for 3rd echelon of motor vehicle maintenance.
c. It is responsible for repair of balloons of a nature beyond the capabilities of the squadron but not requiring depot or factory action.
d. It is responsible for providing suitable weather information.
e. It is responsible for administrative functions normally performed by an Air Corps group.

[redacted]

February 3, 1941

MEMORANDUM FOR - The Chief of Staff:

SUBJECT - Employment of Barrage Balloons.

1. The tactical employment of barrage balloons is based primarily on the following factors:

a. Existing weather conditions.
b. The operation of friendly bombardment and pursuit units.
c. The operation of hostile aircraft.

2. War experience proves that operation of a fixed barrage will be dangerous to our own aircraft unless closely controlled and coordinated with the operation of our own aircraft. A mobile balloon barrage cannot be used unless similarly controlled.

3. The defense of a balloon barrage by antiaircraft artillery is secondary in importance to its coordination with the operation of friendly air units.

4. Information pertaining to the operation of enemy aircraft is a function of the Air Defense Command.

5. The Air Corps operates the Army Weather Service.

6. All previous experience in experimentation, supply, training, and operation of all types of lighter-than-air equipment has always been in the Air Corps.

7. Numerous and continuing studies have been made by this office for the past year with a view to determining the number of barrage balloons required initially in the United States, overseas departments, and leased air bases. Such studies are on file in the Office, Chief of the Air Corps.

8. It is not believed that Coast Artillery control will be as effective as Air Corps control and may result disastrously due to a lack of essential coordination and cooperation with friendly air units.

H. H. ARNOLD,
Major General, Air Corps,
Acting Deputy Chief of Staff.

[redacted]

[redacted] SECURITY INFORMATION

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WAR DEPARTMENT
Office of the Chief of Coast Artillery
Washington

COPY

January 31, 1941

MEMORANDUM To the Chief of Staff.

Subject: Barrage Balloons.

1. Current War Department policy designates the Air Corps as the "developing arm" for barrage balloons and the Coast Artillery Corps as the "using arm." It is my opinion that the Coast Artillery Corps should continue to be designated the "using arm" and that Coast Artillery troops rather than troops of any other arm should man barrage balloons. The reasons for this follow:

a. Military attache reports disclose that when possible barrage balloons should be protected by antiaircraft fire from attack by enemy planes.

b. Both balloons and antiaircraft artillery serve a common purpose. That is, both are used for the defense of limited objectives. Neither the one nor the other is apt to be used exclusively in the defense of an objective if both are available. Commanders of antiaircraft units must have a sound conception of the tactical employment of balloon units, and likewise commanders of balloon units must understand the tactical disposition and the effectiveness and nature of fire of antiaircraft artillery.

c. Because antiaircraft and balloon units normally will be in close juxtaposition, a real economy in the employment of administrative, supply, and operational personnel will result if they are elements of the same commands.

d. The tactical employment of antiaircraft artillery and of balloons should be taught at the same schools and training centers.

e. Further study will in all probability indicate the desirability of including barrage balloon batteries or battalions as component parts of antiaircraft regiments.

2. The crew of a barrage balloon can be taught quickly its duties. After a week of instruction, the enlisted personnel should be able to handle the balloons and ground equipment. Until an emergency occurs, it would be uneconomical and unnecessary to maintain in being any considerable number of troops assigned to barrage balloon units. Selectees, either white or colored, could be trained readily for the purpose.

3. As indicated in Paragraph 1 above, officers assigned to barrage balloon units must have a knowledge of the employment of antiaircraft artillery. Should it become necessary in the immediate future to organize balloon batteries or battalions, the Coast Artillery Corps is in a position to furnish such officer personnel for they could be drawn either from the 16 harbor defense reserve regiments that are not now and will not be required for harbor defense purposes, or they could be taken from the 62

RESTRICTED SECURITY INFORMATION

antiaircraft reserve regiments. Enlisted cadres could be obtained from active antiaircraft regiments and the remaining enlisted personnel from replacement centers.

Under normal peace conditions, it is believed that with few exceptions all balloon units should be in the National Guard, for it is understood that the annual cost to the government of maintaining a National Guardsman is only about one-twentieth (1/20) that of maintaining a regular soldier. There are 22 National Guard antiaircraft regiments. Were a barrage balloon battalion (four batteries) added to each of these regiments, troops would be available for manning approximately 3,000 balloons. (About 1,500 balloons were in daily use in Great Britain early last fall. Military Attache Report 9/23/40.) These batteries, of course, should be maintained at greatly reduced strength, and expansion effected after the emergency occurred.

4. No study has been made to determine the number of barrage balloons required initially or subsequently for the United States under the various categories of defense; or for the overseas departments and bases. Such a study should be made in order to determine the number of balloons that should be maintained in depot storage.

Because of its vital importance and the danger of sudden attack, it would appear that a balloon unit (one or more batteries) should be maintained in the Panama Canal Department at all times, and probably smaller numbers of balloons in one or more of the other overseas departments or bases. A barrage balloon platoon (10 or 12 balloons) likewise should be stationed for purposes of coordinated training at each of the larger antiaircraft training centers in the United States.

It would appear unnecessary at this time to organize more than enough balloon units to man 120 to 150 balloons. Probably this would require from 60 to 80 officers and from 1,000 to 1,200 enlisted men. If small balloon units are to be organized at antiaircraft training centers in the United States, it would be my thought that these units be organized within existing antiaircraft regiments, from personnel already assigned thereto. This same procedure too probably could be followed in the overseas departments.

J. A. GREEN
Major General
Chief of Coast Artillery

Appendix 7.

February 11, 1941

MEMORANDUM FOR: The Chief of Staff

Subject: Barrage Balloon Development

1. The problem presented.

Organization of Barrage Balloon Squadrons.

2. Facts bearing upon the problem.

a. WPD has been directed (Tab A.) to resubmit WPD 1098-15 (Tab B.) covering (a) use of civilians to fill out crews of barrage balloons; (b) the practicability of volunteer civilian units; (c) National Guard units.

b. The present Chief of the Air Corps submitted (10-5-40) a "Program for Barrage Balloon Development" which contemplates operation of barrage balloons by the Air Corps and an increase in the strength therefor.

c. The Air Corps 1st Barrage Balloon Squadron was authorized Sept. 11, 1940, to service test barrage balloons with the Chief of the Air Corps responsible for personnel, organization and training.

d. The Chief of Coast Artillery with Air Corps concurrence, recommended March 30, 1923 (Tab C), the Air Corps to be charged with the development of barrage balloons and AA units be charged with their operation because: (a) the Coast Artillery is charged with the operation of AA artillery, searchlights, etc., required for ground AA defense; (b) barrage balloons are auxiliary to AA and machine gun defense, and the location of balloons and guns require close coordination; (c) the operation of barrage balloons by the Air Corps is wrong in principle and wasteful of personnel;

(d) Training necessary not difficult to give any soldier. W. D. issued a directive implementing these recommendations (Tab C). For generally similar reasons, the present Chief of Coast Artillery recommends no changes in this directive (Tab F).

e. Extensive and reasonably effective use has been made of the barrage balloon in the current war, by both England and Germany under the control of their respective Air Forces. Every major nation (except the U. S.) charges its air arm with operation of barrage balloons (General Chaney). The Acting Chief of Staff (General Arnold) believes that barrage balloons should be under the control of the Air Corps (Tab G).

f. The C. G., GHQ Air Force, stated that barrage balloons should not be a part of the Air Corps.

g. In view of the facts appearing above, a decision placing the responsibility for the development, procurement, and operation of barrage balloons should be made before definite recommendations covering points enumerated in sub paragraph 1, above, are presented.

3. Discussion.

a. Pursuit aviation is the basic defense weapon, due to its mobility and effective fire power. A.A. and barrage balloons complement pursuit aviation. This must necessarily continue to be so, due to their relative immobility. All three should operate as distinct type units in the air defense command. These three elements must be so closely coordinated that they operate virtually as a single unit (Tab D).

b. Barrage balloons and AA are as a rule employed to protect the same limited objectives and areas. Elements are interspersed and mutually supporting.

Since barrage balloons must be protected by AA; must be shifted frequently; and have approximately the same mobility; more efficient and economical administration should be attained if AA and the barrage balloons were under the same commander.

c. The tactical employment of balloons and AA constitutes an integrated problem for which AA and barrage balloon commanders should be thoroughly trained. Since training of crews is neither complicated nor arduous, the maintenance of any considerable number with barrage balloon units is uneconomical and unnecessary, until an emergency arises. The question of trained officer personnel will be the bottleneck. The Air Corps trained officer and specialist situation is acute, due to the tremendous expansion it is experiencing. The Coast Artillery states that it can provide both officer and enlisted cadres from the 16 harbor defense reserve regiments that are not now and will not be required for harbor defense purposes, or from the 62 reserve AA regiments (Tab F-1) existing and projected training facilities favor assignment of barrage balloons to the Coast Artillery.

d. Barrage balloons are a comparatively new weapon and facilities and supply organizations lack development. For speedy development and efficient operation, unified control is essential.

4. Action Recommended.

a. That the Chief of the Coast Artillery Corps be charged with the development, procurement, and operation of barrage balloons.

b. That General Staff Divisions, Army and Departmental Commanders, the Chief of the Air Corps, and the Chief of the Coast Artillery be notified of the action taken.

c. That all papers be returned to the War Plans Division for compliance with memorandum OCS 21165-3, December 5, 1940 (Tab.A).

L. T. Gerow,
Brig. General
Acting Assistant Chief of Staff

Incls:

Tab A - OCS/21165-3 (12-5-40) /for Ass't Chief of Staff, WPD/
Tab B - WPD 1098-15 (10-19-40) /memo for Chief of Staff/
Tab C - AG 452.3 (3-30-23) (misc.) D 1st Ind. /action of 1923/
Tab D - Page 2 of G-3 paper on Barrage Balloon Trps (G3.42550) /Sept. 11, 1940/
Tab E - OCS 21165-3 (11-27-40) /Officers sent abroad Mount etc/
Tab F - Memo fr. C. of CA to DC/S(11-6-40)
Tab F1- Memo. fr. C of CA to C/S (1-31-41)
Tab G - Memo fr. Gen. Arnold to C/S (2-3-41)
Tab H - Memo fr. Gen. Arnold (3-14-41) / Issues instructions placing Chief of Staff's decision into effect/

Appendix 8

March 1941

MEMORANDUM FOR: Assistant Chief of Staff, G-3
Assistant Chief of Staff, G-4
Assistant Chief of Staff, WPD
Assistant Chief of Staff, G-1
Chief of Coast Artillery
General Brett, OCAC

Subject: Barrage Balloon Development.

