TM 11-2405

WAR DEPARTMENT TECHNICAL MANUAL

METEOROLOGICAL BALLOONS

WAR DEPARTMENT • 24 APRIL 1944

TM 11-2405
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TM 11:2405
1944

TECHNICAL MANUAL

METEOROLOGICAL BALLOONS

CHANGES No. 1

WAR DEPARTMENT
Washington 25, D. C., 13 April 1945

TM 11-2405, 24 April 1944, is changed as follows:

2. Types

* * * * * * *

b. PILOT BALLOONS.

* * * * * * *

(2) The larger pilot * * * grams (3.53 ounces). The balloon neck is made of relatively thick rubber, is about 2½ inches long, and is **½ inch or** 1½ inches in diameter. Pilot balloons are [illegible] and red (par. 4).

* * * * * * *

3. Definitions (Superseded)

a. FREE LIFT. Free lift is the actual upward force which causes the balloon to rise, and it is measured in ounces or grams. (A means of measuring free lift is provided by the selection of the proper cock or nozzle.)

b. TOTAL LIFT. Total lift is the gross upward force produced by the hydrogen in the balloon. It is equal to the sum of the free lift, the weight of the balloon, and the weight of the carried equipment, if any.

5. Sources of Hydrogen Gas

* * * * * * *

c. (Superseded) HYDROGEN GENERATOR ML-303/TM. Hydrogen Generator ML-303/TM is a cylinder 5 inches in diameter and 15 inches long, with a threaded opening at the top for attaching an outlet tube and a threaded opening at the base for attaching a calcium hydride charge can. Two differen types of charge are used with Hydrogen Generator ML-303/TM. Calcium Hydride Charge ML-304/TM or ML-304A/TM is a metal can containing enough calcium hydride to generate 6 cubic feet of hydrogen gas for the inflation of a 30-gram balloon. Calcium Hydride Charge ML-305/TM or ML-305A/TM contains enough calcium hydride to generate 24 cubic feet of hydrogen gas for the inflation of a 100-gram balloon.

Caution: Rescinded.

d. HYDROGEN GENERATOR SET AN/TMQ-3 (Added). Hydrogen Generator Set AN/TMQ-3 consists essentially of four Hydrogen Generators ML-303/TM (*c* above), Manifold ML-344/TM, four 6-inch lengths of Hose ML-81, and Case CY-219/TMQ-3. The manifold is a square, sheet-iron plate with a hole located in each corner to accommodate one Hydrogen Generator ML-303/TM. A tube, 11 inches long, is welded to the center of the plate and is provided with four branches located 7 inches above the plate. Each Hydrogen Generator ML-303/TM is connected to the center tube by means of Hose ML-81. Hydrogen Generator Set AN/TMQ-3 is used with four Calcium

*These changes supersede TB 11-2405-1, 18 May 1944, and TB SIG 100, 28 September 1944.

AGO 165C—Apr. 637403°—45

Hydride Charges ML–305/TM or ML–305A/TM or with Calcium Hydride Charges ML–305/TM or ML–305A/TM in combination with Calcium Hydride Charges ML–304/TM or ML–304A/TM to produce hydrogen gas necessary to inflate 350-gram balloons.

6. Shelter

*   *   *   *   *   *   *

b. INFLATION SHELTER S–13/TM (fig. 2). **Inflation Shelter S–13/TM is a** portable balloon inflation shelter made of 8-ounce canvas duck which is mildewproofed and waterproofed. The shelter is * * * 9 feet (fig. 2). **A D-ring is sewn to the canvas at the center of each side panel and the back panel. A 35-foot length of rope is provided to be cut into three lengths for threading through the D-rings and fastening to the corner stakes to prevent the sides and back from bowing inward.**

c. UNPACKING INFLATION SHELTER S–13/TM.

*   *   *   *   *   *   *

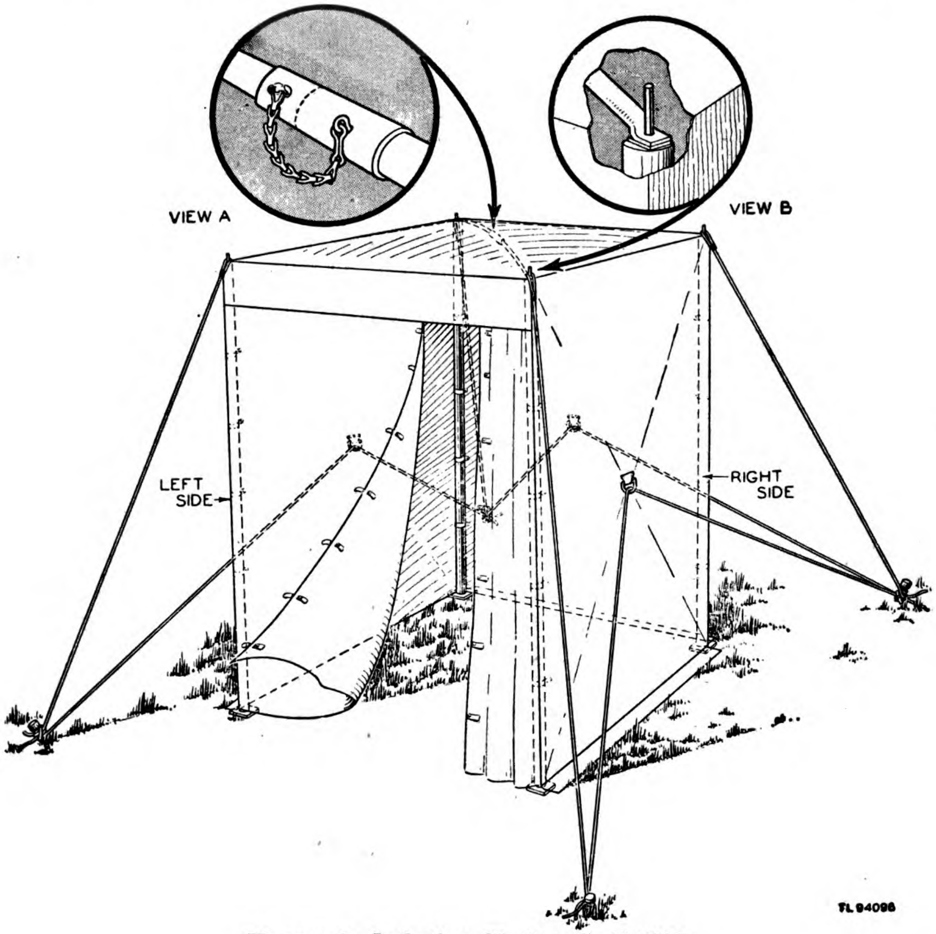

FIGURE 2. *Inflation Shelter S–13/TM.*

(4) Lift out the * * * wrapped around it. **The 35-foot length of rope for the D-rings is packed in the tent roll.**

*   *   *   *   *   *   *

FIGURE 3. *Inflation Shelter S–13/TM unfolded.*

d. Erecting Portable Shelter.

* * * * * * *

(12) **Cut three lengths of rope long enough to run from one corner stake through the D-ring on the side or back panel and to the other corner stake on the same side. Thread the ropes through the D-rings and tie the ends to the stakes just tightly enough to hold out the shelter walls (fig. 2).**

(13) Finally, make the * * * sides and back.

* * * * * * *

7. Preparation for Inflation

a. Balloon Temperatures. Warm a cold **rubber** balloon before inflation by gently kneading it between the hands, by holding it under the garments, or by keeping it in a warm place for a short period of time before use. (See par. 20 * * * warming neoprene balloons.)

***Note.*—Loose talc used for preservation of stored balloons should be dumped out of the balloon neck before inflation. The talc tends to clog nozzles and cocks.**

* * * * * * *

c. Preparation of Sources of Hydrogen.

* * * * * * *

(2) *Preparation of Generator ML–185–(&) (hydrogen), Hydrogen Generator ML–303/TM*, ***and Hydrogen Generator Set AN/TMQ–3.*** Full instructions for * * * with the equipment. Detailed information for the use of Hydrogen Generator ML–303/TM is contained in **TM 11–2413, 15 June 1944, which is packed with** the equipment. **Detailed instruction for the use of Hydrogen Generator Set AN/TMQ–3 is contained in the revised edition of TM 11–2413.**

Note (Supersedeed).—Hydrogen Generator ML–303KM and Hydrogen Generator Set AN/TMQ–3 are different from the other sources because they generate hydrogen *while* they inflate balloons.

d. Precaution. **HYDROGEN MIXED WITH AIR FORMS AN EXPLOSIVE MIXTURE. BE SURE TO OBSERVE THE FOLLOWING PRECAUTIONS:**

(1) Do not use hydrogen where there is likelihood of arcing from electrical apparatus, or in the neighborhood of open flames. Do not smoke in the vicinity of hydrogen.

(2) Ground the equipment so that any static electricity generated in the equipment can be dissipated to ground without danger of an electric spark which might ignite the gas. This may be done by connecting all metal parts of the equipment (from the cylinder or generator body to the hosecock or nozzle) to each other by wire, and to a well-grounded object, such as a cold water pipe. Use ground clamps or alligator clips to make the connections of wire to metal. Use sandpaper on the metal surface beforehand to insure a clean surface, which is necessary for a good connection. If a cold water pipe is not available, use the following procedure to obtain a satisfactory ground:

***(a)* Space two ground rods approximately 20 feet apart and drive the rods into the ground to a depth of approximately 4 feet.**

***(b)* Measure the resistance between these two rods with an ohmmeter.**

(*c*) If the resistance is 1,000 ohms or less, electrically connect the two rods and use the pair as the ground.

(*d*) If the resistance is greater than 1,000 ohms, drive another pair of rods into the ground to form two rows of rods with the distance between each rod in a row approximately 5 feet. Connect each row of rods electrically and measure the resistance between the two rows with an ohmmeter.

(*e*) If the resistance now is 1,000 ohms or less, electrically connect the two rows and use the combination as the ground.

(*f*) If the resistance still is greater than 1,000 ohms, drive additional rods in each row, still maintaining a distance of 5 feet between each rod and electrically connecting each rod to the others in its row, until the resistance between the rows measures 1,000 ohms or less. Then electrically connect the rows and use the combination as the ground.

(3) A charge of static electricity may be created on the clothing of personnel or on personnel themselves when heavy woolen or fur clothing is worn. To guard against this, wear a wrist band of metal which has a connected wire running to a well-grounded object ((2) above). For convenience, the wire running from the wrist band may end in a telephone plug which can be inserted in a jack which, in turn, is permanently grounded.

(4) Expel all air from a balloon before filling it with hydrogen.

(5) Do not wear shoes which have exposed nails which might strike against metal or concrete and create a spark. Handle iron tools with care so as not to create a spark when struck against other metal or concrete.

Caution: The generation and use of hydrogen is inherently dangerous and only by exercising extreme care can the dangers of fire or explosion be minimized.

e. CAPACITY OF BALLOONS. The average volume of gas required for inflation of meteorological balloons, at normal sea level pressure and at a temperature of about 70° F., is as follows:

Type of balloon	*Cubic feet*
* * *	* * *
100-gram pilot balloon	21.2
* * *	* * *

The cubic foot scale on the hydrogen regulator should not be used to measure inflation, however, because the scale is not sufficiently accurate.

8. Inflation Ceiling Balloons

* * * * * * *

e. Slowly open the * * * to avoid overinflation. When the balloon just lifts Nozzle ML–186 off of the supporting surface, immediately close the regulator valve, for exactly at this point the balloon is inflated to the desired free lift of 40 grams. (Nozzle ML–186 * * * weighs 1 gram.)

* * * * * * *

Figure 4, change legend: ① *Hose ML81* to read "① *Hose ML–81.*"

9. Inflating Pilot Balloons

a. THIRTY-GRAM BALLOONS.

* * * * * * *

(2) *Inflating with Generator ML–185–(&) or Hydrogen Generator ML–303/TM.*

* * * * * * *

(*b*) To inflate balloon with Generator ML–185–(&), or with Hydrogen Generator ML–303/TM, refer to the instructions packed with the equipment.

* * * * * * *

On Figure 6, change "HYDOGEN CYLINDER" to read: "HYDROGEN CYLINDER."

10. Inflating Sounding Balloons (fig. 7)

NOTE (Added).—Following is the procedure for inflating sounding balloons from a cylinder of hydrogen. Information about using Hydrogen Generator ML–185–(&) for inflation of sounding balloons is contained in TM 11–2400; information about using Hydrogen Generator Set AN/TMQ–3 for inflation of sounding balloons is contained in the revised edition of TM 11–2413.

a. **Determine proper nozzle weight.**

(1) Nozzle ML–196 **(fig. 4②)** alone weighs 1,500 grams, but it is furnished with several separate weights of 100-, 200-, 400-, and 500-gram sizes which can be added to obtain a nozzle weight of 1,500 to 2,700 grams in 100-gram steps. Enough of these separate weights must be added to Nozzle ML–196 so that its total weight **equals the free lift required plus** the weight of the equipment which the sounding balloon will carry aloft. The following list * * * the extra loading.

(2) As an example * * * grams in all. Since the basic portion of Nozzle **ML–196** weighs only 1,500 grams, 800 grams must be added by using a 500-gram, a 200-gram and a 100-gram weight. The 2,300-gram * * * obtain proper inflation.

* * * * * * *

(*b*) During high winds * * * in this example. If a ballast balloon of lesser weight than **400** grams is used, a free lift of either 400 or 500 grams should be computed, based upon the individual's own judgment.

b. Insert the vertical spout of Nozzle ML–196 into the neck of the sounding balloon, **first making sure that the air is expelled from the balloon.**

* * * * * * *

14. Night Use of Pilot Balloons

* * * * * * *

b. LIGHTING UNITS.

* * * * * * *

(1) *Battery light unit.*

* * * * * * *

(*a*) *Preparing parachute.* Locate the cord * * * when suspended (fig. 12). **Parachutes are now being manufactured with the center cord already loose and the parachute ready for use.**

* * * * * * *

15. Use of Balloons During Precipitation

a. PILOT BALLOONS (Superseded). Rain, snow, or sleet decreases the rate of rise of the balloon and results in inaccurate observations. For this reason no pilot balloon flights are recommended during precipitation.

* * * * * * *

16. Rate of Ascent

* * * * * * *

a. CEILING BALLOONS.

* * * * * * *

(3) In some cases, an entirely different method, such as a pilot's report, **or double theodolite measurement,** should be used. For example, if * * * balloon is required.

* * * * * * *

c. ONE-HUNDRED-GRAM PILOT BALLOONS. The 100-gram pilot balloon rises at a rate of approximately **320 to** 330 yards per minute and consequently requires less time than the 30-gram balloon for high altitude flight. The 100-gram balloon travels faster during the first 14 minutes of flight. The corrections to be added, **using 320 yards per minute as the average basic rate of rise,** for the first 14 minutes are 22, 19, 19, 16, 16, 12, 12, 8, 8, 6, 3, 3, and 3 percent, respectively. **Altitudes of 100-gram pilot balloons at the end of each minute of flight are contained in TM 11–2411.**

* * * * * * *

16.1. Normal Bursting Altitudes (Added)

The normal bursting altitudes given in this paragraph are the altitudes with neoprene balloons at about 40° N. latitude in the spring of the year. It may be found that lower altitudes are obtained in arctic regions, higher altitudes in tropic regions; lower altitudes in winter, higher altitudes in summer. For this reason, the figures quoted should serve only as a guide. Also, since some lots of balloons contain a few "duds", it is not expected that *all* balloons will reach the normal bursting altitudes.

a. THIRTY-GRAM BALLOON. Balloons ML–50–A, ML–51–A, ML–64–A, ML–155–A, and ML–156–A will normally burst at 30,000 feet when rising at a rate of about 600 feet per minute and carrying no load.

b. ONE-HUNDRED-GRAM BALLOON. (1) *Pilot.* Balloons ML–159–A, ML–160–A, and ML–161–A have a normal bursting altitude of 45,000 feet when rising at a rate of about 1,000 feet per minute and carrying no load.

(2) *Radar target.* A 100-gram balloon for carrying Radar Target ML–350/AP aloft is inflated so that, considering the wind prevailing at the time of release, the balloon will attain the highest possible altitude before passing out of the range of the radar set. For average prevailing wind in the temperate zones a free lift of 1,100 grams usually is satisfactory for this purpose.

c. THREE-HUNDRED AND FIFTY-GRAM BALLOON. (1) *Radiosonde,* Balloons ML–131–A, inflated to carry radiosonde aloft have average bursting altitudes which decrease as the rate of ascent increases. The following average bursting altitudes for different rates of ascent have been found for properly treated balloons:

Rate of ascent feet per minute	*Bursting altitude feet*
600	63,000
1,000	58,000
1,200	53,000

(2) *Radar target.* A 350-gram balloon for carrying Radar Target ML–307–A/AP or ML–307–B/AP aloft is inflated so that, considering the wind prevailing at the time of release, the balloon will attain the highest possible altitude before passing out of the range of the radar set. For average prevailing wind in the temperate zones a free lift of 1,700 grams usually is satisfactory, which will carry the balloon to an altitude of about 50,000 feet while it is still in the range of the radar set. In general, it has been observed that for a given amount of free lift, a 350-gram balloon for carrying a radar target aloft has a bursting altitude slightly less than the bursting altitude of a 350-gram balloon for carrying radiosonde aloft.

17. Care of Cocks and Nozzles (Superseded)

a. General. Nozzles ML–186 and ML–196 require no special maintenance because of the large air passage through them. No lubrication is required on the nozzles, since there are no moving parts. However, Cocks ML–56 and ML–201–A *do* require special maintenance and lubrication when used with Hydrogen Generator ML–303/TM. Any accumulation of dirt or foreign matter in the opening of the cock causes a constriction of the passage and prevents a free flow of hydrogen through the cock. The low pressure of Hydrogen Generator ML–303/TM is not sufficient to blow the obstruction out of the cock or to inflate the balloon if the passage is badly constricted. The same condition prevails if the stopcock is not completely opened while inflating a balloon. To prevent this condition, give special attention to keeping the stopcock passages open and unobstructed.

b. Causes of Obstruction. (1) *Talc.* Talc, placed on the inside of meteorological balloons to prevent sticking of the rubber, tends to clog the cocks used for inflation.

(2) *Grease.* Dirt and dust adhere to grease used for lubrication of the stopcock. The combination of grease and dirt obstructs the opening.

(3) *Lime.* Sometimes an accumulation of hardened lime appears in the cock. The caked lime is a chemical byproduct of air and the solution resulting from the generation of gas.

(4) *Dirt or dust.* Careless handling or unusual weather conditions, such as floods or dust storms, may cause an accumulation of foreign matter in the opening of the cock.

c. Cleaning Cocks ML–56 and ML–201–A. (1) *Inspection.* Check the cocks frequently to see that the openings are unobstructed and that they permit a free flow of hydrogen. The cocks will operate properly, if it is possible to blow through them freely, when the stopcocks are completely open.

(2) *Disassembly.* To disassemble Cocks ML–56 and ML–201–A, remove the screw at the bottom of the stopcock and pull out the stopcock.

Note.—When Hydrogen Generator ML–303/TM is used, the cocks should be examined daily or oftener if experience shows it to be necessary.

(3) *Cleaning*. (*a*) If there is an accumulation of hardened lime or other caked material in the cock opening, loosen it with a stiff wire. Knock the loosened foreign material out of the cock by hitting the cock opening down into the palm of the hand. Wash the cock in clear water.

(*b*) If an excess of grease is present, remove it with Solvent, Dry-Cleaning, Federal Spec. No. P–S–661a.

(4) *Reassembly*. Insert the stopcock into the cock in its former position and tighten the screw.

d. LUBRICATION. (1) The following table lists the lubricating material recommended for servicing Cocks ML–56 and ML–201–A:

Approved symbol	Standard nomenclature	Specification No.
GA	Graphite	U. S. Army 2–64A.
PS	Oil, Lubricating, Preservative, Special.	U. S. Army 2–120.
SD	Solvent, Dry Cleaning	Federal P–S–661a.

(2) Periodic lubrication of cocks is not required. Lubricate only after accumulated dirt and grease have been removed.

(3) When lubrication is necessary, use powdered graphite (GA) in small amounts.

(4) If powdered graphite (GA) is not available, apply a small amount of special preservative lubricating oil (PS). Too much oil, combined with dirt, is likely to form a greasy mass obstructing the free flow of hydrogen.

18. Storage of Rubber Balloons

a. Keep **rubber** balloons in their original, sealed containers, and store them in a cool, dry, dark place until needed for use. ***Rubber*** *balloons deteriorate in high temperature.* Provide special storage * * * shape when inflated.

* * * * * * *

20. (Superseded) Storage and Use of Neoprene Balloons

a. GENERAL. Neoprene balloons require different conditions of storage and use than *natural rubber balloons require.*

(1) Neoprene balloons can be identified by the nomenclature which is the same as for a rubber balloon of the same weight and color, except that a suffix "A" is placed after the nomenclature. For example, Balloon ML–131–A is made of neoprene, while Balloon ML–131 is made of natural rubber.

(2) Neoprene balloons have been found to burst prematurely if subjected to low or moderate temperatures in transit or in storage. Even 6 months' storage at 70° F. will reduce the maximum obtainable bursting altitude. *Neoprene balloons can be reconditioned. This is done by heating the balloon.*

b. STORAGE. Neoprene balloons should be stored in their original containers at a temperature of about 85° F. This storage temperature is not critical. Storage for several months at temperatures between 40° F. and 120° F. is permissible. Balloons stored at a temperature near 40° F. will require reconditioning, but if they are stored at a temperature near 100° F., reconditioning may not be necessary.

c. RECONDITIONING NEOPRENE BALLOONS. The technique described in this paragraph has given the best results, and will be used in the field. The treatment consists of boiling in water for 5 minutes, as follows:

(1) Prepare the balloon for heat treatment by first removing any air that may be inside. Expel the air either by rolling up the balloon or by sucking the air out of the balloon neck. Double the balloon neck and tie it tightly with a shoelace or a cloth ribbon. In the case of thin-necked 30-gram balloons, stretch the neck over a tube or wooden cylinder, 1¾ inches in diameter, and tie the neck over the cylinder. The reason for tying the neck is twofold: first, it prevents air from entering the balloon, making it easier to keep the balloon submerged in the boiling water; and second, it prevents water entering the balloon.

(2) The container in which the balloon is boiled should be about the size of a 4-gallon pail. A 5-gallon oil can or a gasoline can will serve the purpose very well. Carefully eliminate all sharp edges, so that the balloon will not be punctured. Remember that a heated balloon becomes extremely soft and may be easily damaged, even by a fingernail.

(3) While the water is boiling, keep the balloon submerged in the water. A stick with a handkerchief wrapped around the end may be used to keep the balloon submerged. It is not necessary to keep the neck of the balloon under water. Take care that the balloon does not touch the portion of the container where the heat is applied, since this may cause the balloon to be damaged by overheating. Keep the balloon moving in the water to insure its being heated uniformly. After boiling for 5 minutes, remove the balloon from the water.

(4) If boiling the balloon is impossible, any heating will help, even if it will not totally recondition the balloon. The balloon may be placed over a radiator, near the field stove, or wrapped around an electric light bulb with insulation between the bulb and the balloon to prevent heating above 212° F. Another alternative is to lay the balloon on the cooler part of Generator ML–185–(&) when hydrogen is being generated and when the temperature is below 212° F. These alternatives shall be used only if boiling water is unobtainable.

d. CARE AND INFLATION. Neoprene balloons become very fragile when warm or wet. Always handle them carefully to avoid abrasion, tearing, etc. When using Balloon ML–131–A, it is recommended that equipment, parachute, and line be prepared and ready to be tied to the balloon before the balloon is inflated. This sounding balloon may be allowed to dry, or may be inflated while still wet if it is not freezing outdoors. Pilot balloons *must* be dry before inflation in order to obtain correct lifts. Balloons may be dried in a warm room or near a field stove. Inflate and release balloons as soon as possible after reconditioning to prevent subsequent "refreezing."

e. SUMMARY. (1) Neoprene balloons perform poorly when subjected to cold (40° F.) for a short period or to moderate temperatures (70° F.) for a longer period.

(2) Neoprene balloons may be reconditioned by heating, preferably for 5 minutes in boiling water.

(3) Neoprene balloons are fragile and must be handled carefully.

22. List of Balloons and Associated Equipment

* * * * * * *

Signal Corps stock No.	Item	Function	Color	Weight		Dimensions and remarks
				Grams	Ounces	
*	*	*	*	*	*	*
7A179	Balloon ML-159—(*)	Pilot	White	100	3.53	Spherical, 16-in. diameter; neck 2½–3 in. long, ½ in. or 1½ in. diameter.
7A180	Balloon ML-160—	Pilot	Black	100	3.53	Spherical, 16-in. diameter; neck 2½–3 in. long, ½ in. or 1½ in. diameter.
7A181	Balloon ML-161—	Pilot	Red	100	3.53	Spherical, 16-in. diameter; neck 2½–3 in. long, ½ in. or 1½ in. diameter.
*	*	*	*	*	*	*
7A1207-100	Parachute (miniature).	Used with lighting unit.		4	0.14	Paper, approximately 16-in. diameter.
*	*	*	*	*	*	*

23. Maintenance Parts for Inflation Shelter S–13/TM (Added)

The following information was compiled on 3 March 1945. The appropriate section of the ASF Signal Supply Catalog for Inflation Shelter S–13/TM is:

SIG 10–900.1, Inflation Shelter S–13/TM, Fixed Plant Maintenance List (when published).

For the latest index of available catalog sections, see ASF Signal Supply Catalog SIG 2.

[AG 300.7 (9 Dec 44)]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL
Chief of Staff

OFFICIAL:
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Refer to FM 21–6 for explanation of distribution formula.

U. S. GOVERNMENT PRINTING OFFICE: 1945

WAR DEPARTMENT TECHNICAL MANUAL

TM 11-2405

METEOROLOGICAL

BALLOONS

WAR DEPARTMENT • 24 APRIL 1944

United States Government Printing Office
Washington : 1944

WAR DEPARTMENT,
WASHINGTON 25, D. C., 24 April 1944.

TM 11-2405, Meteorological Balloons, is published for the information and guidance of all concerned.