The Chief of Staff has designated the Coast Artillery as the using arm, and for the time being, the Air Corps as responsible for the experimentation, development and procurement of barrage balloons. The following initial instructions are issued to place this decision into effect:

1. The 1st and 2nd Balloon Squadrons will furnish at least 50% of their existing personnel which will be utilized as a cadre for the organization of a barrage balloon training center and a development and experimentation station. In accordance with existing instructions, the 3rd Barrage Balloon Squadron is designated to service test the proposed Table of Organization and the equipment now under procurement.

2. The Assistant Chief of Staff, G-3, will:

a. Issue necessary instructions to appoint a Board of Officers to make recommendation as to the location of a suitable site for a barrage balloon training center. The Board will consist of two Coast Artillery officers and one Air Corps officer nominated by the respective Chiefs of Arms. Instructions to the Board will include a directive that the site will be so selected as not to interfere with scheduled commerical air line operations or military and naval flying activities.

b. Submit recommendations to the Chief of Staff as to the number of barrage balloon groups and squadrons to be organized; their assignment to air defense commands, A.A. training centers and to foreign service departments; and the procurement of personnel.

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Appendix 8.

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March 14, 1941

MEMORANDUM FOR: Assistant Chief of Staff, G-3
Assistant Chief of Staff, G-4
Assistant Chief of Staff, WPD
Assistant Chief of Staff, G-1
Chief of Coast Artillery
General Brett, OCAC

Subject: Barrage Balloon Development.

3. The Chief of Coast Artillery will:

a. Furnish the Assistant Chief of Staff, G-3, without delay, the names of two Coast Artillery officers for detail to the Board of Officers designated in paragraph 2 a above.

b. Submit recommendations covering:

(1) Organization of a barrage balloon training center;

(2) Personnel to be made available therefor;

(3) Necessary housing and other facilities

Plans will be based on the initial organization and training of 12 squadrons and necessary headquarters at the training center.

c. Be responsible for the training of barrage balloon units and the development of operational doctrine.

d. Submit immediately recommendations concerning the advisability of transferring the 3rd Barrage Balloon Squadron to Camp Bowie, Texas, or other location, for the purpose of expediting the service test of the Table of Organization for a barrage balloon squadron and the barrage balloon equipment now under procurement, pending decision as to the location of the barrage balloon training center. Housing for this unit at Camp Bowie has already been constructed.

4. The Chief of the Air Corps will:

a. Be responsible initially for experimentation, development, and procurement of barrage balloons and such accessories as are Air Corps items of equipment.

b. Initiate action to procure immediately additional barrage balloons and accessory equipment in order to maintain continuity of production making available therefor not to exceed $10,000,000 from current funds available to the Air Corps. The amount so used will be replaced by funds included in 1942 estimates for the procurement of 2500 balloons as approved by the Chief of Staff in 003/21165-3 dated December 5, 1940.

c. Furnish the Assistant Chief of Staff, G-3, without delay the name of one Air Corps officer for detail to the Board of Officers designated in paragraph 2 b above.

d. Submit to the Chief of Coast Artillery the names of all officers of the Air Corps experienced in the operation of lighter-than-air equipment, who can be made available for the barrage balloon program. This list will include Reserve Officers not now on active duty.

e. Submit to the Chief of Coast Artillery the names and qualifications of those Air Corps enlisted men now assigned to the 1st and 2nd Balloon Squadrons that can be made available for the barrage balloon program. The men so transferred will be qualified in the maintenance, repair, and operation of captive balloons and balloon winches.

5. The Chief of the Air Corps and the Chief of Coast Artillery will cooperate and will coordinate their ideas to the fullest extent.

(Signed) H. H. Arnold

H. H. ARNOLD
Major General, Air Corps,
Acting Deputy Chief of Staff.

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INTER-OFFICE MEMORANDUM

WAR DEPARTMENT, AIR CORPS
Office, Assistant Chief
Materiel Division

[redacted]

JFB:ags:51
Wright Field, Dayton, Ohio
Date September 2, 1941

TO: Chief, Experimental Engineering Section, Wright Field

SUBJECT: Equipment for Barrage Balloon Organizations.

[redacted]

1. This is with reference to Inter-Office Memorandum from Executive, Office Chief of the Air Corps addressed to the Technical Executive, Materiel Division, Wright Field, dated August 25, 1941.

2. Reference requirements for equipping five battalions by January 15, 1942, and fourteen battalions by April 15, 1942, efforts will be made to provide the items of equipment, procurement of which has been assigned to the Experimental Engineering Section.

3. Requirements per battalion are as follows:

Item No.	Item	Quantity
1	Balloon, Barrage L.A.	135
2	Balloon, Barrage H.A.	13.6
3	Cable, Low Altitude	111
4	Cable, High Altitude	10.8
9	Hydrogen Generator	2.4
20	Truck, Balloon Winch	111
21	Winch, Type A-9 (L.A.)	111
22	Winch, Type A-11 (mobile)	22.2
23	Winch, Type A-10 (H.A.)	21.6
24	Tractor and semi-trailer	22.2

4. Total requirements for five and fourteen battalions:

Item No.	Item	Quantities Jan. 15	April 15
1	Balloon, Barrage L.A.	675	1890
2	Balloon, Barrage H.A.	68	190
3	Cable, Low Altitude	555	1554
4	Cable, High Altitude	54	151
9	Generator, Hydrogen	12	168
20	Truck, Balloon Winch	555	1554
21	Winch, Type A-9 (L.A.)	555	1554

[redacted]

Signature

[redacted]

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SECURITY INFORMATION

Chief, Exper. Engr. Sec., W.F.
Equip. for Barrage Balloon Organizations.
September 2, 1941

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4. (continued)

Item No.	Item	Quantities Jan. 15	April 15
22	Winch, Type A-11 (mobile)	111	310
23	Winch, Type A-10 (H.A.)	108	302
24	Tractor and semi-trailer	111	310

5. With reference to availability of equipment required by January 15, 1942, deliveries may be expected according to the following:

a. Items 1, 3, 9, and 20 and 21 in required quantities.

b. Items 4, 22, and 23, 70 percent of requirements.

c. Items 2 and 24, not over 10 percent of requirements.

6. Requirements for April 15, 1942, with respect to availability of equipment, are being investigated.

P. M. KEMMER,
Lt. Colonel, Air Corps,
Chief, Aircraft Laboratory

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M97-40

January 5, 1942

MEMORANDUM FOR: Chief Statistics Branch, G. S., Room 2506, Munitions Building

Subject: Monthly Report on Balloons, Balloon Winches, Hydrogen Cylinders and Generating Plants, and Parachutes.

1. In compliance with your memo of May 2, 1941 the following information for the month of December is furnished:

Item	On Hand	Station	On Order unDelivered	Delivery Schedule	Starting Date
Barrage Balloons					
D-3	4	Ft. Sill			
D-3	2	Camp Davis			
D-4	8	Ft. Sill	5		
D-4	21	Camp Davis			
D-4	34	301st Battalion			
D-4	5	Fairfield	204	9 per wk,	1/3/42
D-4	--	Destination to be furnished later.	500		
D-5	1	Ft. Sill			
D-5	28	Camp Davis			
D-5	43	301st Battalion			
D-5	1	302nd Battalion			
D-5	61	303rd Battalion Puget Sound			
D-5	1	304th Battalion			
D-5	1	305th Battalion			
D-5	45	Parris Island	105	3 per wk.	1/5/42
				5 per wk	2/9/42
D-5	3	Fairfield	1053	12 per wk	1/3/42
				17 per wk	2/21/42
D-6	2	Ft. Sill	4		
D-6	12	Camp Davis			
D-6	6	301st Battalion			
D-6	8	Fairfield	25	11 per wk.	1/3/42
D-6		Destination to be furnished later	488		
High Alt.	1	Ft. Sill			

[redacted] SECURITY INFORMATION

Winches	On hand	Station	On hand undelivered	Delivery Schedule	Starting Date
A-9	3	Ft. Sill			
A-9	36	Camp Davis			
A-9	42	301st Battalion			
A-9	18	303rd Battalion			
A-9	28	Parris Island	10		
A-9	0	Fairfield	1350	Current rate 70 per wk.	
A-10	1	Ft. Sill			
A-10	9	Fairfield			
A-11	2	Ft. Sill			
A-11	9	301st Battalion			
A-11	1	305th Battalion			
A-11	0	Fairfield	100	2 per wk.	2/1/42
Hydrogen Generators					
A-1	1	Camp Davis	1.	1	
A-1	1	Norfolk			
A-1		Parris Island	3	1	1/3/42
A-1		Fairfield	29	1	1/17/42
Hydrogen Cylinders:					
A-1	30,000		241,750	8,000	12/1/41

Increasing to 12,000 per month 2/1/42 and to 18,000 per month 5/1/42.

For the Chief of the Air Corps:

/s/ F. I. ORDWAY, JR.,
F. I. ORDWAY, JR.,
Major, Air Corps
Asst. Exec., Materiel Division

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SECURITY INFORMATION

The following list of desirable military characteristics for barrage balloon equipment was drawn up and approved by the Joint Barrage Balloon Committee at a meeting held in the Munitions Building, Washington, D. C., on January 3, 1942:

DESIRABLE MILITARY CHARACTERISTICS IN A LOW ALTITUDE BALLOON

1. A non-pressure closed ballonet balloon with a gas valve, which operates only when the balloon has reached the ballonet ceiling. Fins to be air-inflated.

2. An operational height of approximately 5000 feet at sea-level under the following conditions:
   a. Air temperature at ground: 60°F.
   b. Air pressure at ground: 29.92 in. mercury.
   c. No wind.
   d. Weight of balloon cable: Not over 90 pounds per 1,000 feet.
   e. A free lift of 35 pounds at operating altitude.
   f. Cable armed with a lethal device weighing not over 50 pounds.
   g. Inflation with hydrogen of 92% purity.
   h. To be rigged for mechanical handling designed to reduce the operating personnel to a minimum.

3. The ballonet ceiling shall be 8,000 feet under the conditions set forth in Paragraph 2 -a-b-c.

4. Balloon to valve gas when the internal pressure becomes dangerous to the fabric. Valve setting or point of operation should be easily adjusted.

5. Design of Balloon to be such as to allow rate of haul down of not less than 300 feet per minute in a 20 mi. per hour wind, with a haul down rate of 1,000 feet per minute desired.