[A. G. 300.7 (22 Mar 44).]

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G. C. MARSHALL,
Chief of Staff.

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For explanation of symbols see FM 21-6.

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CONTENTS

DESTRUCTION NOTICE

WHY—To prevent the enemy from using or salvaging any of this equipment for his benefit.

WHEN—When ordered by your commander.

HOW—1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools, etc.
2. Cut—Use axes, handaxes, machetes, etc.
3. Burn—Use gasoline, kerosene, oil, flame throwers, incendiary grenades, etc.
4. Explosives—Use firearms, grenades, TNT, etc.
5. Disposal—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT

WHAT—1. Smash—Generators, tanks, couplings, hosecocks, nozzles, lighting units, etc.
2. Cut—Balloons, tubing, parachutes, etc.
3. Burn—Technical Manuals, balloons, lanterns, parachutes, etc.
4. Bury or scatter—Any or all of the above pieces after breaking.

DESTROY EVERYTHING

SAFETY NOTICE

Hydrogen mixed with air forms a very explosive mixture that needs only a small flame or spark to cause it to explode violently. Do not smoke or strike matches near hydrogen. Make sure that all electrical contacts are tight to avoid electric arcing. Place caution signs in conspicuous positions in the area.

SECTION I

DESCRIPTION

1. General

Meteorological balloons are used to determine the direction and speed of winds aloft, to determine the height of clouds, and to carry aloft equipment which will take soundings of the temperature, humidity, and pressure of the upper air. The symbol (&), found in paragraph 5*b*, refers to all models of procurements of the Generator ML–185 series.

2. Types

Three types of balloons are used in meteorological work; ceiling balloons, pilot balloons, and sounding balloons. When in use, all three types are inflated with hydrogen gas.

a. CEILING BALLOONS. Ceiling balloons are small balloons which ascend at an average rate of 360 feet per minute after the first 1½ minutes (par. 16*a*). They are used in the daytime to determine the cloud heights whenever the ceiling is approximately 2,500 feet or less. Ceiling balloons are supplied in two colors, in red and in a dark color (black, dark blue, or purple to contrast with the color of the sky at the time of observation (par. 4). Ceiling balloons, before inflation, are approximately 3½ inches in diameter and weigh about 10 grams (0.35 ounce). The balloon neck is about 2 inches long and approximately 1 inch in diameter.

b. PILOT BALLOONS. Pilot balloons are used to determine the direction and speed of the wind in the upper air and to determine cloud heights at night if a ceiling light projector is not available. Pilot balloons are supplied in two sizes.

(1) The smaller pilot balloons (fig. 1) are approximately 6 inches in diameter before inflation and weigh about 30 grams (1.06 ounces). The balloon neck is about 2½ inches long and 1½ inches in diameter. The balloon is of one-piece seamless construction. Thirty-gram pilot balloons are inflated to ascend at a constant rate of about 200 yards per minute (par. 16*b*) and are used for low-level observation (up to 30,000 feet). They are supplied in the following colors: white or uncolored, a dark color (black, dark blue, or purple), red, orange, and yellow to contrast with the condition of the sky at the time of observation (par. 4).

(2) The larger pilot balloons are approximately 16 inches in diameter before inflation and weigh about 100 grams (3.53 ounces). The balloon neck is made of relatively thick rubber, is about 2½ inches long, and is 7/16 inch to 1½ inches in diameter. Pilot balloons

are of one-piece seamless construction. Some 100-gram balloons have a mold mark near the center, but this does *not* weaken the balloon. The balloons are designed to ascend at a rate of approximately 330 yards per minute. Since they ascend faster than the smaller balloons, the 100-gram balloons are used when observations are of short duration or whenever an observation of the higher level is desired without increasing the time of observation. They are supplied in three colors; white, black, and red (par. 4).

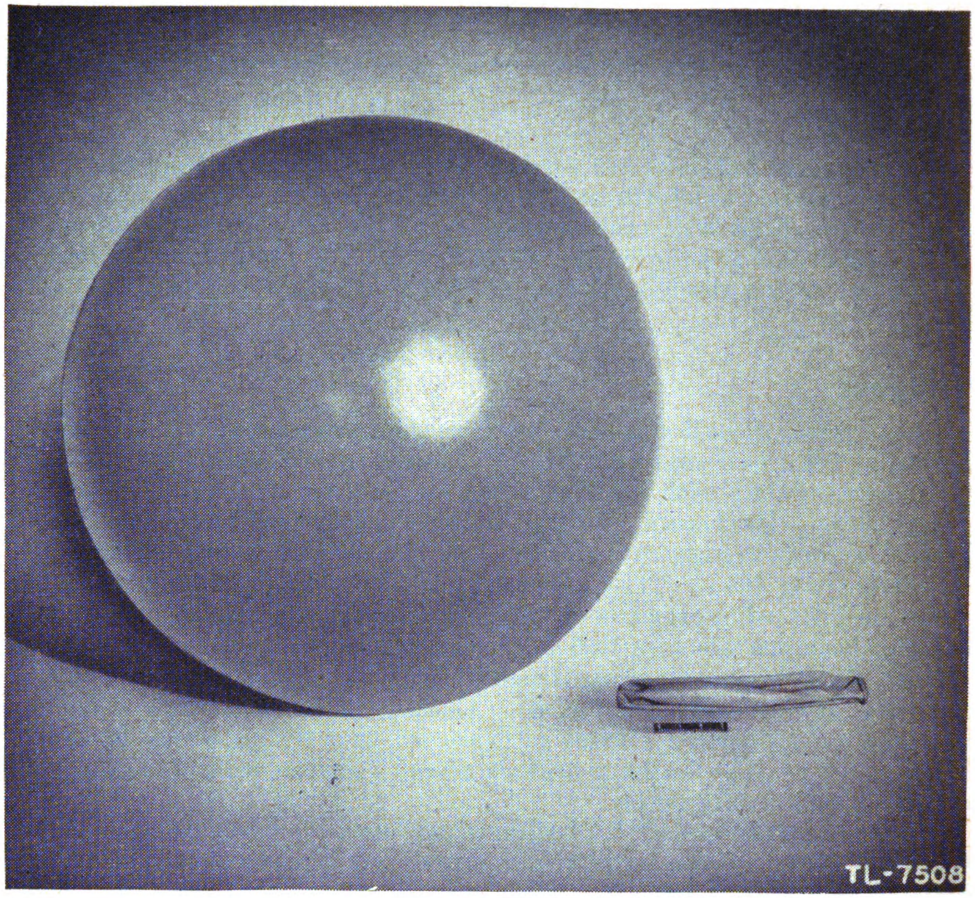

FIGURE 1. *Thirty-gram pilot balloon, inflated and deflated.*

c. SOUNDING BALLOONS. Sounding balloons are larger than ceiling and pilot balloons because they are designed to carry aloft sounding equipment. The average sounding balloon is 2 to 3 feet in diameter before inflation, weighs approximately 350 grams (¾ pound), and has a neck about 4½ inches long and 1 inch in diameter. Sounding balloons are always white since their visibility in the sky is not important. Usually, sounding balloons carrying meteorological instruments are inflated to ascend at a rate of about 450 to 600 feet per minute and will reach altitudes in excess of 50,000 feet before they burst (par. 16*d*).

3. Definitions

a. Balance. When a balloon is inflated just enough to float in the air at release, without rising or falling, it is balanced.

b. Free Lift. Free lift is the force required to raise the balloon and its equipment over and above the point of balance and is measured in pounds, ounces, or grams. When a balloon has reached the point of balance, any additional gas will cause it to rise at a *definite rate*. As gas is added, the rate of ascent will increase.

c. Total Lift. Total lift is free lift plus the weight of the balloon and any equipment it will carry in flight.

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SECTION II

INSTALLATION AND OPERATION

4. Selection of Color of Balloon

The appearance of the sky at the time of observation determines the color of the balloon which is to be used.

a. White or Uncolored Balloons. Use the white or uncolored balloon when the sky is clear. A white or uncolored balloon is observed satisfactorily even when there is light dust, light smoke, light fog, or haze in the lower layers of the atmosphere and when only a few clouds which are not increasing are present. In the upper regions, the balloon will appear as a pin point of reflected sunlight (*d* below).

b. Black Balloons. The black balloon stands out most clearly in an overcast sky with thick or thin clouds or a dense haze aloft. Regardless of other sky conditions, a black balloon will give the best results in the early morning at sunrise or in the late evening at sunset (when the sky is still sufficiently bright to make the use of a night light unnecessary).

c. Red Balloons. Use a red balloon when the sky is partly cloudy and provides either a blue or a cloudy background. Use the red balloon when conditions are indefinite or changeable.

d. Yellow and Orange Balloons. The yellow or orange balloon is best used when very thin cirrus clouds or a haze partially covers the sky. Some observers prefer a yellow balloon to a white one when the sky is clear, and some observers prefer an orange balloon to a red one in a partly cloudy situation.

e. Summary. Color sense varies with individuals; the observer should experiment to determine whether his color perception is different from that outlined above. Learn to use balloon colors to the best advantage. The general rule is the darker the sky, the darker the color of the balloon to be used.

5. Sources of Hydrogen Gas

Meteorological balloons are inflated with hydrogen gas from one of the following sources:

a. Cylinder Filled with Hydrogen. The usual hydrogen cylinder contains about 190-cubic feet of hydrogen gas at sea-level pressure and at a temperature of 70° F. Excess heating from any source will produce increased pressure of the gas within the container and will result in a false lift measurement. Keep the container in the place where the balloon is to be inflated since the gas inside the balloon must be at the same temperature as the air in which the balloon is weighed off. Keep hydrogen cylinders out of the sun.

b. GENERATOR ML–185–(&). Generator ML–185–(&) generates from 90 to 100 cubic feet of hydrogen. Five pounds of caustic soda (sodium hydroxide), 4½ pounds of ferro-silicon, and 16 quarts of water are thoroughly mixed in the generator by shaking. A full cylinder of hydrogen gas is generated two hours after the cylinder is charged.

c. HYDROGEN GENERATOR ML–303/TM(XO–1). Hydrogen Generator ML–303/TM(XO–1) is a cylinder 5 inches in diameter by 15 inches long with a threaded opening at the top for a hose nozzle attachment and a threaded opening at the base for attaching a calcium hydride charge can. Two different charges are used with Hydrogen Generator ML–303/TM(XO–1). Calcium Hydride Charge ML–304/TM(XO–1) is a metal can containing enough calcium hydride briquettes to generate 6-cubic feet of hydrogen gas for the inflation of a 30-gram balloon. Calcium Hydride Charge ML–305/TM(XO–1) contains enough calcium hydride briquettes to generate 24-cubic feet of hydrogen gas for the inflation of a 100-gram balloon.

Caution: HYDROGEN MIXED WITH AIR FORMS AN EXPLOSIVE MIXTURE. Expel all air from a balloon before filling it with hydrogen. Electrically ground the hydrogen cylinder and all the metal parts from the cylinder to the hosecock or valve so that any static electricity can be dissipated without danger of an electric spark which might ignite the gas. Do not wear nailed shoes on a concrete floor during inflation because they might cause a spark.

6. Shelter

a. PERMANENT SHELTER. Inflate balloons under a shelter since even the slightest wind will hinder determination of the correct inflation. Overhead ventilation should be provided for the removal of any hydrogen which might collect in the ceiling. For sounding balloons, the shelter should be at least 10 feet square with 8-foot doors on opposite sides. If only one door is possible, locate it on the side opposite the prevailing winds.

NOTE.—If a permanent shelter is *not* available, use the portable shelter described below.

b. PORTABLE BALLOON INFLATION SHELTER. A portable balloon inflation shelter is made of 8-ounce canvas duck which is mildewproofed and waterproofed. The shelter is 7 feet square and 10 feet high. It is supported by four two-section poles and is guyed by four ropes from the tops of these corner poles. The roof is given a slight pitch by a ½-inch iron bar placed diagonally from the rear top left corner to the front top right corner. The door is a two-sectioned flap which slides on a cable to form an opening 7 by 9 feet (fig. 2).

c. UNPACKING AND ASSEMBLING PORTABLE BALLOON INFLATION SHELTER. (1) Carry the balloon inflation shelter in its folded form to the desired location (fig. 3).

(2) Unbuckle the four canvas straps on the folded shelter case, and unfold the large side flaps.

(3) Unbuckle the two canvas straps now accessible, and unfold the end flaps of the case.