6. Topping-up to be possible from a close-haul position of balloon.

7. Fabric.
   a. A known fabric with the least permeability obtainable, consistent with other requirements, particularly long life and low weight.
   b. Fabric deterioration under storage or use not to limit the life of the balloon to less than 9 months.
   c. Fabric to be treated to prevent excessive superheat.

8. Flying behavior.
   a. Capable of flying in a 50 m.p.h. wind without loss of or damage to balloon.
   b. Under steady wind conditions balloon not to pitch or yaw or fly off wind to the degree that the balloon becomes unmanageable.
   c. Design and rigging to be such that no ballast is required.

[redacted]

9. Minimum weight and volume consistent with characteristics previously described.
10. Maximum simplicity of design consistent with the above requirements.

DESIRABLE MILITARY CHARACTERISTICS IN A LOW ALTITUDE

SKID MOUNTED BARRAGE BALLOON WINCH

1. Power

a. It should be driven by an internal combustion gasoline engine sufficiently powered to overcome the static forces plus the high variable dynamic forces of lift of the barrage balloon.

b. Minimum performance requirements. It should be capable of:

(1) A hauling down speed in high gear of at least 1,000 feet per minute.

(2) A cable pull in high gear of at least 1700 pounds.

(3) A cable pull of at least 1,300 pounds at a haul-down speed of 1,000 feet per minute.

(4) A cable pull in low gear of at least 5,100 pounds.

(5) A hauling down speed of at least 100 feet per minute at a cable pull of 5,100 pounds.

(6) A paying out speed in reverse which can reach at least 1,000 feet per minute.

(7) Paying out should be possible in free wheeling, with 400 pound static lift of the balloon.

c. Power plant should have a magneto ignition system and an electric starting system, including a battery, generator and starter, and a self starter.

d. Power plant should be so designed as not to offer any health hazard to winch operator, through exhaust fumes, or other characteristics.

e. Power plant should be sufficiently sturdy and well-designed to offer a minimum likelihood of breakdown or frequent repair operations.

f. Parts used in power plant should be standard, easily manufactured parts, to minimize manufacturing and supply problems.

2. Transmission of Power to Surge Drums, etc.

a. A standard type transmission capable of giving the above performance with the power plant used. It should include an intermediate as well as high and low gear, and reverse.

b. Transmission should provide for independent transfer of power to either the surge drums, or the capstan mentioned below, or both.

3. Surge Drums.

a. Winch line pull should be taken entirely on surge drums. Line pull at surge drum is not necessarily vertical, as lead-off gear changes the cable direction. Surge drums provide the power transfer which moves the cable, and hauls balloon down.

b. Surge drums should function without slippage when the tension between the surge drums and storage drum is sufficient to take out the slack in the cable between those drums.

c. Two surge drums should be provided.

d. Both surge drums should rotate at the same speed.

e. Surge-drums should be able to use the cable described in characteristics for low altitude barrage balloon cable with grooves and drum diameters approprate to this requirement.

f. A foot-brake and snatch-brake should be directly connected to the surge drum shafts, or otherwise connected so as to be independent of the power plant.

g. The surge-drum unit should be designed for convenient accessibility for adjustments or repair.

h. The surge-drum unit should be housed in a rust-proof cover.

i. Design of the surge-drum unit should be such that cable cannot slip out of grooves or off surge-drums during operation.

4. Storage Drum Unit.

a. Should have sufficient capacity for 3,000 feet of the cable specified in 3 e above, without distortion of the flanges.

b. Should be so driven that sufficient tension will be maintained between the surge drums and the storage drum to insure proper spooling of the cable about the storage drum; however, it should not be capable of building up excessive tensions in the cable wound on the drum.

c. Drive of storage drum should be smooth in operation and with the minimum tendency to over-rum, bind, wear or change adjustment.

d. There should be a brake connected to the storage drum, actuated by the service (foot) brake. It should overcome the inertia of the storage drum when the surge drums are braked.

5. Lead-off Gear.

a. Should be all-directional within a cone from -20° to the horizontal -140° measured from the rear of winch, to take care of any angle of cable at the winch.

b. Should be non-restricted and non-impeded in assuming any direction to correspond to direction of the cable within limits described above.

c. Should produce:
(1) Minimum wear of cable through rubbing.
(2) No kinking or binding in cable.
(3) No cutting of cable or strands of cable, either tight or slack, through design of lead-off gear.

d. Should be capable of being used with an external snatch-block.

e. Should provide for grounding of cable while in motion or at rest (without friction on cable) when potential of cable with respect to ground exceeds 200 volts.

6. Capstan. There should be a capstan built into the winch, with the following characteristics.

a. Driven independently by the winch power plant.

b. Capable of being engaged or disengaged by means of an independent clutch.

c. Capable of paying off rope or cable at a speed of 50 feet per minute at normal operating speed of power plant motor.

d. Capable of handling four or five turns of 1-inch rope.

e. Conveniently located on the side of the winch so that it may be used at the same time that the balloon is flying.

f. Capable of exerting a minimum pull of 2,000 lbs.

7. Shock Absorber.

a. The shock absorber shall absorb 5,000 lbs. tension with cable movement of at least 36 inches.

8. Instruments.

a. Tension meter. There should be a tension meter built into the winch, which will indicate the tension in the cable between the balloon and the winch up to at least 5,000 pounds, both when the winch is in operation and when it is stopped.

b. Cable-meter. A meter indicating the amount of cable paid out in feet adjustment for this meter should be provided.

9. Location of Instruments. Instruments conveniently located in the winch operator should include:

a. Tension meter.
b. Cable meter.
c. Fuel indicator
d. Engine oil pressure gauge.
e. Engine temperature gauge.
f. Ammeter.

10. Provision for effective functioning and safety of Operator.

a. Winch operator should be protected by overhead cover which will allow him to see the balloon readily at all angles.

b. It is desirable that a headrest be provided for the operator.

c. Winch operating controls should be readily accessible to winch operator, and easily and smoothly operated. Control of power plant speed should be flexible and have at least the fineness of adjustment found in passenger motor vehicles.

d. Power plant should be so designed as to minimize danger of explosion from contact of sparks or heated surfaces with hydrogen-air mixtures.

11. Lightning Protection.

a. Operator's cage should provide protection from electrical surges in cable.

b. The winch should be equipped with a grounding wire capable of carrying a 2,000 ampere current without excessive temperature rise. This should be attached so that it provides grounding for all portions of winch without excessive electrical resistance at point of contact.

12. Mounting.

a. The winch should be capable of rigid attachment to the standard truck chassis.

b. (1) It should be possible to fly the balloon from the winch, when the winch is mounted on either a trailer or truck.

(2) Each winch should be provided with skids so that it can be removed from the trailer. Skids should be such that winch can be transported short distances over normal terrain after removal from trailer. Skids should allow anchoring to "deadman" and be so designed that it is possible to load the winch on a standard military cargo truck.

DESIRABLE MILITARY CHARACTERISTICS OF MOBILE WINCHES

1. All the characteristics of the skid mounted winches except those that conflict with the requirements below.

2. Permanently mounted on a truck chassis.

3. Powered by the truck motor.

4. Minimum size and weight for the purpose.

5. Simplicity of design, from the operational standpoint.

[redacted]

DESIRABLE MILITARY CHARACTERISTICS OF LOW ALTITUDE

BARRAGE BALLOON CABLES

1. General Requirements.
   a. Resistant to
      (1) Corrosion
      (2) Damage from flexing and unflexing in passing over sheaves of surgedrum grooves.
      (3) Kinking in normal operation.
   b. Minimum tendency to unwrap itself during normal operation.
   c. Single stranded 6 x 1 cable over a lubricated hemp core with a lay of 2 inches and lay tolerance of/or 2½.

2. Special Requirements.
   a. Minimum breaking strength .....7,000 lbs.
   b. Desirable breaking strength.....7,300 lbs.
   c. Maximum weight per 1,000 ft..... ..... 100 lbs.
   d. Maximum diameter..... ¾ inch.

DESIRABLE MILITARY CHARACTERISTICS OF VERY LOW ALTITUDE

BARRAGE BALLOON CABLES

1. General Requirements.
   a. Resistant to
      (1) Corrosion
      (2) Damage from flexing and unflexing in passing over sheaves of surgedrum grooves.
      (3) Kinking in normal operation
   b. Single wire.

2. Special Requirements.
   a. Minimum Breaking Strength.....1,300 lbs.
   b. Maximum Weight per 1,000 ft..... ... 15 lbs.

REQUIREMENTS FOR GROUND CLOTHS

1. Standard sizes, 20' x 20' and 10' x 10'.

2. Made of 10-ounce army or double filled duck. Other materials possessing the same durability may be considered.

3. Should be resistant to mold or to deterioration in storage under damp conditions.

4. Color: olive -- drab or khaki.

[redacted]

REQUIREMENTS FOR JUNCTION ASSEMBLY

1. Should permit the use of a freely acting swivel joint or other device to prevent cable kinking.

2. There should be minimum likelihood of entanglement of the rip-cord in the junction assembly during operation.

3. Terminal assembly should not cause any sharp bend in the cable at region of attachment, and should cause minimum of flexing and unflexing of cable under operating conditions; such flexure should occur over a suitable length of a bearing surface with a radius of initial curvature of at least 20 inches.

4. A safety device to prevent breakaway balloons carrying cable with them, and to pull the rip-cord when balloon breaks away, should be incorporated in junction assemblies.

5. Balloon should be readily detachable at the junction assembly, preferably without the use of tools.

DESIRABLE MILITARY CHARACTERISTICS FOR A LETHAL DEVICE

1. A device which will render incapable of further flight, any airplane which strikes the balloon cable, the weight of such device to be not over 50 pounds.

DESIRABLE MILITARY CHARACTERISTICS FOR AIR BLOWER

1. Portable.

2. Capable of blowing at least 50,000 cubic feet of air per hour against 1" of water pressure.

3. So constructed as to be usable for transferring helium from one balloon to another, as well as air inflating. Therefore, it must be gas-tight so that purity of helium is unchanged in the transfer.

DESIRABLE MILITARY CHARACTERISTICS FOR A PORTABLE HYDROGEN GENERATOR

1. Capable of generating at least 6,000 cubic feet of hydrogen per hour of operation.

2. Capable of generating gas continuously while unit is in operation.

3. Produce hydrogen of 99.0 per cent purity.

4. Produce hydrogen at a pressure corresponding to that used in the cylinders in use.

5. Require a minimum of materials for the generation of hydrogen by:
   a. Proper choice of reaction to be used.
   b. Maximum chemical efficiency during that reaction, consistent with other requirements.
   c. Minimum requirements of cooling water.