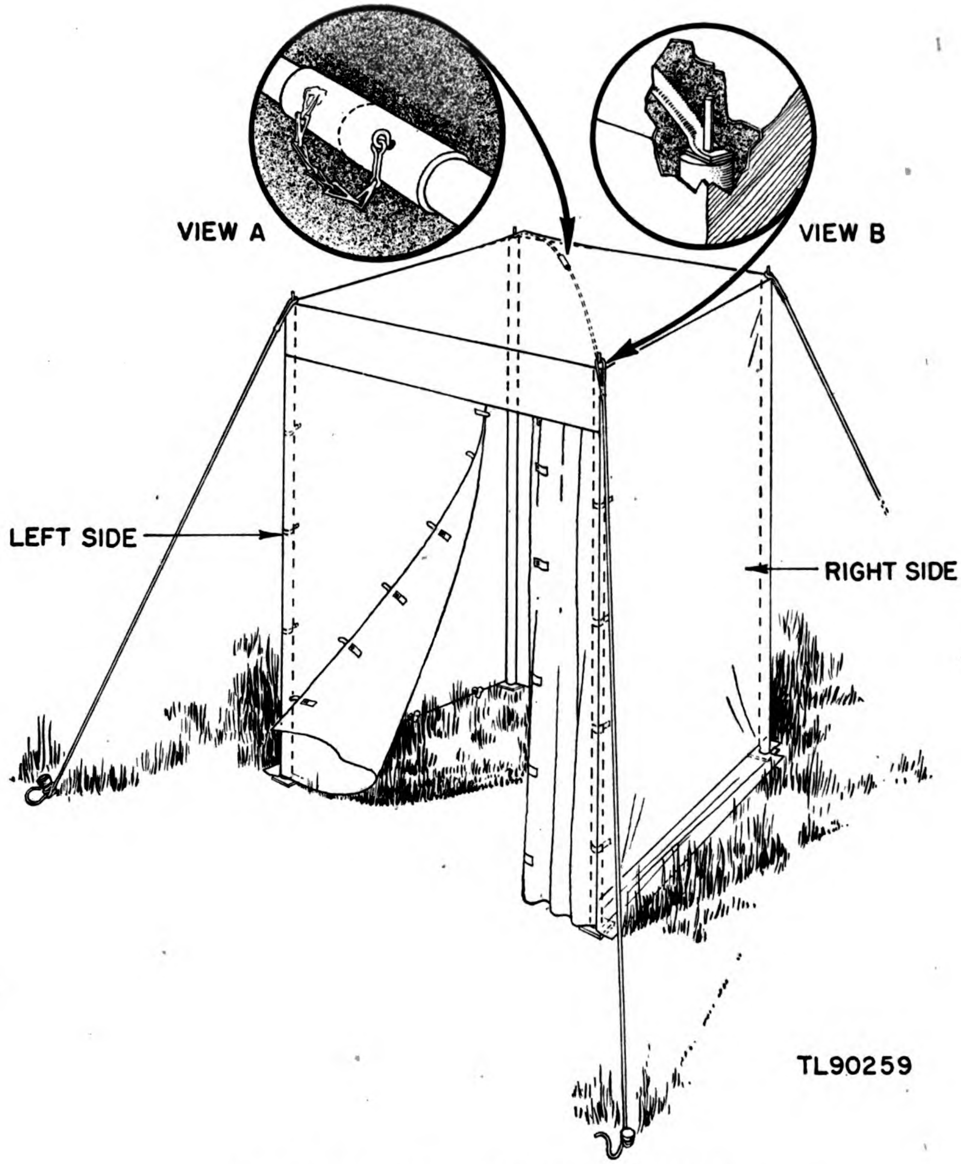


FIGURE 2. *Portable balloon inflation shelter.*

(4) Lift out the tent and the four guy ropes wrapped around it.

(5) Take out the four bearing plates packed loosely in the case.

(6) Unfold the small canvas flaps at one end of each group of shelter pole sections packed in the large side flaps of the case, and slide the eight pole sections from the canvas pockets and loops that hold them.

(7) Unfold the small flaps at the ends of the two curved roof support rods; unbuckle the strap holding the rods and remove them.

(8) Unfold the flaps from one end of the four wooden stakes packed in the center of the case, and slide the stakes from the pockets and loops that hold them.

(9) Unfold the flap from the end of each of the two groups of Stakes GP–2 packed in the end flaps of the case, and take out the nine stakes.

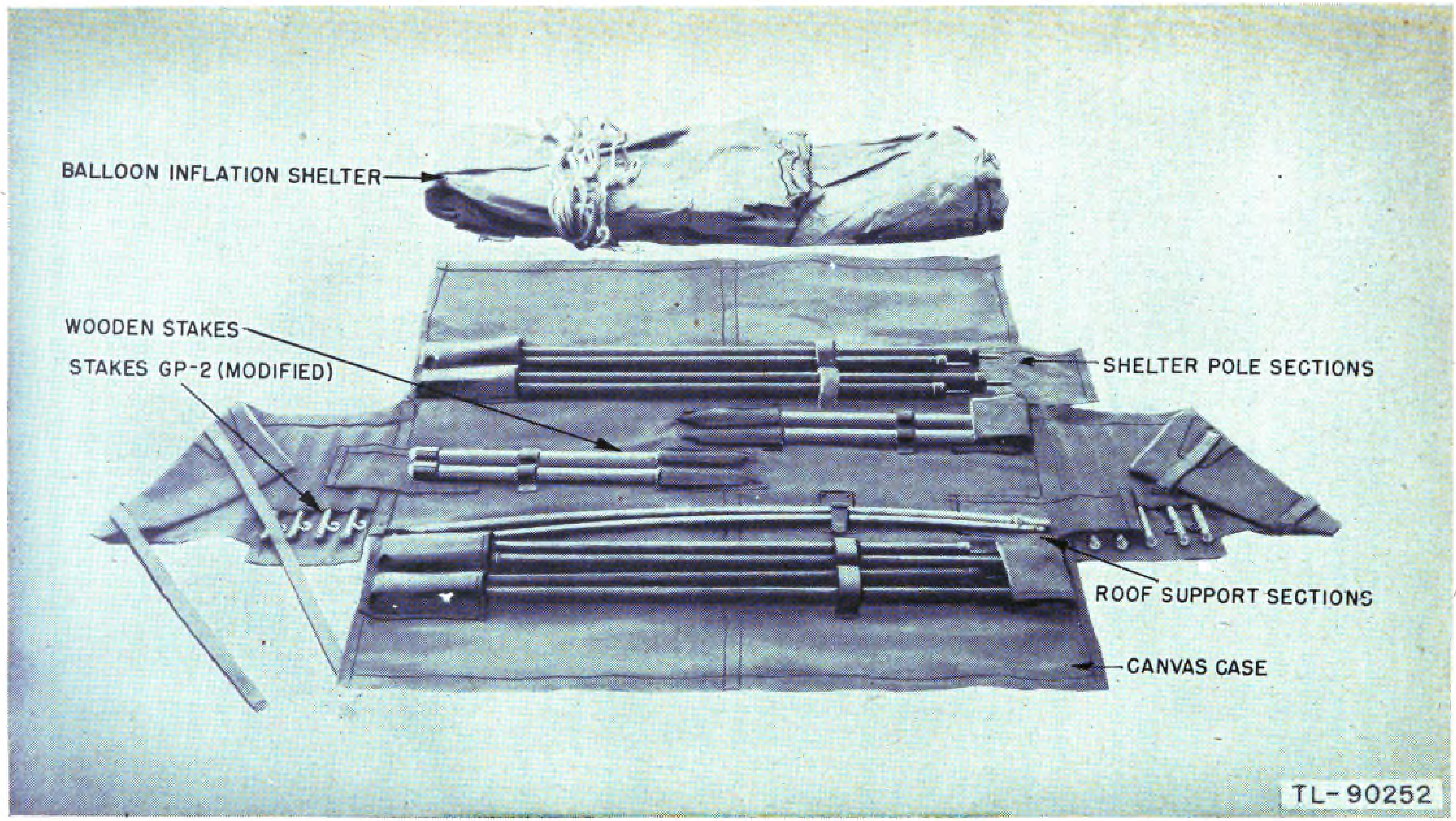


FIGURE 3. *Portable balloon inflation shelter, unfolded.*

d. Erecting Portable Shelter. (1) Take the four large wooden stakes, and drive one each into the ground at the corners of a 20-foot square.

(2) Assemble the two roof support rods (view A, fig. 2) by inserting the plain end of one rod into the hollow-sleeved end of the other. Match the holes in each of the joined ends, and insert the pin that is chained to the sleeved end of the rod.

(3) Unwind the four guy ropes from around the tent, and lay them aside.

(4) Unfold the tent. Place the roof support curve-up under the roof so that the support extends from the *rear* left corner to the *front* right corner (fig. 2). Fasten the support to the roof by the canvas straps.

(5) Assemble the eight pole sections to form the four shelter poles. Four of these sections have a hollow sleeve at one end and a pin extending from the other. These are the bottom sections of the shelter poles. The other four sections each have a longer pin extending from one end while the other end is plain. These are the top sections of the shelter poles. Take one top section and insert its plain end into the sleeve of a bottom section. Repeat to assemble each of the other three poles.

(6) Insert the long pin of one shelter pole into the hole in one end of the roof support and up through the grommet in that corner of the roof; so that the pin extends above the roof. Likewise insert another pole in the corner diagonally opposite.

(7) Slip the looped end of a guy rope over each of the pole pins extending through the tent roof, and raise the two poles and tent upright. Fasten each guy rope to a stake.

(8) Insert the long pin of a shelter pole through each of the grommets in the other two corners of the roof. Slip a guy rope over each protruding pin, raise the poles upright, and fasten each guy rope to a stake.

(9) Put a bearing plate on the ground under each shelter pole, and insert the pin through the hole in the plate and into the ground.

(10) Fasten the tent to the front poles by buckling the web straps provided in those corners.

(11) Drive a modified Stake GP–2 into the ground *inside* the tent beside each grommet provided along the bottom of the sides and along the back of the tent. Fasten each grommet on the adjacent stake hook, and drive the stakes further into the ground to tighten the sides and the back of the tent.

(12) Finally, make the tent as secure and as windtight as possible by piling earth on top of the flaps provided at the *outside* bottom of the sides and back.

e. Using Portable Shelter. Close the sliding front sections, and lap them over. Tie the web straps at the end of the outside laps to the straps on the outside of the tent. Tie the straps at the end of the inside laps to the straps on the inside of the tent.

Note.—Whenever a balloon bursts during inflation, immediately ventilate the shelter.

7. Preparation for Inflation

a. Balloon Temperatures. Warm a cold balloon before inflation by gently kneading it between the hands, by holding it under the garments, or by keeping it in a warm place for a short period of time before use. (See par. 20 for method of warming neoprene balloons.)

b. Required Equipment. Couplings, hosecocks, nozzles, hose, tubing (fig. 4), and a source of hydrogen are used to inflate meteorological balloons. The specific size of equipment required is determined by the type of balloon being inflated.

c. Preparation of Sources of Hydrogen. (1) *Preparation of hydrogen cylinder.* (*a*) Tightly attach Hose ML–81 (fig. 4①) to Coupling ML–49 (fig. 4④) or to Hydrogen Regulator ML–193 (fig. 7) if the regulator is used *instead* of the coupling. If the joint is loose, fasten a hose clamp, cord, or wire around it.

(*b*) Quickly open and close the valve of the hydrogen cylinder to expel any dirt that may have accumulated in the valve opening.

(*c*) Screw Regulator ML–193 or the proper coupling onto hydrogen cylinder, and tighten the connections with a wrench. All connections have left-hand threads.

(*d*) Further preparation of inflation equipment varies with the type of balloon to be inflated.

(2) *Preparation of Generator ML–185—(&) (hydrogen) and Hydrogen Generator ML–303/TM (XO–1).* Full instructions for setting up, charging and using Generator ML–185–(&) are given in TM 11–2400, which is packed with the equipment. Detailed information for the use of Hydrogen Generator ML–303/TM(XO–1) is contained in the instructions accompanying the equipment.

Note.—Hydrogen Generator ML–303/TM (XO–1) is different from the other sources because it generates hydrogen *while* it inflates.

d. Capacity of Balloons. At normal inflation, at normal sea level pressure, and at a temperature of about 70° F., the capacities of meteorological balloons are as follows:

Type of balloon	*Cubic feet*
10-gram ceiling balloon	1. 6
30-gram pilot balloon	5. 1
100-gram pilot balloon	21. 3
350-gram sounding balloon	60 to 90

The cubic foot gauge on the hydrogen regulator should not be used to measure inflation, however, because the gauge is not sufficiently accurate.

8. Inflating Ceiling Balloons

a. Connect Tubing ML–188 (fig. 4⑦) to Nozzle ML–186 (fig. 4⑥) and Coupling ML–187, and place the entire assembly on a table or other support on which it can rest.

b. Pull the neck of the ceiling balloon over the plug end of the cylinder of Nozzle ML–186, and secure it there with two rubber bands or with a cord tied with a square knot (fig. 5).

c. Roll up the balloon to expel the air.

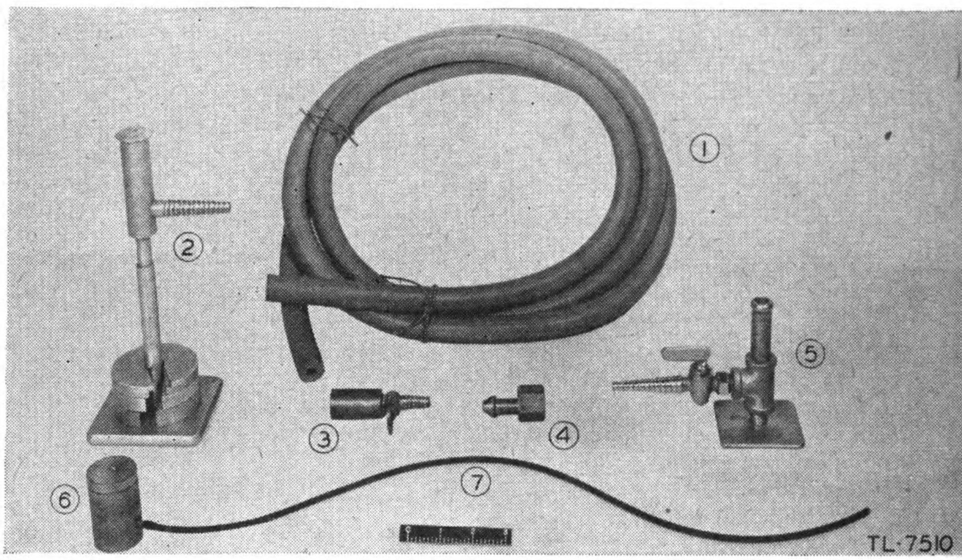
d. Attach Hose ML–81 (fig. 4①), which is already attached to the hydrogen container or generator, to Coupling ML–187.

e. Slowly open the valve on the hydrogen container (and the valve on Hydrogen Regulator ML–193 if it is used. *Do not open the valve too quickly because the pressure will blow the hose off*. For at least 1 minute, continue to inflate slowly in order to avoid overinflation. When the balloon just lifts Nozzle ML–186, immediately close the regulator valve, for exactly at this point the balloon is inflated to the desired free lift of 40 grams. (Nozzle ML–186 weighs 39 grams and 4 inches of its tubing weighs 1 gram.)

f. With one hand, grasp the portion of the balloon neck which is on Nozzle ML–186, and turn the balloon with the other hand so that the portion immediately above Nozzle ML–186 is completely twisted once or twice. Prevent that portion from untwisting by holding it between the fingers.

g. Slide off the rubber bands holding the balloon on Nozzle ML–186, and remove the balloon.

h. Loop the two rubber bands several times around on the balloon neck until they seal it tightly. The balloon is then ready for release (par. 13).



① *Hose ML81.*
② *Nozzle ML–196.*
③ *Cock ML–56.*
④ *Coupling ML–49.*
⑤ *Cock ML–201–A.*
⑥ *Nozzle ML–186.*
⑦ *Tubing ML–188.*

FIGURE 4. *Inflation equipment.*

9. Inflating Pilot Balloons

a. THIRTY-GRAM BALLOONS. Use Hose ML–81 and Cock ML–56 in the inflation of 30-gram pilot balloons regardless of the source of hydrogen used. Draw the balloon neck over the large end of Cock ML–56 (fig. 4③), and fasten it with two rubber bands. Open the stopcock of Cock ML–56, and roll up the pilot balloon to expel the air. Then close the stopcock.

(1) *Inflating from cylinder filled with hydrogen* (fig. 6). (*a*) Open the valve on the hydrogen container, and allow a slow flow of

gas to pass through Coupling ML–49 (fig. 4④) and Hose ML–81 in order to expel air from coupling and hose. If Hydrogen Regulator ML–193 is used instead of Coupling ML–49, slowly open the valve on the regulator also, and expel air from the regulator and hose.

(*b*) Attach the free end of Hose ML–81 to the small end of Cock ML–56, and open the stopcock of Cock ML–56 to start inflation of the balloon.

(*c*) Continue opening the regulator valve slowly to increase the flow of gas into the balloon. Continue inflation about 1 minute or more until the balloon just lifts Cock ML–56.

(*d*) Close the valve on the hydrogen cylinder (and the valve on the regulator if the regulator is used), and then close the stopcock of Cock ML–56.

(*e*) Remove Cock ML–56 from Hose ML–81 to see whether the balloon and attached Cock ML–56 will float motionless in the air. If the balloon rises, it has too much gas; if it sinks, it doesn't have enough. Add or release gas, as the case may require, until the balloon and attached Cock ML–56 remain suspended motionless in the air. The balloon then has the required lift.

(*f*) Put one hand firmly around the neck of the balloon on Cock ML–56. With the other hand, lift the upper part of the neck, and completely twist it once or twice.

(*g*) Grasp the twisted part with the fingers, slide off the rubber bands holding the balloon neck on Cock ML–56, and remove the balloon.

(*h*) Loop the two rubber bands around the twisted part of the neck several times until they seal the balloon. The balloon is then ready for ordinary daytime release (par. 13).

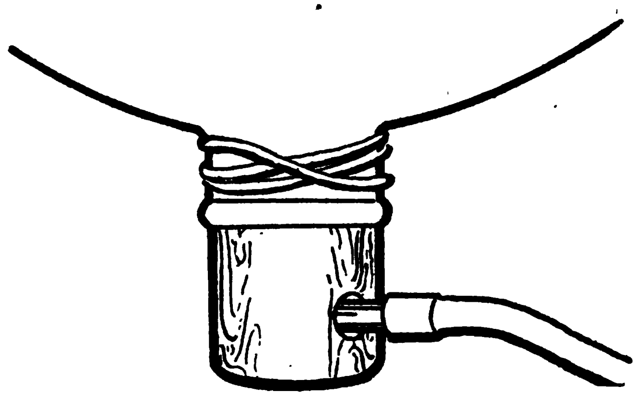


FIGURE 5. *Ceiling balloon attached to Nozzle ML–186.*

(2) *Inflating with Generator ML–185–(&) or Hydrogen Generator ML–303/TM(XO–1).* (*a*) Attach one end of Hose ML–81 to the gas outlet tube of the generator being used. Attach the free end of Hose ML–81 to the small end of Cock ML–56.

(*b*) To inflate balloon with Generator ML–185–(&), or with Hydrogen Generator ML–303/TM(XO–1), refer to the instructions packed with the equipment.

(*c*) Test for proper inflation, and fasten the neck of the balloon as indicated in paragraph 9*a* (1).

b. HUNDRED-GRAM BALLOON. (1) To inflate the 100-gram pilot balloon, draw the balloon neck over the injector portion (the vertical pipe) of Cock ML-201-A (fig. 4⑤). The usual 100-gram pilot balloon should fit snugly on Cock ML-201-A. If the fit appears too tight, stretch the neck so that it just goes over the end, and use a twisting motion to slip it on all the way. Occasionally a 100-gram balloon will have a neck 1½ inch in diameter, which fits loosely on Cock ML-201-A. A loose neck must be securely tied around the pipe of Cock ML-201-A with a 12-inch length of twine.

(2) The actual inflation of a 100-gram balloon is done by the same method described in paragraph 9*a* for the 30-gram balloon, and the test for proper inflation is similar. The inflation time, of course, may be longer although a more rapid rate of inflation is used.

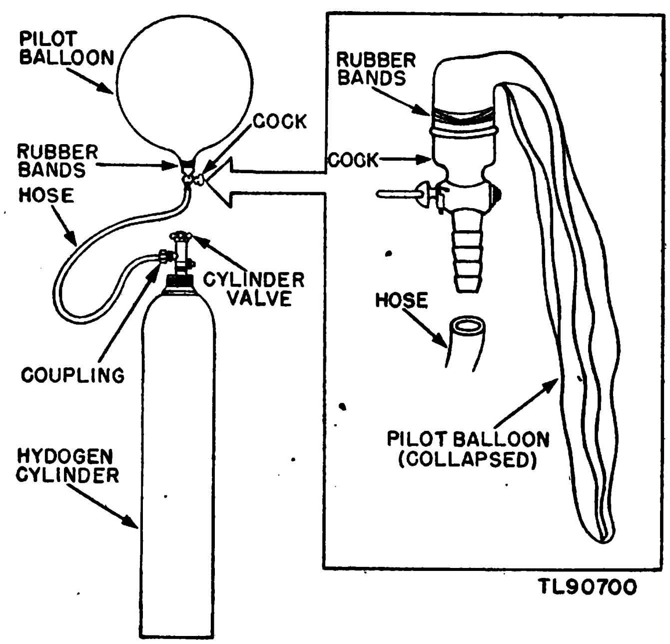


FIGURE 6. *Inflating pilot balloon.*

(3) When the 100-gram balloon is properly inflated and Cock ML-201-A is removed from Hose ML-81, double a piece of twine about 12 inches long, and lay it around the balloon neck immediately above the portion that is attached to Cock ML-201-A. Slip the cut ends through the looped end of the twine, separate them, and pull tight. Wrap the ends around the neck again, and tie with a square knot (fig. 40, FM 24-5). Make certain that the twine has been pulled tight so that the balloon is sealed. Twist the balloon once or twice, wrap the twine over the twisted portion, and tie another square knot. Repeat the twisting and tying. Keep the twine taut in all these tying operations.

(4) Remove the balloon from the Cock ML-201-A. It is now ready for release.

10. Inflating Sounding Balloons (fig. 7)

a. Weigh off Nozzle ML–196 (fig. 4②).

(1) Nozzle ML–196 alone weighs 1,500 grams, but it is furnished with several separate weights of 100-, 200-, 400-, and 500-gram sizes which can be added to obtain a nozzle weight of 1,500 to 2,700 grams in 100-gram steps. Enough of these separate weights must be added to Nozzle ML–196 so that its total weight exceeds, by the amount of free lift required, the weight of the equipment which the sounding balloon will carry aloft. The following list gives approximate weights of equipment the balloon may be required to carry:

Equipment	Weight (grams)	Equipment	Weight (grams)
Parachute, paper	100	Radiosonde battery	700
Parachute, cloth	200	Ballast balloon	400
Radiosonde	700		

Free lift needed: 500 grams if no ballast balloon is used; 400 grams if a ballast balloon is used. During sleet or moderate to heavy rain, an additional lift up to 200 grams is required to compensate for the extra loading.

(2) As an example, a sounding balloon is being prepared to carry a radiosonde, a paper parachute, and a ballast balloon. The radiosonde weighs 700 grams, the battery 700 grams, the parachute 100 grams, and the ballast balloon 400 grams—a total of 1,900 grams in weight. The nozzle must weigh 1,900 grams plus 400 grams free lift, or 2,300 grams in all. Since the basic portion of Nozzle ML–186 weighs only 1,500 grams, 800 grams must be added by using a 500-gram, a 200-gram and a 100-gram weight. The 2,300-gram nozzle is then used to obtain proper inflation.

(*a*) If rain or icing conditions exist or are expected to exist aloft, add 200 grams more to the nozzle to compensate for the extra weight which might be acquired by the balloon in flight under such conditions. The additional 200 grams will make the nozzle weigh a total of 2,500 grams.

(*b*) During high winds, the ballast balloon would not be used, and consequently, the nozzle would have to weigh only 2,100 grams. This is computed as follows: radiosonde 700 grams, battery 700 grams, and free lift 700 grams (an additional 200 grams has been included because of the icing conditions assumed in this example. If a ballast balloon of lesser weight than 4 grams is used, a free lift of either 400 or 500 grams should be computed, based upon the individual's own judgment.

b. Insert the vertical spout of Nozzle ML–196 into the neck of the sounding balloon while the balloon is still in its carton (fig. 7).

c. Attach Hose ML–81, already attached to the hydrogen cylinder (par. 7*c* (1)), to the other spout of the nozzle. This will prevent air from entering the balloon when it is unfolded.

d. Slowly open the regulator valve, if it is used, and the valve on the hydrogen container. Allow the gas to flow to the balloon for about 3 minutes.

e. Close the regulator valve. If a hissing sound of gas leaking from the balloon is heard, immediately twist and grasp the neck of the balloon. Remove it from Nozzle ML–196, and take the balloon to the open air where it can be safely deflated. *Never deflate a balloon inside the shelter*. If the balloon does not leak, continue inflation until the weighted Nozzle ML–196 is lifted. Usually the balloon is sufficiently inflated in about 10 minutes.

f. Close the regulator valve and the cylinder valve, and remove Hose ML–81 from the nozzle.