6. Have minimum size and weight, consistent with other requirements.

7. Require a minimum of personnel to operate it.

8. Should be capable of being towed at not less than 10 miles per hour over hard surfaced roads.

DESIRABLE MILITARY CHARACTERISTICS FOR TRAILERS -

WINCH AND GAS

1. It should be a dual-purpose trailer capable of transporting either the winch, or an equal weight of charged cylinders.

2. It should have sufficiently powerful brakes operable from the towing truck, and a mechanical parking brake operable from the trailer.

3. It should be equipped with a tail gate which when lowered will serve as a loading and unloading ramp for the winch.

4. It should be provided with clearance and skid construction similar to that of the antiaircraft artillery searchlight trailer.

5. It should be capable of a road speed, loaded, of 45 m.p.h. on good roads.

6. It should allow flying of the balloon while the winch is mounted on the trailer. This includes requirements for non-restricting of the angle of the cable by the sides of the trailer when the balloon is flying.

7. It should permit charging and discharging of the gas cylinders in one batch without removal from the trailer.

DESIRABLE MILITARY CHARACTERISTICS FOR SCREW PICKETS

1. A minimum holding strength of 1,000 pounds in sandy loam when turned down flush with the ground.

2. Strong enough to withstand the force necessary to turn it into the ground.

3. A ring or other attachment, either an integral or separately applied part, to fasten cables or rope lines from balloon.

4. A satisfactory means for easily turning into and for removal from the ground by not more than two men.

5. Completely removable from the ground for re-use.

DESIRABLE MILITARY CHARACTERISTICS FOR A VERY LOW ALTITUDE BALLOON

1. Balloon which will reach an operational height of 2,000 feet minimum, at sea-level under the following conditions:
   a. Air temperature at ground: 60° F.
   b. Air pressure at ground: 29.92 in. mercury.
   c. No wind.
   d. Weight of balloon cable: 15 pounds per 1,000 feet.
   e. A free lift of 25 pounds at operating altitude.
   f. Cable armed with a lethal device weighing not to exceed 10 lbs.
   g. Inflation with hydrogen of 92% purity.

2. Design of balloon to be such as to allow a maximum rate haul-down.

3. Fabric.
   a. A known fabric with the least permeability obtainable, consistent with other requirements, particularly long life and low weight.
   b. Fabric to be treated to prevent excessive superheat.

4. Flying behavior.
   a. Capable of flying in a 45 m.p.h. wind without loss of or damage to balloon.
   b. Under steady wind conditions, balloon not to pitch or yaw or fly off wind to the degree that the balloon becomes unmanageable.

5. Minimum weight and volume, consistent with above characteristics.

6. Maximum simplicity of design consistent with the above requirements.

DESIRABLE MILITARY CHARACTERISTICS OF MOBILE

EQUIPMENT FOR VERY LOW ALTITUDE BALLOONS

1. A light, skid mounted winch from which the balloon may be flown, put in ascension, or hauled down, while transporting vehicle is in motion.

2. Winch to be capable of being operated when removed from vehicle and hauling in or paying out cable under tension of 300 pounds at a speed of 450 feet per minute, and to permit the use of a lethal device.

3. To be equipped with a detachable drum capable of holding 7,000 feet of the cable specified for the very low altitude barrage balloon.

DESIRABLE MILITARY CHARACTERISTICS OF RIGGING SYSTEMS

OF BALLOONS

1. To provide the maximum safety and care in handling of balloon.

2. To require the minimum number of personnel.

3. To be so designed that no excessive stress is placed on balloon fabric or patches.

4. To require minimum amount of adjustment.

5. To allow balloon to be brought as close to the ground as possible before handling by personnel is necessary.

6. To permit mechanical handling.

DESIRABLE MILITARY CHARACTERISTICS OF EQUIPMENT FOR

MECHANICAL HANDLING.

1. Should be able to take balloon when it is brought to minimum altitude by winch, and secure it safely so as to minimize liability to damage or breakaway.

2. Should require the minimum number of personnel and minimum exertion by such.

3. Should cause no damage to balloon during functioning.

4. Should require the minimum amount of time for installation at a site and the minimum amount of extra materials. Should occupy the minimum area.

5. Include safety precautions against lightening or fire hazard.

DESIRABLE MILITARY CHARACTERISTICS OF INSTRUMENT TO DETERMINE CONDITIONS IN THE VICINITY OF A BALLOON WHILE IN ASCENSION

1. In addition to the instrument usually used by the weather section on the ground, the following should be measurable by an instrument to be attached to the balloon or the balloon cable, and means provided for indicating the information on the ground. Preferably this instrument should transmit data through radio to a receiver on the ground.
   a. Wind velocity at height of balloon.
   b. Presence or absence of clouds surrounding the balloon.
   c. Gas pressure or fullness of balloon.
   d. Probability of lightning.

DESIRABLE MILITARY CHARACTERISTICS FOR RIPPING LINK

1. A safety device to prevent breakaway balloons carrying cable with them.

2. Device should deflate the balloon when it breaks away.

3. Device should be of minimum weight for the purpose.

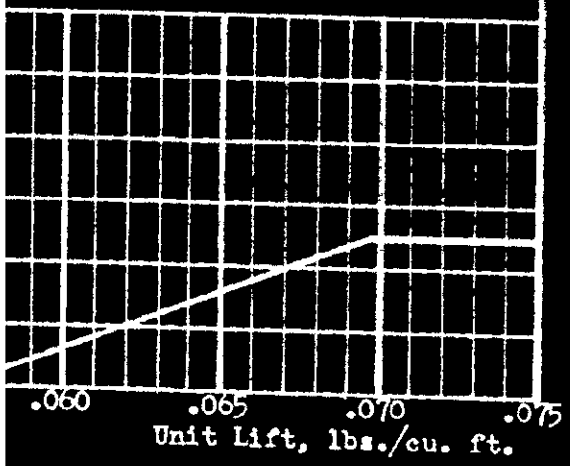
4. Device should not materially affect flying performance or tactical performance of balloon, or cause entanglement of rigging.

5. May be combined with lethal device.

Date June 20, 1941

DILATABLE

y	Cost Each	Scheduled Contract Completion
	7261	February 16, 1941

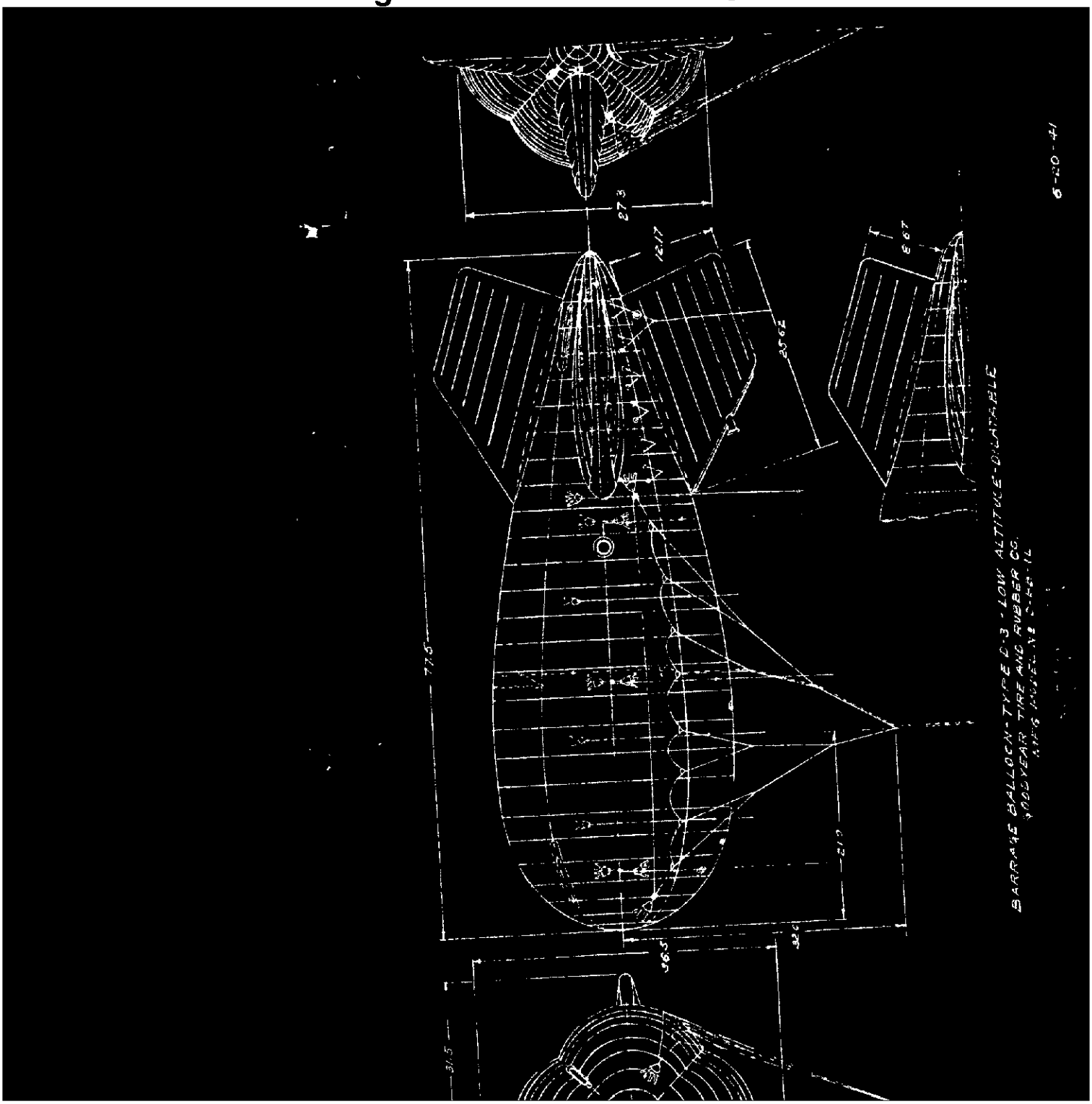


250 to 1200 ft./min.
125 to 1000 ft./min.
ee 50 m.p.h.
62 m.p.h.
3/16 inch.
Helium or Hydrogen.
13 degrees.

as indicated depending on net
oon, and winch pay-out ability.
y as indicated depending on wind

19,960 cu. ft.
24,950 cu. ft.

863 lbs.
40 lbs.
903 lbs.