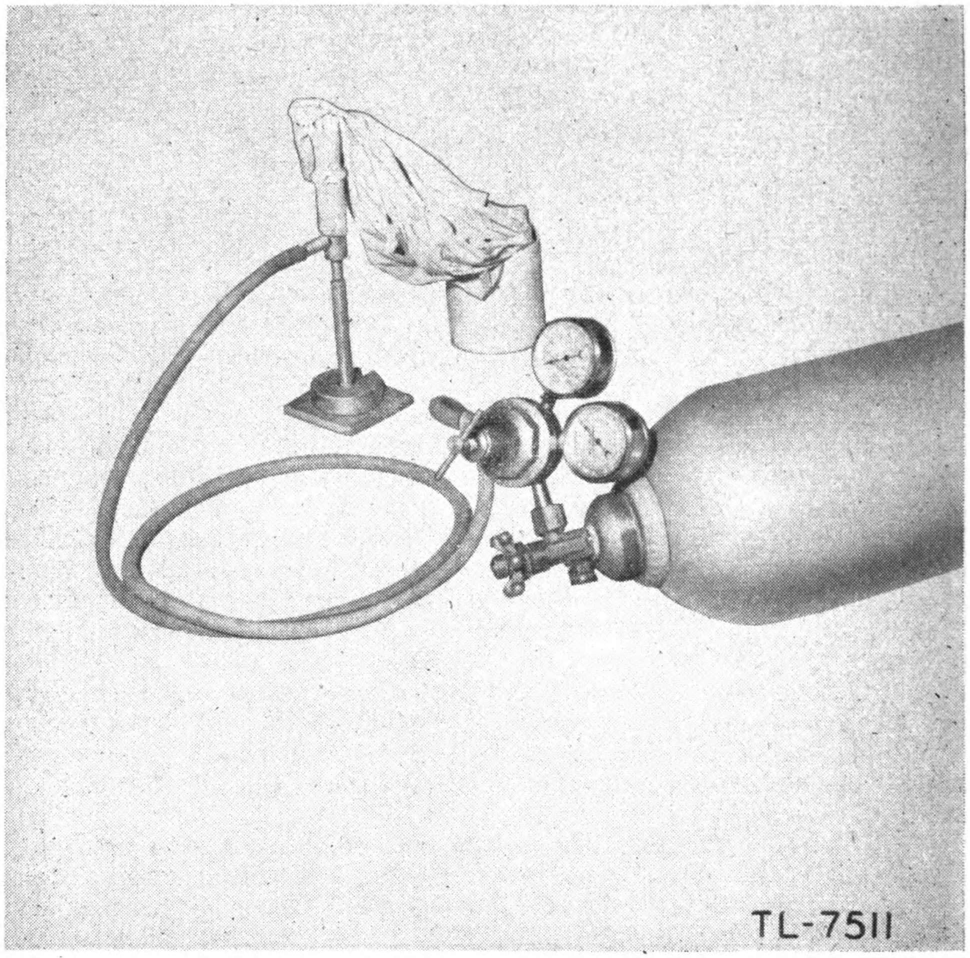


FIGURE 7. *Inflation of sounding balloon.*

Caution: Take care that the balloon does not rub or scrape any rough surface that may damage it.

g. Double a 6-foot length of cord, and place it around the balloon neck above Nozzle ML–196. Slip the cut ends of the cord through the looped end, separate them, and pull as tightly as possible. Wrap the ends around the neck, and tie a square knot. Again wrap the cord ends around the neck, and tie another square knot. There is little danger of cutting the neck with the cord. Pull it tight so that a good seal will be secured.

h. Remove the balloon from Nozzle ML–196, fold the neck of the balloon back, and tie another square knot. *Make certain that the cord has been tied around the neck in such a manner that the balloon is sealed.*

i. Attach the parachute to the sounding balloon.

(1) Tie one end of a 9-foot length of cord to the top part of the parachute to be used. (Use a single length of 16-ply cord or a double length of 8-ply cord.)

(2) Tie the other end to the neck of the sounding balloon. Make certain that there are at least 4 feet of doubled cord between the balloon and the parachute, and be sure that there are no tangles in the parachute before tying it to the balloon.

(3) Tie one end of a single 50-foot length of cord to the bottom of the parachute, and tie the other end to the radiosonde.

j. The ballast balloon is tied to the radiosonde according to directions in paragraph 11.

11. Use and Inflation of Ballast Balloons

a. USE OF BALLAST BALLOON. A ceiling balloon (par. 2*a*) containing about 400 grams of dry sand and inflated with air or hydrogen is used for a ballast balloon in radiosonde flights. A ballast balloon slows down the rate of rise of the sounding balloon during the first few thousand feet of ascent, so that the radiosonde soundings of the important lower levels will be more accurate. The ballast balloon bursts at an altitude of about 10,000 feet, releases its sand, and relieves the sounding balloon of that weight. Consequently, the rest of the flight is made at a faster rate of rise. *Use a ballast balloon whenever possible.* A high wind may make its use impracticable, and in moderate winds the amount of sand used in the balloon may have to be reduced.

b. BALLAST. The cylindrical box in which a sounding balloon is packed can be used to gauge the correct amount of sand required for a ballast balloon.

(1) Cut the sides of this box to a uniform height of ⅞ inch from the bottom. This will provide a measure which, when filled and leveled off with dry sand, will contain 400 grams of sand.

(2) Pour the sand into the neck of the balloon.

NOTE.—During the summer months and over isolated sections, water may be substituted for sand. In inhabited areas, however, this might be dangerous to life and property since water may freeze solid in the upper air.

c. INFLATION OF BALLAST BALLOON. (1) Attach the balloon to Nozzle ML–186 or directly to Hose ML–81 which is attached to the hydrogen container.

(2) Inflate the balloon until it is about 18 inches in diameter. (If a nonspherical balloon is used, inflate it until it is about 22 inches long.) Learn to determine the exact size to which a ballast balloon must be inflated so that it will burst at the proper altitude. Devise some gauge or measuring stick for this purpose.

(3) Seal the balloon neck with rubber bands as described in paragraph 9*a*(1)(*h*).

(4) Tie the neck with a square knot in the center of a 6-foot length of cord.

(5) Attach the balloon to the radiosonde by threading one end of the cord through the ring on top of the radiosonde and tying the two ends together with a square knot. *The ballast balloon must hang far enough below the radiosonde so that the lower end of the antenna does not touch it.*

12. Use of Parachutes

The use of parachutes with meteorological equipment sent aloft prevents damage to persons or property by falling equipment. When used with the radiosonde, a parachute also diminishes the shock the equipment receives when it falls to the ground. A recovered radiosonde *can be repaired* and recalibrated for further use. Do not use a parachute when the equipment is expected to land in enemy territory. A parachute is not used with a battery lighting unit when there is no danger that the equipment will strike anything of value.

13. Releasing Procedure

a. GENERAL. Release a meteorological balloon as soon after inflation as possible because hydrogen gas gradually escapes through the rubber even of a perfectly tied balloon. At normal inflation, a 30-gram balloon loses about 1 gram of lift every 8 minutes, and a 100-gram balloon loses about 1 gram every 2 minutes. Consequently, if release of an inflated balloon is delayed for any length of time, the balloon becomes underinflated and must be reweighed before release (par. 20*b*).

b. CEILING BALLOONS. To release a ceiling balloon, hold it by the neck, and let it go at the proper moment. Release it on the even minute, and use a stop watch to time the release and the flight observations (par. 16*a*).

c. PILOT BALLOONS. To release a pilot balloon, hold it by the neck, and let it go at the proper moment. Stand in the open, as near the theodolite[1] as possible. The exact moment of release is determined by Time Interval Unit ML–138, which gives an audible signal every minute. The signal lasts 5 seconds. The beginning of the signal serves as a warning to get ready. The balloon must be released the moment the signal ends.

d. SOUNDING BALLOONS. (1) *Release by one operator* (*in calm or very light winds*). (*a*) Hold the balloon by the cord that fastens the radiosonde to it, and gradually pay out this cord as far as the radiosonde.

(*b*) Lift the radiosonde and let the balloon take it away.

(2) *Release by two operators* (*during moderate or high winds*). (*a*) Operator 1 holds the balloon neck in one hand, and the radiosonde, raised in flight position, in the other hand (fig. 8).

(*b*) Operator 2 connects the two black leads at the side of the radiosonde, and then tunes the ground station to the radiosonde signal.

(*c*) Ground-station operator 2 takes the radiosonde, holding it upright by the bottom of the case.

(*d*) Operator 1 releases the balloon, maintaining a sliding grip on the line between the balloon and parachute and transferring this grip to the line leading to the radiosonde as the parachute rises into the air.

[1] Instruction in the use of the theodolite may be found in the following Technical Manuals: TM 1–235, TM 4–240, and TM 11–423.

(*e*) The operator holding the radiosonde approaches the position of the release of the balloon and follows the balloon as the line shortens, running if necessary, until the radiosonde is lifted gently from his hands by the ascending balloon (fig. 8).

(3) *Release in very high wind.* In a very high wind, the line from the parachute to the radiosonde should be shortened to about 20 feet. Heavy rubber bands are tied in this line (called "spanning a bight," as shown in fig. 9) to absorb the shock when the balloon lifts the radiosonde.

(4) *Release in downdraft.* Occasionally a balloon may not rise in a downdraft. Do not release the radiosonde if the balloon has not risen sufficiently; in this way all danger that the radiosonde will strike

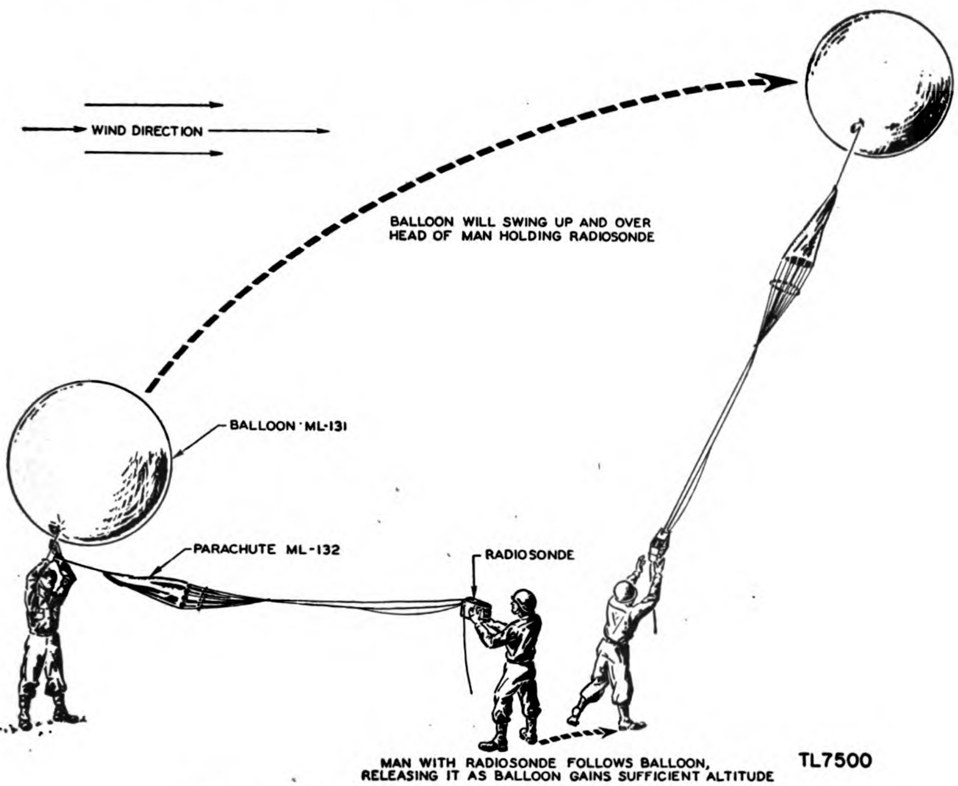


FIGURE 8. *Method of releasing sounding balloons.*

the ground will be eliminated. *The radiosonde must be saved, even if the balloon itself breaks away and is lost.*

14. Night Use of Pilot Balloons

a. GENERAL. Thirty-gram pilot balloons, fitted with a lighting unit, are used for night observation of wind direction and velocity. If no ceiling light projector is available, lighted pilot balloons may also be used for the determination of ceiling height at night, since they have a known rate of rise and can be timed by the same method used for daylight observation of ceiling balloons (par. 16*a*).

b. LIGHTING UNITS. Two types of lighting units, battery light and candle lantern, are available for 30-gram pilot balloons.

(1) *Battery light unit.* The battery light unit consists of a battery, a bulb, and a parachute (figs. 10, 11, and 12).

(*a*) *Preparing parachute.* Locate the cord which extends from the inside center of the parachute to a knot which joins the side cords (fig. 10). Break this cord just above the knot, and turn the parachute inside out, thereby furnishing a cord extending from the top outside of the parachute. Take a short cord, and loop it around the battery

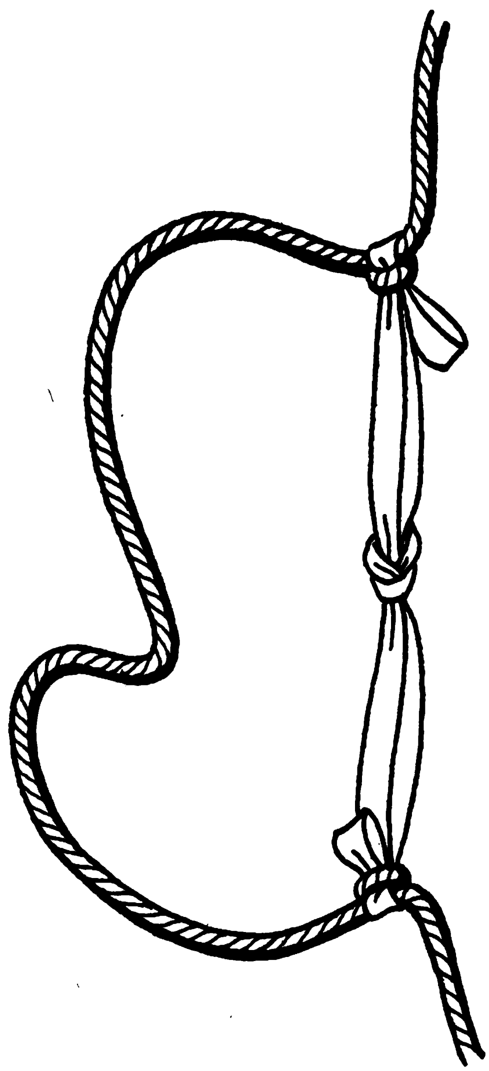


FIGURE 9. *Spanning a bight.*

(fig. 11). Tie the ends of this cord to the knotted lines which extend from the sides of the parachute so that the bulb will hang down when suspended (fig. 12).

(*b*) *Inflating balloon.* Inflate the balloon as described in paragraph 9*a*. Because of the additional load of the battery unit, the battery and an extra 40-gram weight must be tied to Cock ML–56. The balloon will be inflated to the free lift of 172 grams required to maintain a rate of rise of 200 yards per minute.

(*c*) *Final steps.* Tie the top cord of the parachute to the inflated balloon (fig. 12), and screw the light bulb so that it lights.

(2) *Candle lantern set.* The candle lantern set consists of a paper lantern and a small candle packed separately. The lantern is packed flat (fig. 13).

(*a*) *Preparing lantern.* Open the top flap of the lantern, and push the lantern walls aside. Attach the candle either by sticking a straight pin up through the center of the bottom of the lantern and into the candle or by temporarily lighting the candle and letting a few drops of the molten wax fall on the inside bottom of the lantern, and then setting the candle in the soft wax which will harden and hold the candle. Tie a 4-foot cord to the lantern handle.

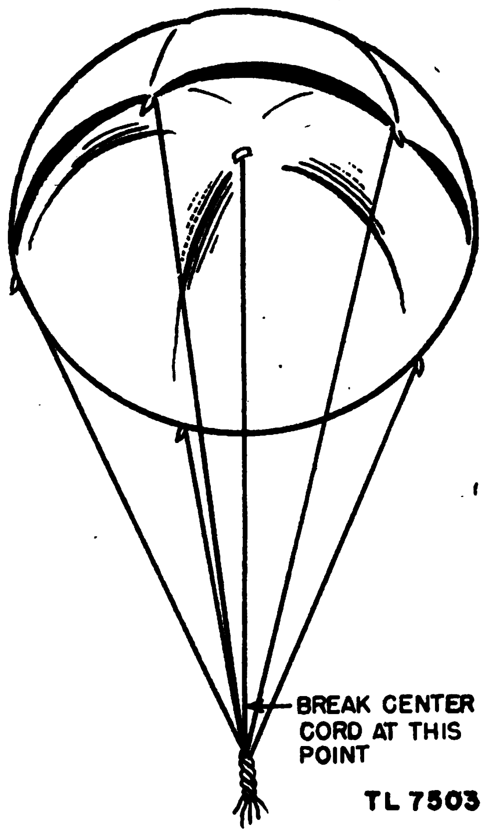


FIGURE 10. *Parachute for battery lighting unit.*

Caution: Do not light the candle where there is hydrogen or when very close to the inflated balloon.

(*b*) *Inflating balloon.* Inflate the balloon as described in paragraph 9*a*. Because of the additional load of the candle lantern, weigh the balloon with the cord and lantern hanging from Cock ML–56. (This maintains a free lift of 132 grams. The rate of rise is decreased only 4 percent; this does not materially affect the accuracy of an observation.)

(*c*) *Final steps.* Light the candle, and unfold the lantern (fig. 13) by twisting and separating the cardboard ends. Take care that the lantern walls do not catch fire. If there is a high wind, it may be necessary to place the lantern in a wastebasket or bucket to provide shelter for lighting the candle. Tie the cord from the lantern handle to the neck of the inflated balloon. Push the top flap of the lantern through to the inside of the lantern to permit air to reach the candle flame.

NOTE.—The burning life of the candle is only 40 minutes; release the balloon as soon as possible after lighting the candle.

c. NIGHT RELEASE OF BALLOONS. (1) Hold the neck of the balloon in one hand and the lighting unit in the other. Be sure that the cord between them is fairly taut and untangled. If a lantern is being used, hold the balloon down wind from the lantern.

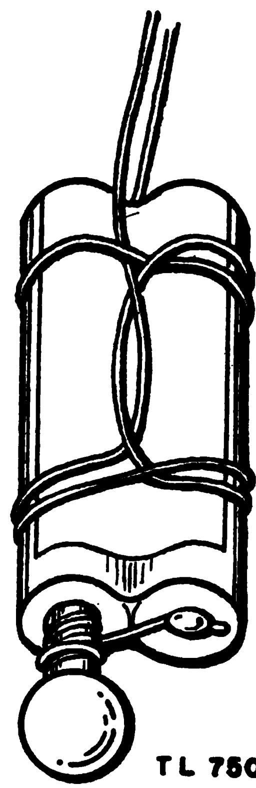


FIGURE 11. *Battery lighting unit.*

(2) Swing the hands toward the wind, and release the balloon and the lighting unit at the same time. A wind stronger than moderate may cause some difficulty in releasing a balloon with lantern attached. Link three or four rubber bands together, and insert them in the cord at a point halfway between the balloon and lantern (fig. 9). This arrangement will absorb the initial shock to the lantern. Hold the balloon and lantern so that there is slight tension on the rubber bands, and release both at the same time. Successful launchings in winds 25 miles per hour or over can be accomplished by this method.

15. Use of Balloons during Precipitation

a. PILOT BALLOONS. Rain, snow, or sleet might decrease the rate of rise of the balloon and might result in inaccurate observations. *Pilot* *balloon flights can be made during a light rain or snow with very little difference in the ascension rate.*

b. Ceiling Balloons. In very light rain or drizzle, ceiling balloon flights can still provide an estimate of cloud heights.

c. Sounding Balloons. The ascent of sounding balloons with attached radiosonde equipment can be made regardless of weather conditions because no definite rate of rise is necessary in such observations.

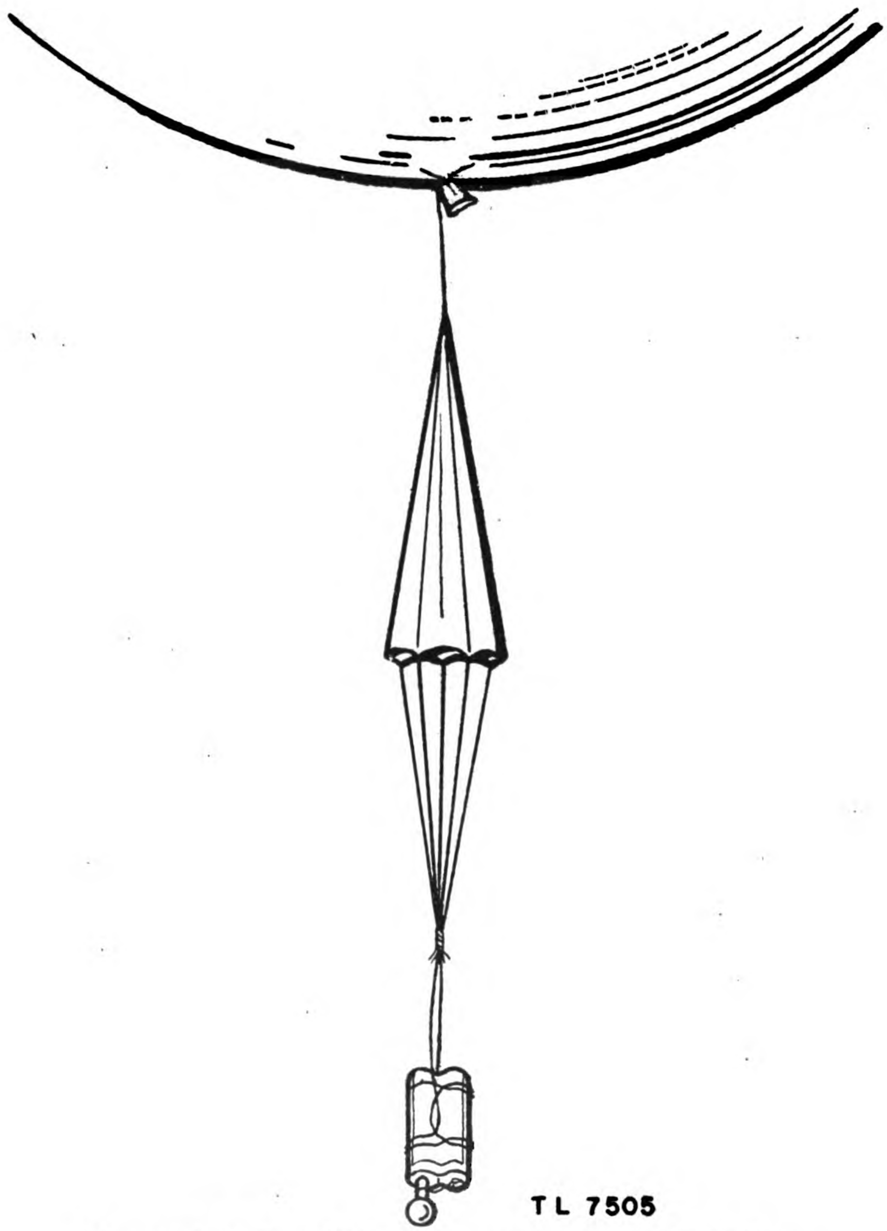


Figure 12. *Battery light and parachute attached to balloon.*

16. Rate of Ascent

The following tables and formulas are based on average rates of rise of meteorological balloons:

a. Ceiling Balloons. The average rate of rise of a ceiling balloon inflated to a free lift of 40 grams is 360 feet per minute after the first

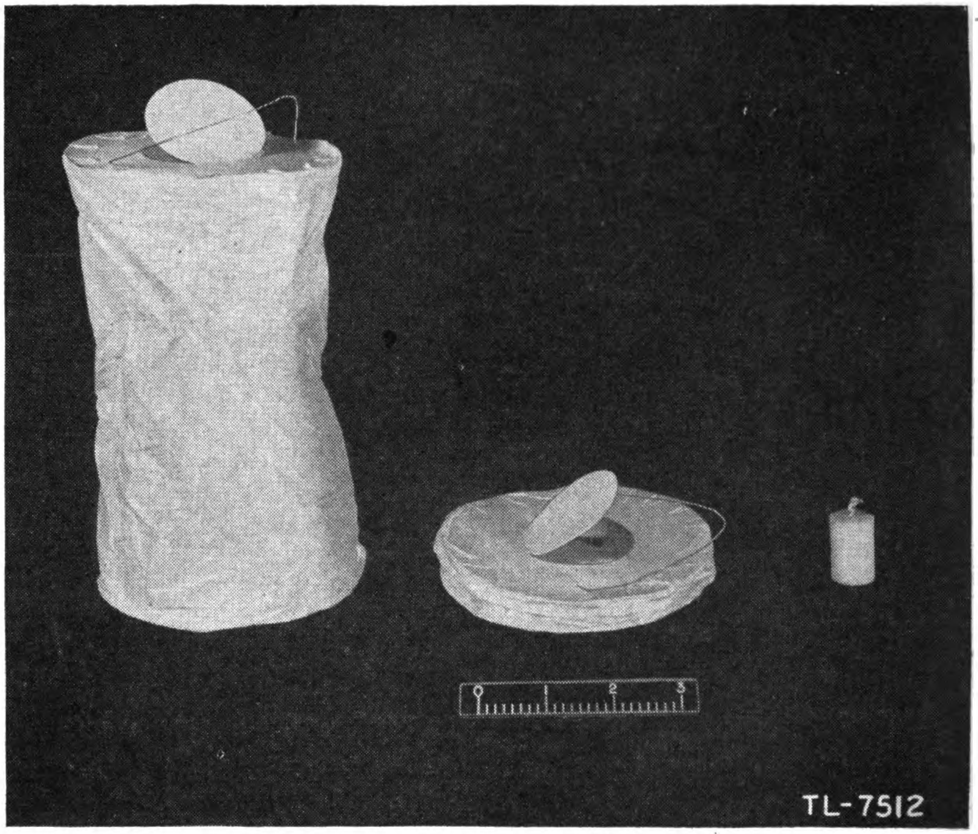


Figure 13. *Candle lantern light unit.*

1½ minutes. Use the following table to determine ceiling height after timing a ceiling balloon flight:

Time (minutes)	Altitude (feet)	Time (minutes)	Altitude (feet)	Time (minutes)	Altitude (feet)	Time (minutes)	Altitude (feet)
¼	130	2¼	940	4¼	1, 660	6¼	2, 380
½	250	2½	1, 030	4½	1, 750	6½	2, 470
¾	370	2¾	1, 120	4¾	1, 840	6¾	2, 560
1	480	3	1, 210	5	1, 930	7	2, 650
1¼	580	3¼	1, 300	5¼	2, 020	7¼	2, 740
1½	670	3½	1, 390	5½	2, 110	7½	2, 830
1¾	760	3¾	1, 480	5¾	2, 200	7¾	2, 920
2	850	4	1, 570	6	2, 290	8	3, 010

(1) Use a stop watch (or a watch with a second hand) to time a ceiling balloon flight. Release the balloon exactly on an even minute,

and note the exact time the balloon enters the cloud. Calculate exactly the number of seconds or minutes this occurs after release, and use the preceding table to determine the ceiling. Some clouds have smooth bases into which the balloon may disappear at once; others have ragged bases. If the balloon enters one of the lower portions, it indicates the ceiling more accurately than if it enters a hollow in the cloud (fig. 14). If clouds are broken, the balloon may drift into openings between the clouds and disappear. Such disappearances do not indicate true cloud height. *Whenever a measurement is doubtful, immediately release another balloon, and take another measurement.* Repeat as many times as necessary, taking the lowest of the several readings as the ceiling.