Date June 20, 1941

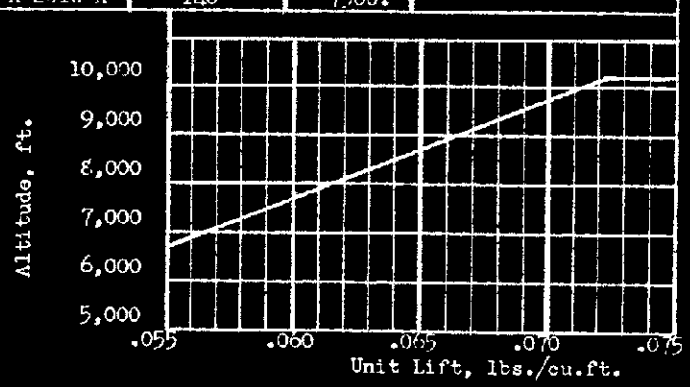
BARRAGE BALLOON TYPE B-4 LOW ALTITUDE BALLONET

Contractor: Air Cruiser, Inc.

Contract No.	Model Spec.	A.C. Type Spec.	Quantity	Cost Each	Scheduled Contract Completion
15470	1362	R-2010-A	6	7666.	Jan. 25, 1941
17332	1362	R-2010-A	20	7500.	May 10, 1941
17881	1362-B	R-2010-A	20	7500.	June 1, 1941
19641	1362-C	R-2010-A	140	7500.	

I. PERFORMANCE

1. Altitude (Still Air)

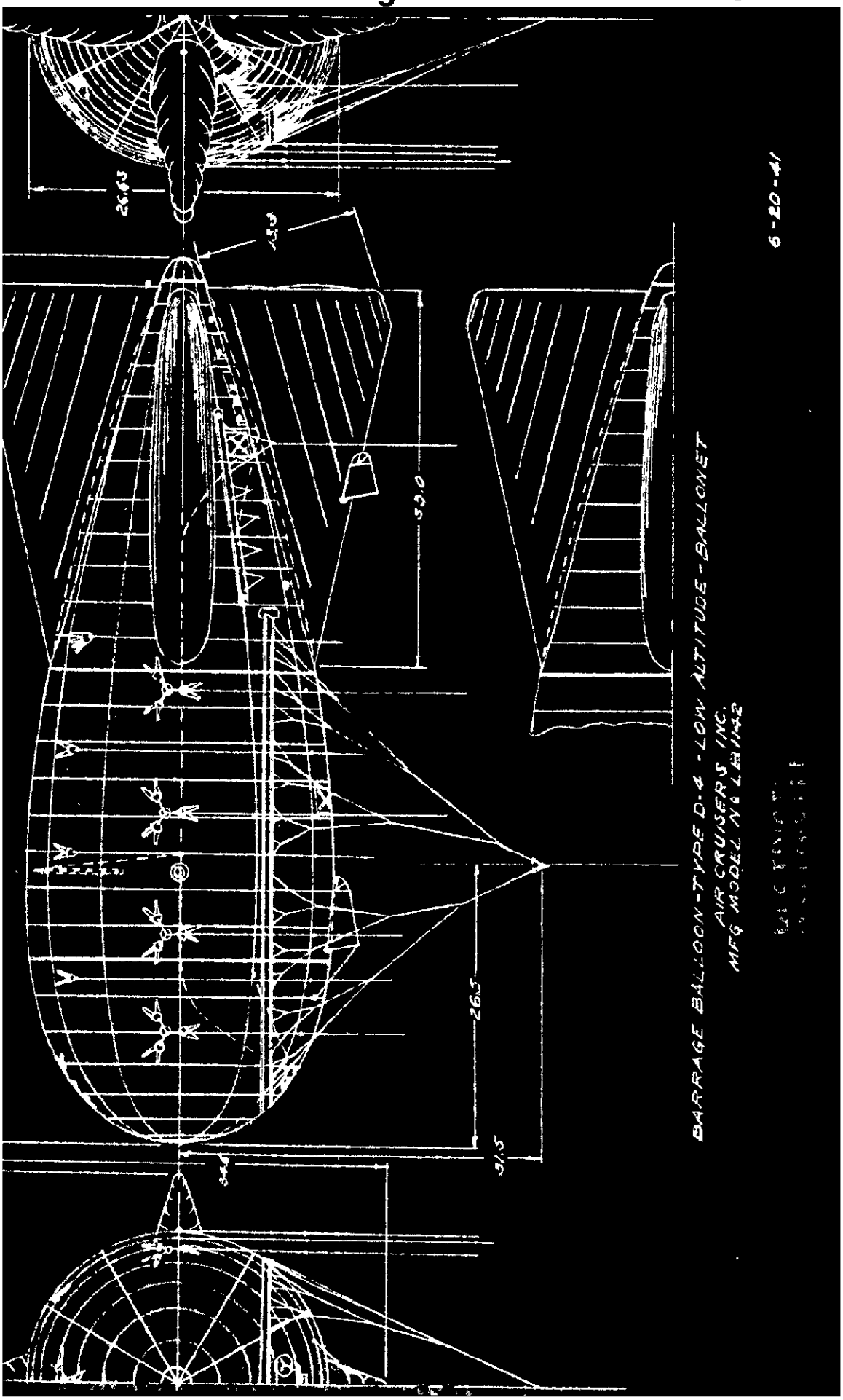


2. Rate of Ascent — 250 to 1200 ft./min.
3. Rate of Descent — 50 to 1000 ft./min.
4. Flight, wind speed, contractor guarantee — 50 m.p.h.
   Maximum operated to date — 56 m.p.h.
5. Flying Cable, diameter — 3/16 inch.
6. Inflation Gas — Helium or Hydrogen.
7. Trim Angle, static — 13 degrees.

Notes. a. Rate of ascent will vary as indicated depending on net lift, wind speed at balloon, and winch pay-out ability.
b. Rate of descent will vary as indicated depending on wind speed at balloon.

II. VOLUMES and WEIGHTS.

1. Total Gas Displacement
   a. Basic Condition, ballonet 83.3% full, — 20,490 cu. ft.
   b. Full condition, ballonet empty — 27,950 cu. ft.
   c. Ballonet Capacity — 8,950 cu. ft.
2. Weights
   a. Balloon, complete — 720 lbs.
   b. Ballast — 100 lbs.
   c. Gross — 820 lbs.



Date June 20, 1941

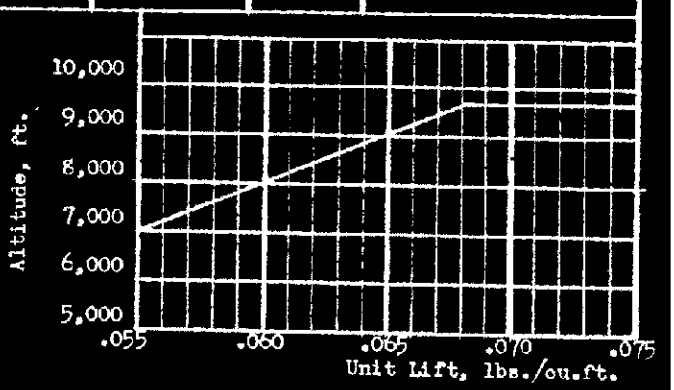
BARRAGE BALLOON TYPE D-4 LOW ALTITUDE BALLONET

Contractor: United States Rubber Co.

Contract A.C. No.	Model Spec.	A.C. Type Spec.	Quantity	Cost Each	Scheduled Contract Completion
19977	5-1	R-2010-A	4	9750	

I. PERFORMANCE

1. Altitude (Still Air)

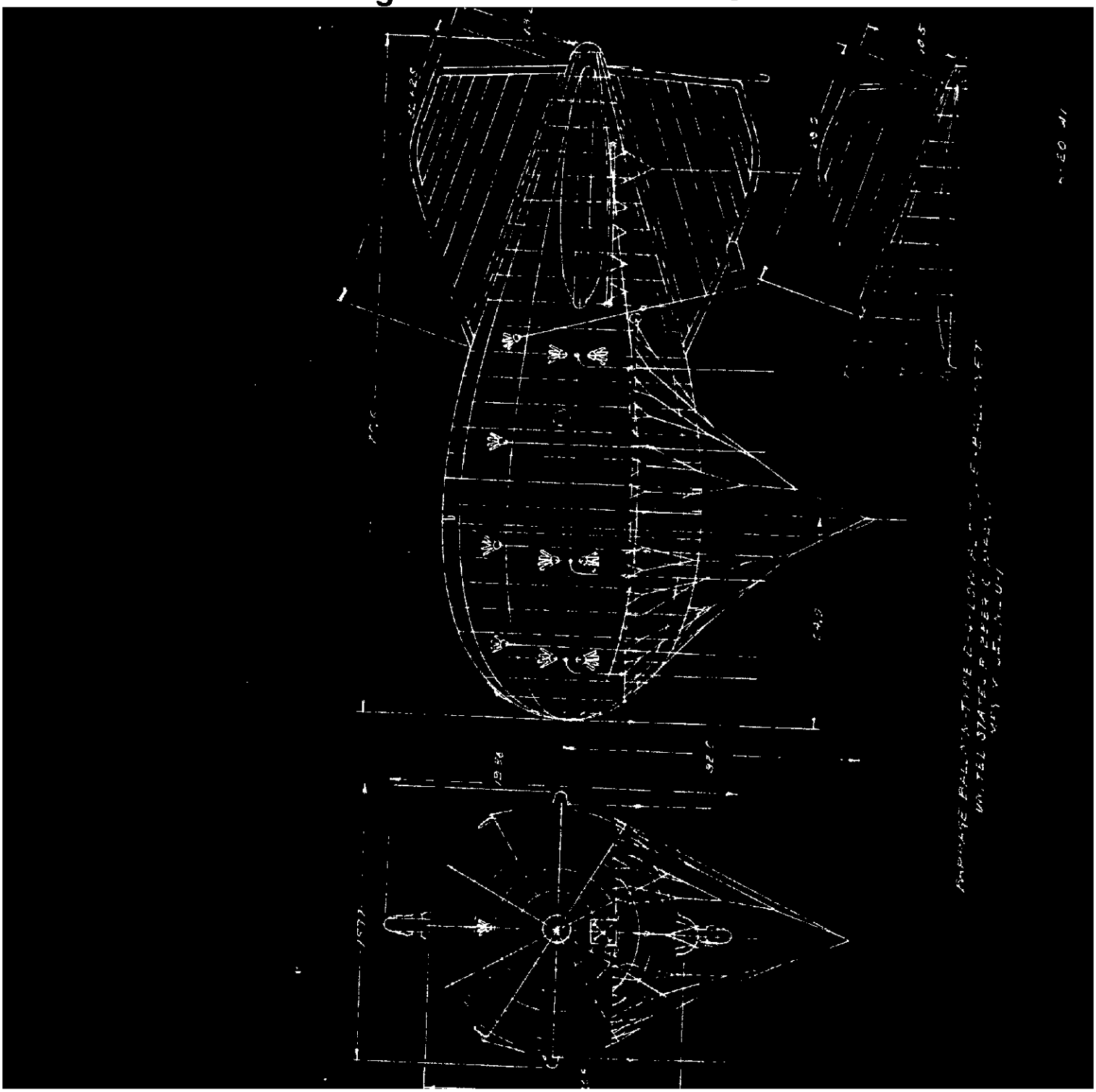


2. Rate of Ascent — 250 to 1200 ft./min.
3. Rate of Descent — 50 to 1000 ft./min.
4. Flight, wind speed, contractor guarantee — 50 m.p.h.
   Maximum operated to date
5. Flying Cable, diameter — 3/16 inch.
6. Inflation Gas — Helium or Hydrogen.
7. Trim Angle, static — 13 degrees.

Notes. a. Rate of ascent will vary as indicated depending on net lift, wind speed at balloon, and winch pay-out ability.
b. Rate of descent will vary as indicated depending on wind speed at balloon.

II. VOLUMES and WEIGHTS

1. Total Gas Displacement
   a. Basic Condition, ballonet 83.3% full, — 20,875 cu. ft.
   b. Full condition, ballonet empty — 28,000 cu. ft.
   c. Ballonet Capacity — 8,550 cu. ft.
2. Weights
   a. Balloon, complete. — 694 lbs.
   b. Ballast — 100 lbs.
   c. Gross — 794 lbs.



Date June 20, 1941

LLOON TYPE D-4 LOW ALTITUDE BALLONET

: General Tire and Rubber Co.

Model Spec.	A.C. Type Spec.	Quantity	Cost Each	Scheduled Contract Completion
G-155-A	R-2010-A	4	9760	July 23, 1941
G-155-B	R-2010-A	25	7700	Oct. 15, 1941

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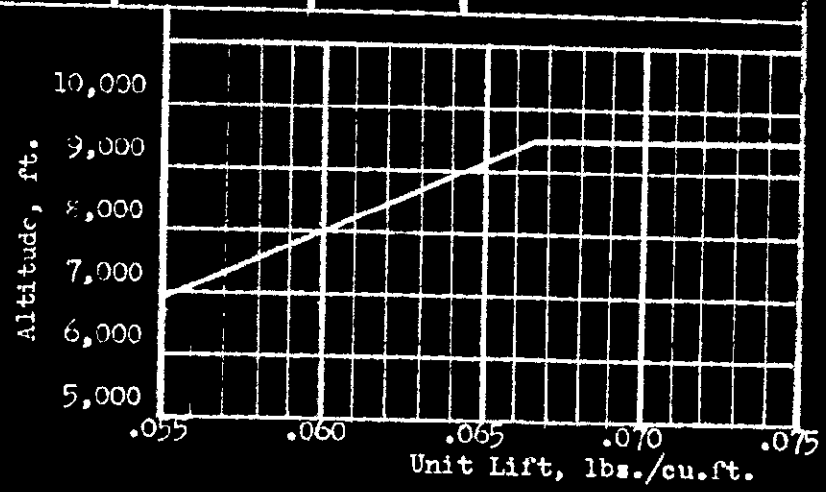
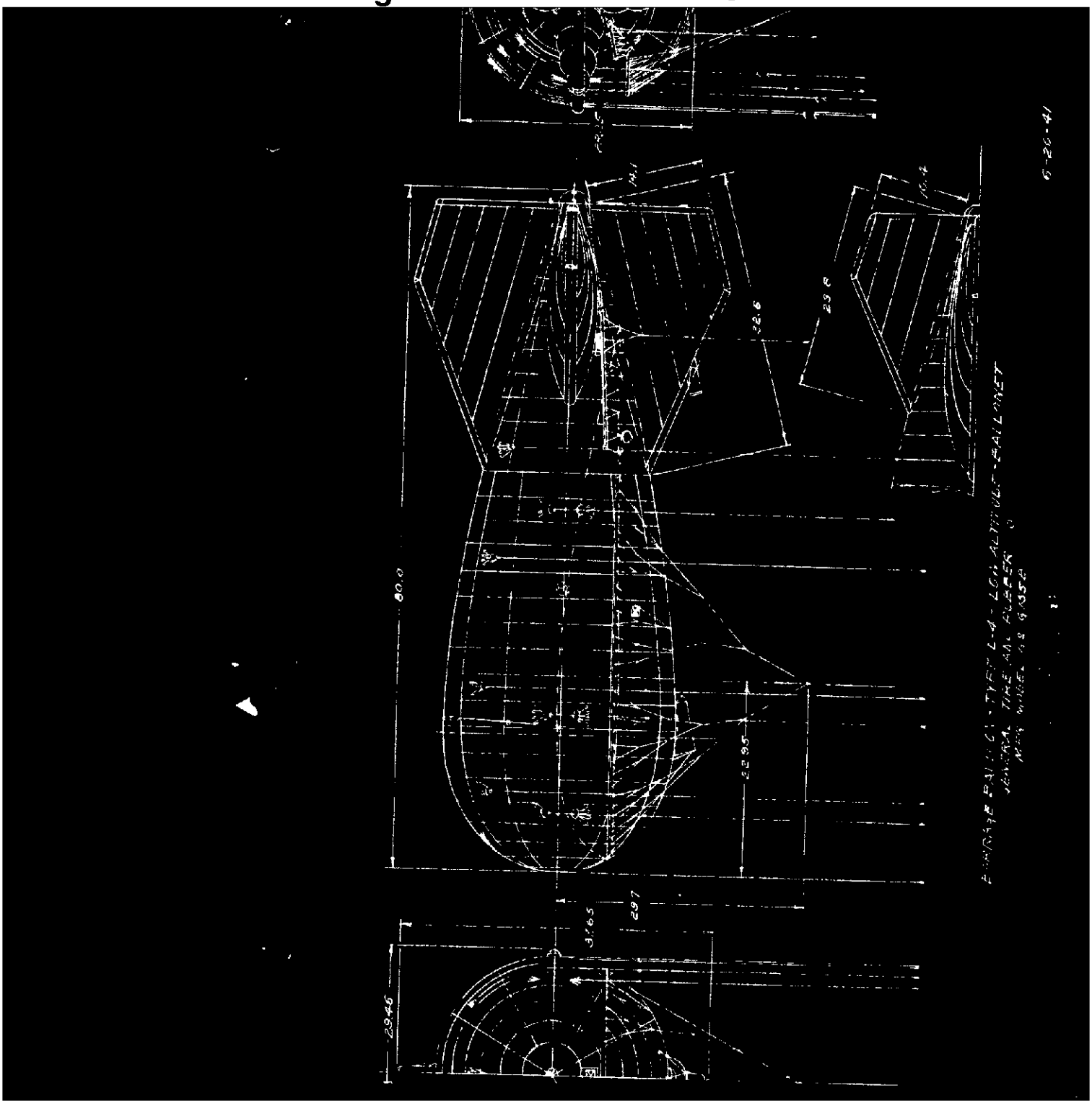


e of Ascent	250 to 1200 ft./min.
e of Descent	50 to 1000 ft./min.
ght, wind speed, contractor guarantee	50 m.p.h.
Maximum operated to date	56 m.p.h.
ing Cable, diameter	3/16 inch.
lation Gas	Helium or Hydrogen.
m Angle, static	13 degrees.

Notes. a. Rate of ascent will vary as indicated depending on net lift, wind speed at balloon, and winch pay-out ability.
b. Rate of descent will vary as indicated depending on wind speed at balloon.

and WEIGHTS.

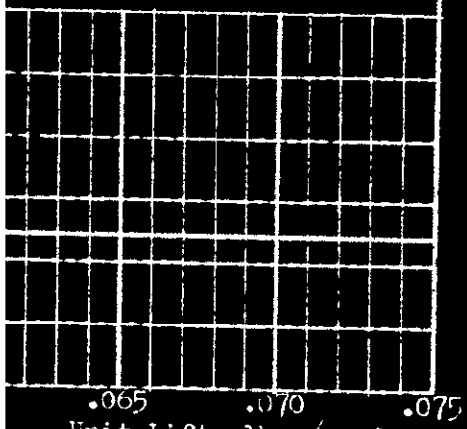
el Gas Displacement	
. Basic Condition, ballonet 83.3% full,	22,950 cu. ft.
. Full Condition, ballonet empty	30,600 cu. ft.
. Ballonet Capacity	9,180 cu. ft.
ghts	
. Balloon, complete	874 lbs.
. Ballast	40 lbs.
. Gross	914 lbs.