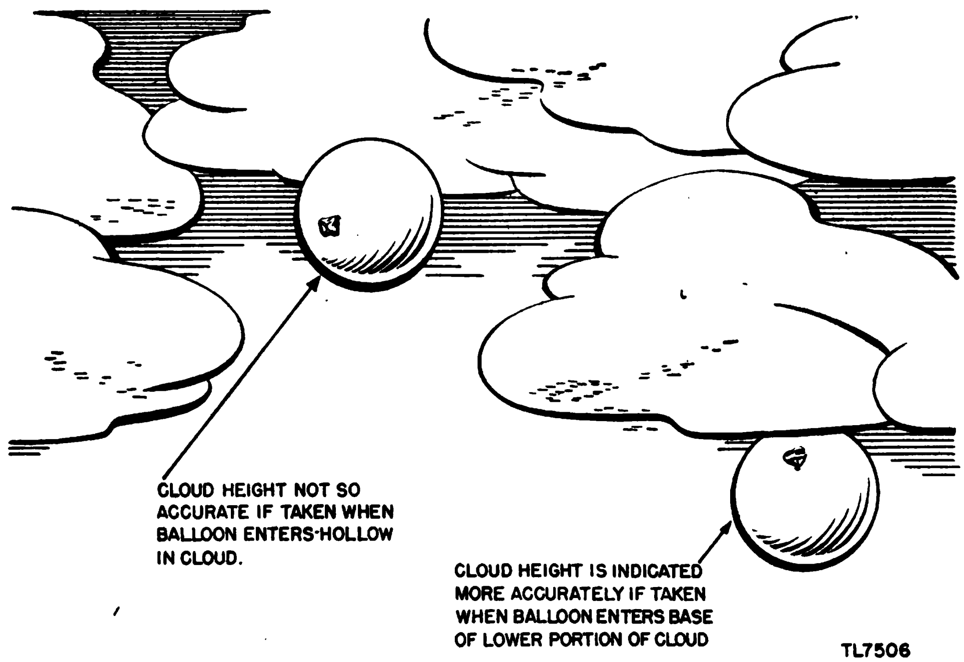


FIGURE 14. *Cloud heights.*

(2) Whenever very accurate determination of cloud height is required, employ two or more theodolites separated by some distance. The height can be computed from the theodolite readings.

(3) In some cases, an entirely different method, such as a pilot's report, should be used. For example, if the ceiling must be known to within 200 feet at an altitude of 2,000 feet, a more accurate method than timing the ascent of the ceiling balloon is required.

b. THIRTY-GRAM PILOT BALLOONS. (1) The rate of ascent of 30-gram pilot balloons is determined by the following formula:

$$V=158\left(\frac{F}{T^{2/3}}\right)^{5/8}$$

V=rate of ascent in yards per minute.

F=the free lift or actual lifting force of the inflated balloon expressed in ounces.

T=the total lift (free lift, F, plus the weight of the balloon) expressed in ounces.

The same formula in metric units is:

$$V=72\left(\frac{F}{T^{2/3}}\right)^{5/8}$$

V=the rate of ascent in meters per minute.
F=free lift in grams.
T=total lift in grams.

Cock ML–56 weighs 132 grams (4.66 ounces) which is the lift necessary for a balloon weighing 30 grams (1.06 ounces) to rise at a rate of 200 yards per minute. Therefore, the total lift for a balloon of this size without any attached accessories is 5.72 ounces.

(2) A pilot balloon near the ground will ascend faster than the calculated rate of rise of 200 yards per minute. This increase in rate averages 20 percent during the first minute after release, 10 percent during the second and third minutes, and 5 percent during the fourth and fifth minutes. Thus, a 30-gram pilot balloon with a free lift of 132 grams (4.66 ounces) will ascend at the following rates:

First minute, 240 yards.
Second minute, 220 yards.
Third minute, 220 yards.
Fourth minute, 210 yards.
Fifth minute, 210 yards.
Each subsequent minute, 200 yards.

c. ONE-HUNDRED-GRAM PILOT BALLOONS. The 100-gram pilot balloon rises at a rate of approximately 330 yards per minute and consequently requires less time than the 30-gram balloon for a high altitude flight. The 100-gram pilot balloon travels faster during the first 14 minutes of flight. The corrections to be added to the rate of rise for the first 14 minutes are 22, 19, 19, 16, 16, 12, 12, 12, 8, 8, 6, 3, 3, and 3 percent, respectively.

d. SOUNDING BALLOONS. The rate of rise of a sounding balloon, fully equipped with radiosonde and inflated to an approximate free life of 500 grams, is about 450 to 600 feet per minute. Uniformity of rate of rise is of minor importance for sounding balloon flights because altitude is accurately computed from the radiosonde record.

REMEMBER THESE POINTS

1. Differently colored balloons are furnished so that the balloon which will contrast best with the appearance of the sky at the moment can be chosen. Take time to consider the choice!
2. Hydrogen is highly inflammable. Be extremely careful when using it. *Do not smoke near it!*
3. Do not become careless in weighing off the balloon. Be certain that it is inflated just enough to get the desired free lift. Do not underinflate or overinflate. Get it right!
4. When tying off a balloon after inflation, be sure that it is tied tightly enough to keep the gas in the balloon. Even a very slow leak affects the rate of rise and may make the observations inaccurate!
5. Keep in mind the fact that hydrogen gradually seeps through rubber. Do not inflate the balloon until shortly before the time to release it.

SECTION III

MAINTENANCE

17. Care of Hosecocks and Nozzles

a. CLEANING. Large amounts of talc, placed on the inner surfaces of meteorological balloons to prevent sticking of the rubber, tend to clog the hosecocks and nozzles used for inflation. Keep hosecocks and nozzles clean of talc by shaking regularly. In extreme cases, clean by inserting a thin flexible wire into the hosecock or nozzle to loosen the talc; then shake out the talc.

b. LUBRICATING. Use graphite or a paraffin-base oil to lubricate hosecocks and nozzles. NEVER USE OIL FOR LUBRICATING ANY PART OF A HOSECOCK OR NOZZLE UNLESS IT IS A PARAFFIN-BASE OIL. HYDROGEN REACTS CHEMICALLY WHEN PASSED THROUGH MANY OILS.

18. Storage of Balloons

a. Keep balloons in their original, sealed containers, and store them in a cool, dry, dark place until needed for use. *Balloons deteriorate rapidly in high temperature.* Provide special storage in summer. In winter, do not store them in an overheated room. If a balloon has been stored in a cold place, it must be warmed before using so that the balloon will retain its spherical shape when inflated.

b. Use balloons while they are fresh. Never allow an oversupply to accumulate. Use the old stock before starting on a new supply.

19. Patching Balloons

Occasionally balloons, when received from the manufacturer, will have small pinholes. In some cases, such holes may develop during inflation due to small air bubbles or other defects. These defective balloons can be patched and used on days when clouds are low or a short observation is anticipated for any reason. Use pieces of burst balloons for patches, and hold in place with ordinary rubber cement. Place patches on the inside of the balloon for best results.

20. Care of Neoprene Balloons

a. STORAGE. Neoprene balloons should be stored in place at a WARM temperature from 80° F. to 85° F. Always keep a neoprene balloon warm until the instant it is released in flight.

b. INFLATION. Inflate neoprene balloons in a warm room. Connect all associated equipment, and check the radiosonde *before* taking neoprene balloon out for use. All haste should be made to release a neoprene balloon in flight as soon after inflation as possible.

c. WARMING NEOPRENE BALLOONS. If a neoprene balloon is subjected to cold or becomes cold in transit, it must be conditioned, that is, it must be warmed before it is used. Remove the neoprene balloon from its container, and heat the balloon near a stove to a temperature of about 80° F. Make sure that the heat is distributed evenly over the entire surface of the balloon. Inflate in the usual manner in an inflation shelter.

21. Moistureproofing and Fungiproofing

Moistureproofing and fungiproofing will not be required for this equipment.

SECTION IV

SUPPLEMENTARY DATA

22. List of Balloons and Associated Equipment

The symbol (*) is used in this table to refer to the original model of a series (as ML–157) and the model designated by suffix letter A.

Signal Corps stock No.	Item	Function	Color	Weight		Dimensions and remarks
				Grams	Ounces	
7A177	Balloon ML–157–(*).	Ceiling	Black, dark blue, or purple.	10	0.35	Spherical, 3½-in. diameter; neck 2 in. long, 1-in. diameter.
7A178	Balloon ML–158–(*).	Ceiling	Red	10	.35	Spherical, 3½-in. diameter; neck 2 in. long, 1-in. diameter.
7A150	Balloon ML–50–(*).	Pilot	White or uncolored.	30	1.06	Spherical, 6-in. diameter; neck 2½ in. long, 1½-in. diameter.
7A151	Balloon ML–51–(*).	Pilot	Black, dark blue, or purple.	30	1.06	Spherical, 6-in. diameter; neck 2½ in. long, 1½-in. diameter.
7A164	Balloon ML–64–(*).	Pilot	Red	30	1.06	Spherical, 6-in. diameter; neck 2½ in. long, 1½-in. diameter.
7A175	Balloon ML–155–(*).	Pilot	Orange	30	1.06	Spherical, 6-in. diameter; neck 2½ in. long, 1½-in. diameter.
7A176	Balloon ML–156–(*).	Pilot	Yellow	30	1.06	Spherical, 6-in. diameter; neck 2½ in. long, 1½-in. diameter.
7A179	Balloon ML–159–(*).	Pilot	White	100	3.53	Spherical, 16-in. diameter; neck 2½–3 in. long, 7/16-in. to 1½-in. diameter.
7A180	Balloon ML–160–(*).	Pilot	Black	100	3.53	Spherical, 16-in. diameter; neck 2½–3 in. long, 7/16–1½-in. diameter.
7A181	Balloon ML–161–(*).	Pilot	Red	100	3.53	Spherical, 16-in. diameter; neck 2½–3 in. long, 7/16–1½-in. diameter.

Signal Corps stock No.	Item	Function	Color	Weight		Dimensions and remarks
				Grams	Ounces	
7A171	Balloon ML-131-(*).	Sounding	White	350	12.34	Spherical, 3-ft. diameter; neck 4½ in. long, (or 3 in. long if alternate provision for attachment of load is made 1-in. diameter).
7A849	Coupling ML-49.	Connects Hose ML-81 to hydrogen gas cylinder.				
7A850-187	Coupling ML-187.	Connects Tubing ML-188 to Hose ML-81.				
7A981	Hose ML-81	Used as connection in inflation of all balloons.				5 feet long, rubber.
7A981-10	Hose ML-81	Used as connection in inflation of sounding balloons.				10 feet long, rubber.
7A656	Cock ML-56	Used in inflation of 30-gram balloons.		132	4.66	Gas hosecock with enlarged end for fastening balloon and attachment for rubber hose.
7A700-201A	Cock ML-201-A.	Used in inflation of 100-gram balloons.		575	20.28	Gas hosecock with end for fastening balloon and attachment for rubber hose.
7A1199A-186	Nozzle ML-186.	Used in inflation of 10-gram ceiling balloons.		39	1.38	Consists of wooden nozzle with end for fastening balloon and attachment for rubber tubing.
7A1199A-196	Nozzle ML-196.	Used in inflation of sounding balloons.		1,500 (basic)	52.91	Consists of metal nozzle with end for fastening balloon.
7A401	Candle ML-90.	Used in Lantern ML-91.		7	0.25	Stearic acid and paraffin; melting point about 128° F.
7A1105	Lantern ML-91.	Used in making night flights with pilot balloon.		6	0.21	Paper.
7A1119	Lighting Unit ML-179.	Used in making night flights with pilot balloon.		35	1.23	Consists of battery and bulb.
7A1207-100	Parachute (miniature).	Used with lighting unit		4	0.11	Paper, approximately 16-in. diameter.
7A1207-132	Parachute ML-132.	Used with radiosonde			5	Paper or cloth, approximately 44-in. diameter.
	Pins	Used to hold candle in lantern.				Straight.
7A1334-193	Hydrogen Regulator ML-193.	Used on hydrogen cylinder to indicate pressure and to provide a means of controlling rate of flow of gas. (Cannot be used with hydrogen generator.)				Consists of two gauges with a diaphram type reducing valve.

Signal Corps stock No.	Item	Function	Color	Weight		Dimensions and remarks
				Grams	Ounces	
6M18	Rubber bands No. 16 or 18.	Used for tying off ceiling and 30-gram pilot balloons after inflation and as an aid in releasing lantern unit and radiosonde.				
7A1928	Tubing ML-188.	Used with Nozzle ML-186 for inflation of ceiling balloon.				
6Z8820.1	Twine [1]	Used with lighting unit and lantern, and for tying off sounding balloons and 100-gram pilot balloons.				8-ply cotton.
6Z8822	Twine [1]	Used for suspending radiosonde from sounding balloon.				16-ply cotton.
	Wrench	Used to attach Coupling ML-49 to hydrogen cylinder.				Jaw opening at least 1¼ in.

[1] Any cord of the same weight and about 50 pounds test strength can be used.

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