une 20, 1941

ABLE

Cost Each	Scheduled Contract Completion
9374.	Oct. 8, 1941
3515.	July 15, 1942

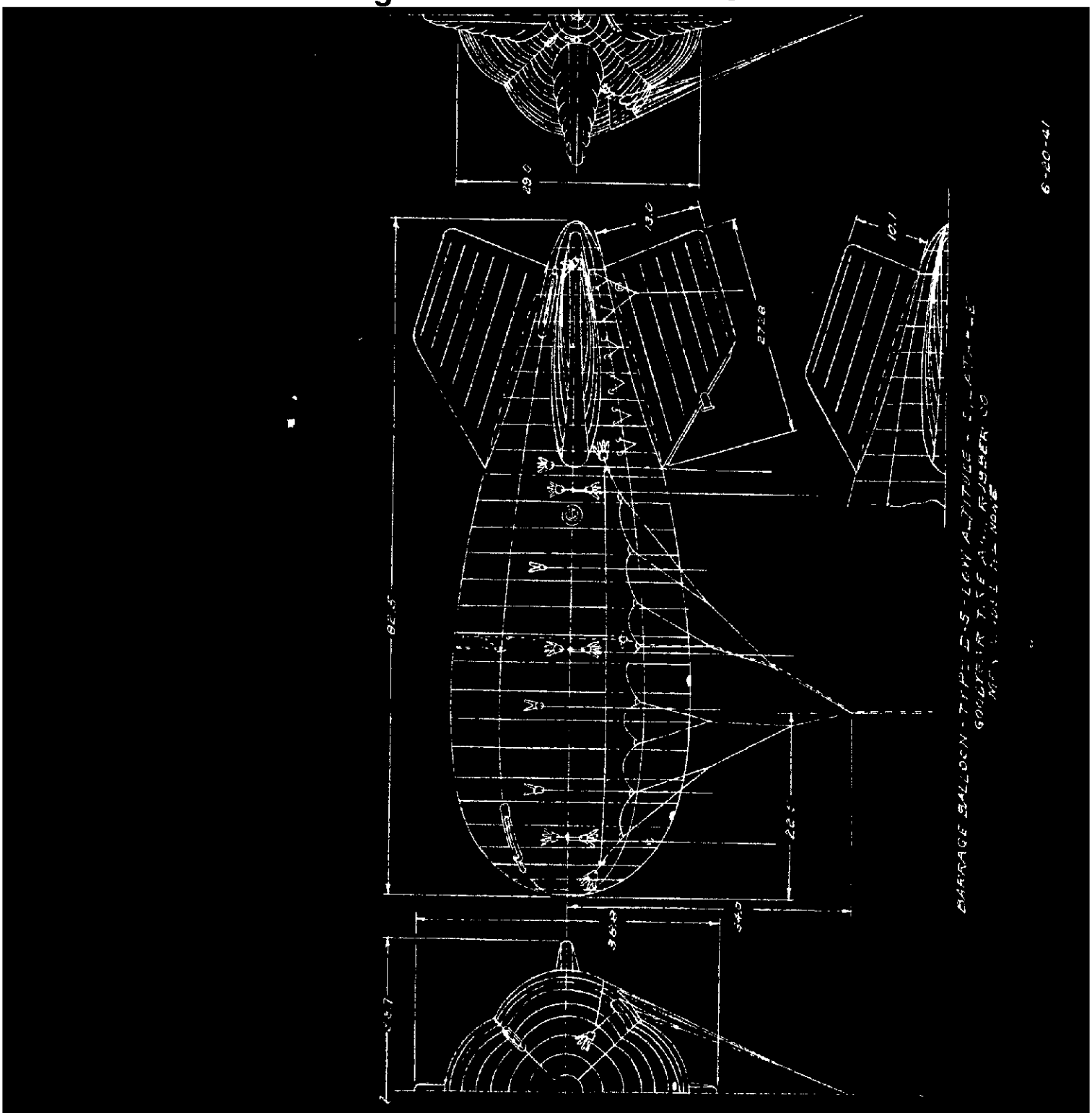


dicated depending
loon, and winch pay-out

ndicated depending on

24,400 cu. ft.
30,500 cu. ft.

920 lbs.
45 lbs.
965 lbs.



Date June 20, 1941

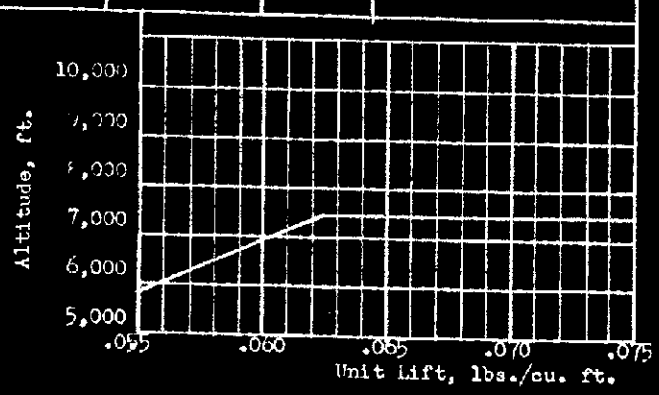
BARRAGE BALLOON TYPE D-6 LOW ALTITUDE DILATABLE

Contractor: Firestone Tire and Rubber Co.

Contract No.	Model Spec.	A.C. Type Spec.	Quantity	Cost Each	Scheduled Contract Completion
18073	B-1	R-2009-A	4	9130	July 31, 1941
19394	B-1, Rev. 1	R-2009-A	37	9413	Oct. 1, 1941

I. PERFORMANCE

1. Altitude (Still Air)

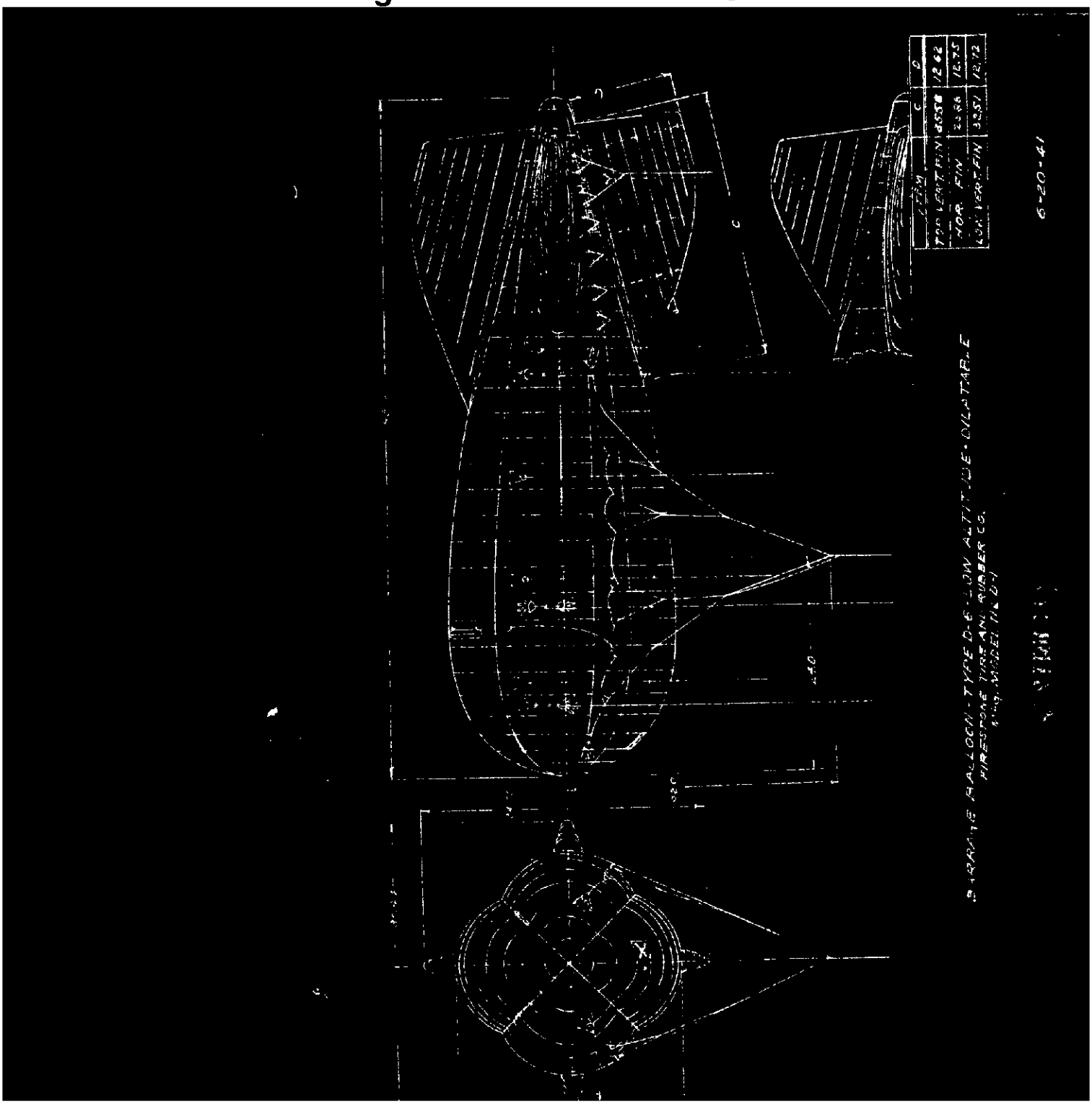


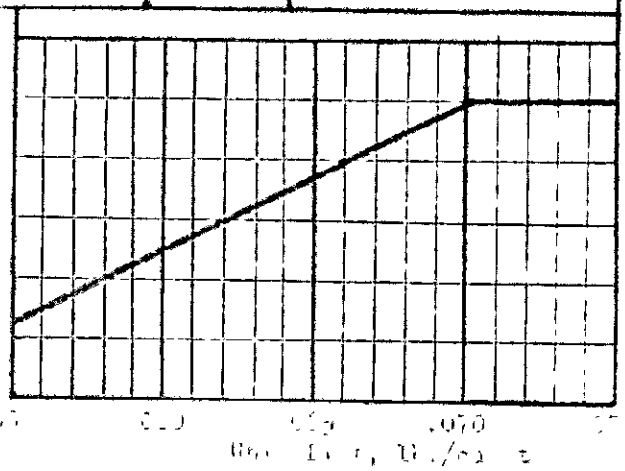
2. Rate of Ascent — 250 to 1200 ft./min.
3. Rate of Descent — 125 to 1000 ft./min.
4. Flight, wind speed, contractor guarantee — 50 m.p.h.
   Maximum operated to date — 51 m.p.h.
5. Flying Cable, diameter — 3/16 inch.
6. Inflation Gas — Helium or Hydrogen.
7. Trim Angle, static — 13 degrees.

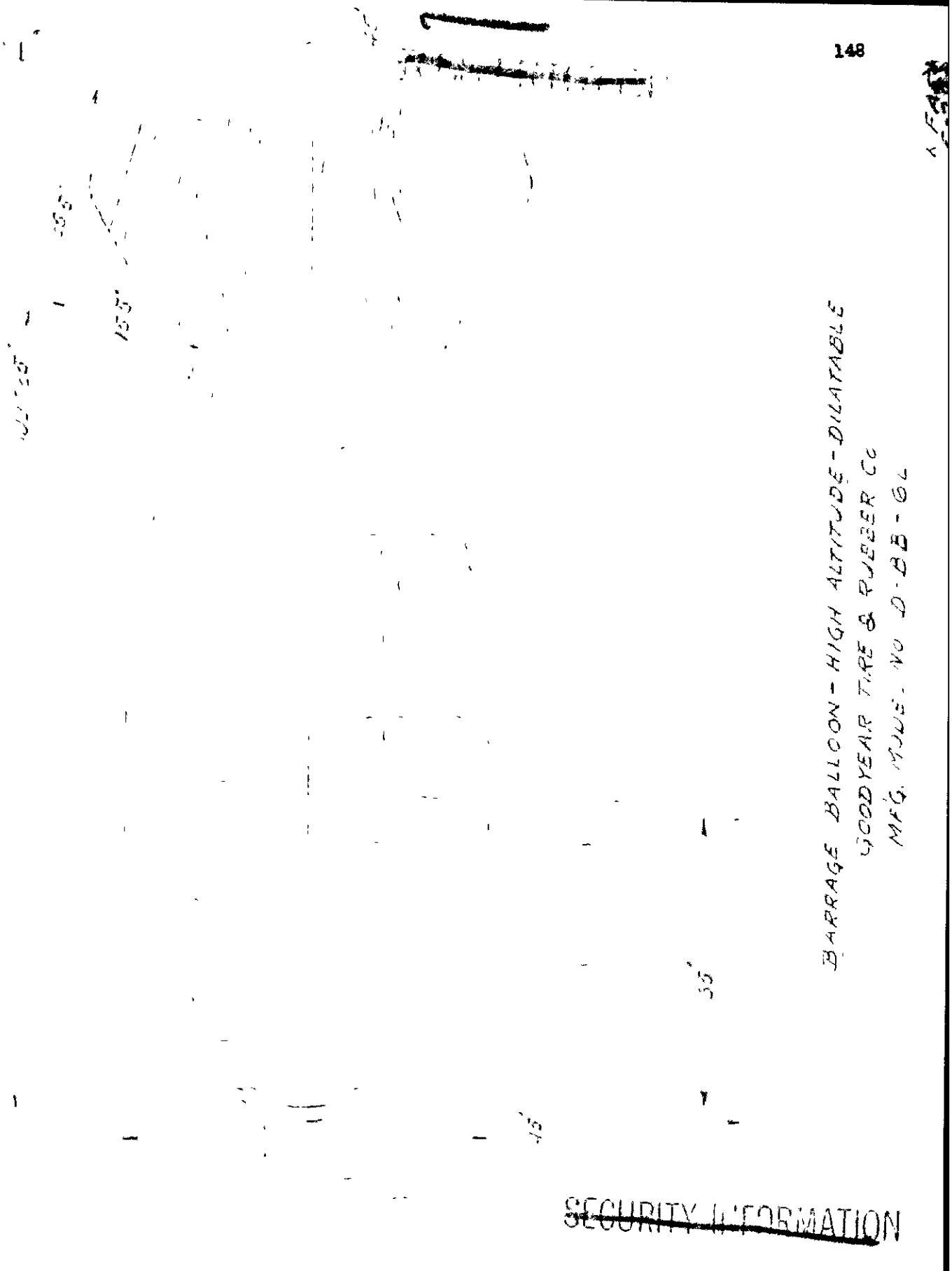
Notes. a. Rate of ascent will vary as indicated depending on net lift, wind speed at balloon, and winch pay-out ability.
b. Rate of descent will vary as indicated depending on wind speed at balloon.

II. VOLUMES and WEIGHTS

1. Total Gas Displacement
   a. Basic Dilation — 22,680 cu. ft.
   b. Full Dilation — 28,350 cu. ft.
2. Weights
   a. Balloon, complete — 920 lbs.
   b. Ballast — 40 lbs.
   c. Gross — 960 lbs.



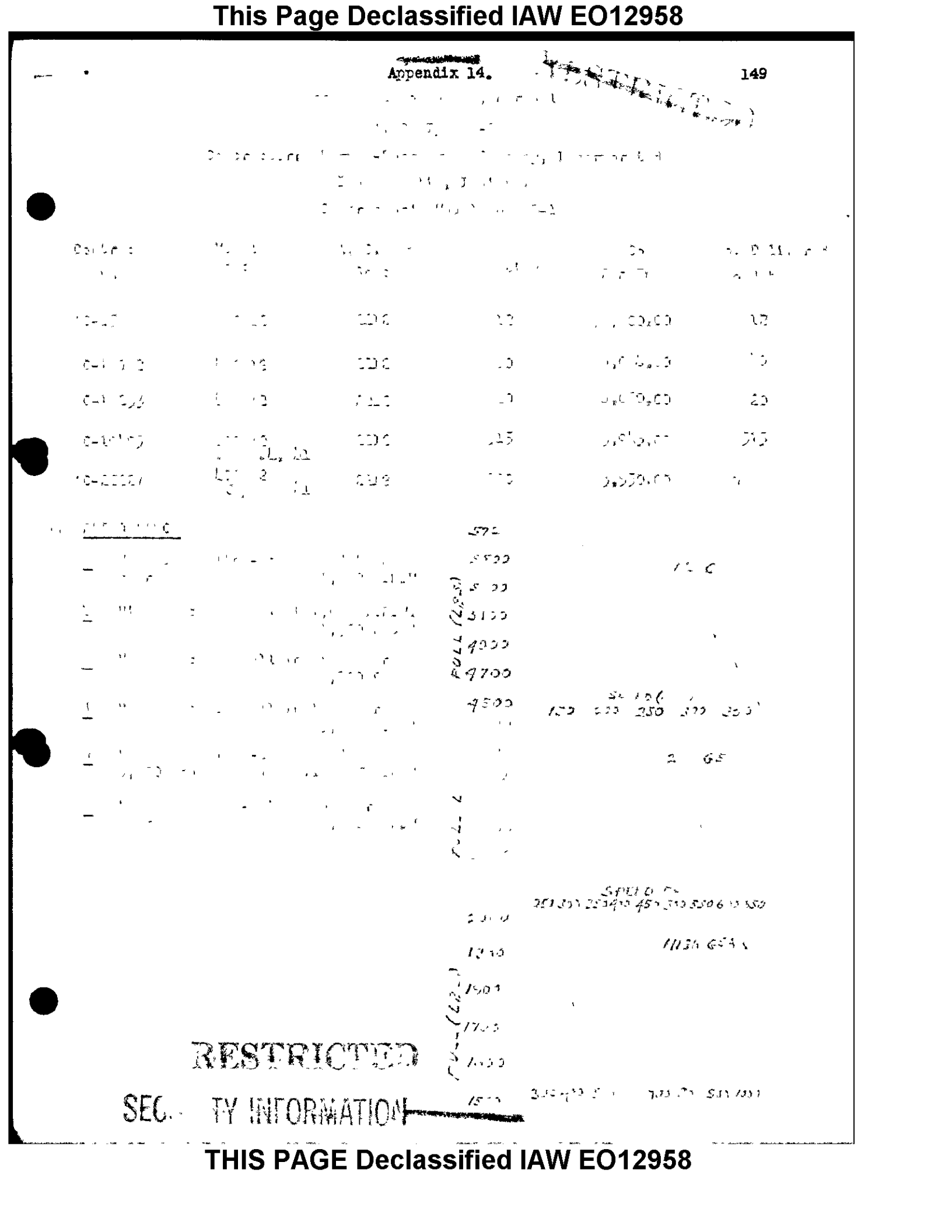




BARRAGE BALLOON - HIGH ALTITUDE - DILATABLE
GOODYEAR TIRE & RUBBER CO
MFG. MODEL NO D-BB-6L

SECURITY INFORMATION

RESTRICTED



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SECURITY INFORMATION

RESTRICTED

RESTRICTED

RESTRICTED

COST BREAKDOWN AND SUMMARY OF BARRAGE BALLOON EQUIPMENT PROCURED BY EXPERIMENTAL ENGINEERING

ITEM NO.**	ITEM	FUNDS			QUANTITY ORDERED		
		Set up A-11***	Obligated A-11	B****	Total Procured	CAC Receipts	Total for CAC
1.	Barrage Balloon, low altitude	21,824,000.00	22,567,798.00	6,639,259.84	3,524	2,737	3,374
2.	Barrage Balloon, high altitude	3,960,000.00	None	26,278.00	2	11	2
3.	Cable, Barrage Balloon, Low alt:	1,431,000.00	1,377,600.00	619,156.00	2,765	2,200	
4.	Cable, Barrage Balloon, High alt.:	518,400.00	None	5,396.00	2	10	2
9.	Generator, Hydrogen	750,000.00	607,698.20	212,428:80	36	30	33
20.	Truck, Winch	3,086,244.00	3,130,200.00	520,856.40	1,554	1,554	1,554
21.	Winch, Type A-9, low alt, portable	3,445,400.00	3,597,000.00	2,441,835.00	1,501	1,443	1,463
21.	Winch, Type A-9, low alt, portable:				204		
22.	Winch, Type A-11, low alt, mobile:	951,825.00	640,500.00	71,500.00	112	111	112
23.	Winch, Type A-10, high alt, portable:	1,548,000.00		85,750.00	10	10	10
24.	Trailers, Gas 80; Tractors 40	1,590,000.00	966,627.20	None	80	80	80
Misc.	Items (Barrage Balloon)	None	55,548.32	249,161.21			
		39,104,869.00	32,942,971.72	10,871,621.30*			

*$6,500,000.00 of the $10,871,621.30 of "B" funds obligated were advanced in 1941 from Project 82 pending

**Item number corresponds to that listed on pages 75 and 76 of the revised expenditure program pertaining to

***A-11 funds are included in revised expenditures program pertaining to regular national defense appropriation

****B funds pertain to research and development program.

TION, MATERIEL DIVISION, W. F. SUMMARY — Prepared April 1, 1942

	QUANTITY DELIVERED		COST OF NAVY DEPT. EQUIPMENT	REMARKS
al: or : CAC : Navy :				
ty :				
)	560	103	1,327,472.47	Funds set up for Items No. 2 and 4 were used to procure add. low alt. balloons.
he	2			
5	1,060	166	325,620.00	
he	2			
3	3	2	90,000.00	
he				
8	479	38	152,565.00	
		70		Letter of intent contract issued in sum of $724,200.00 pending receipt of Navy Funds
he	12			
he	10			
he	none			
			9,992.08	
			1,905,649.55	
			724,200.00	See Item No. 21. Letter of Intent Contract (AC-22227, Change #2, Serial No. 6421.
			2,629,349.55	

eipt of 1942 A-11 funds.

ular national defense appropriation F. Y. 1942.

Y. 1942 (Pages 75 and 76).

[redacted]

I N D E X

[redacted]

[redacted]

[redacted] RESTRICTED

[redacted] SECURITY INFORMATION

MEMORANDUM FOR THE COMMANDING GENERAL, ARMY AIR FORCES: (Office of the Assistant Chief of Air Staff, Intelligence; Attention: Chief, Historical Division)

Subject: Critique of "Barrage Balloon Development in the United States Army Air Corps, 1923 to 1942"

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UNCLASSIFIED

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