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FM 4–196

WAR DEPARTMENT

# ANTIAIRCRAFT ARTILLERY FIELD MANUAL

## BARRAGE BALLOON RIGGING AND FABRIC REPAIR

June 2, 1943

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## BARRAGE BALLOON RIGGING AND FABRIC REPAIR

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# ANTIAIRCRAFT ARTILLERY FIELD MANUAL

## BARRAGE BALLOON

## RIGGING AND FABRIC REPAIR

## CHAPTER 1

## FIBER ROPE


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### SECTION I

### GENERAL

■ 1. GENERAL.—The barrage balloon is a fragile mechanism requiring careful handling and maintenance of rigging and fabric to keep it in satisfactory operating condition. Since using personnel must spend much of their time in the upkeep of balloon matériel, it is essential that they have a thorough knowledge of rigging and fabric repair.

■ 2. SCOPE.—This manual deals with the construction, handling, and repairing of barrage balloon rigging and fabric.

■ 3. REFERENCES.—

FM 4–187, Service of the Balloon and Balloon Equipment, LA.
FM 4–188, Service of the Balloon and Balloon Equipment, VLA.
FM 5–35, Reference Data (Corps of Engineers).
TM 1–440, Parachutes, Aircraft Fabrics, and Clothing.
TM 5–225, Rigging and Engineer Hand Tools.

## SECTION II

## CORDAGE MATERIALS

**4. FIBER ROPES.**—Fiber ropes used in rigging and securing barrage balloons are generally made of manila or sisal hemp. For general information on these materials, see TM 5–225.

**5. CORDS.**—*a. General.*—Cords are small ropes made of a number of thin threads twisted together. Those used in balloon rigging are generally made of cotton or linen. Cords may be waxed with beeswax or paraffin or both. Cords are classified by the weight of a 60-foot length or by the number of threads in the cord. Thus an 8-ounce cord weighs 8 ounces per 60 feet, and a No. 9 cord has nine threads.

*b. Types.*—Several types of cords are used in balloon rigging: serving cords, blocking cords, breakable cords, and the gas-valve operating line.

(1) *Serving cords.*—Serving cords are made of waxed linen or cotton, and are used for serving rope splices and ends, for covering ends of cable splices, and for seizing rope. The proper size of cord for serving rope in common use is shown below.

| *Size of serving cord (number of threads)* | *Size of rope served (inches)* |
|---|---|
| 3 | ¼ |
| 5 | 5/16 |
| 9 | ⅜, ½, and ⅝ |
| 12 | ⅝ to 1 |

(2) *Blocking cords.*—No. 16 cord or larger is blocking cord. Blocking cord is usually made of hemp and has a starch finish. The most satisfactory size of cord for cable work is No. 18. A larger cord than No. 18 does not hold firmly because its diameter is too great in relation to the diameter of the cable ordinarily used for rigging. A smaller size cord requires more time to apply. Cord smaller than No. 9 should never be used.

(3) *Breakable cords.*—Breakable cords, which are cords having a low tensile strength, are used to secure the rip cord to the balloon envelope and to lace the parachute bag.





(4) *Gasvalve operating line.*—The gasvalve operating line used in balloons is made of synthetic silk or linen cord with a covering of synthetic silk. The linen cord has a minimum amount of stretch.

## SECTION III

## CARE AND USE OF FIBER ROPE

**6. CARE.**—For information on the care of rope, see TM 5–225.

**7. TENSILE STRENGTH.**—Tensile strength is the load (measured in pounds) necessary to produce rupture in a rope pulled in the direction of its length. Table I gives the tensile strength of rope commonly used.

TABLE I.—*Maximum tensile strength of rope (in pounds).*

| Size (diameter in inches) | Manila yacht | Cotton | Commercial manila | Sisal | Wartime* | Jute |
|---|---|---|---|---|---|---|
| ⅛ | | 120 | | | | |
| 3/16 | 570 | 250 | 450 | 273 | 336 | 300 |
| ¼ | 770 | 450 | 600 | 358 | 440 | 400 |
| 5/16 | 1,320 | 675 | 1,000 | 608 | 760 | 700 |
| ⅜ | 1,595 | 890 | 1,350 | 829 | 1,020 | 975 |
| 7/16 | 1,925 | | 1,750 | 1,138 | 1,400 | 1,300 |
| ½ | 2,695 | 1,450 | 2,650 | 1,722 | 2,120 | 1,680 |
| 9/16 | 3,465 | | 3,450 | 2,243 | 2,760 | |
| ⅝ | | 2,028 | 4,400 | 2,860 | 3,520 | 2,520 |
| ¾ | 5,390 | 3,100 | 5,400 | 3,510 | 4,320 | 3,400 |
| 13/16 | 6,490 | | 6,500 | 4,225 | 5,200 | |
| ⅞ | 7,700 | 3,900 | | 5,005 | 6,160 | |
| 15/16 | | | 7,700 | 5,428 | 6,660 | |
| 1 | 9,020 | 5,100 | 9,000 | 5,850 | 7,200 | |

* A type of sisal rope.

**8. WORKING STRENGTH.**—*a. Definition.*—Working strength is the maximum load (measured in pounds) to which it is considered a rope may be safely subjected when in service.

*b. Factor of safety.*—A factor of safety, expressed as

a ratio of the tensile strength to the working strength, is used in determining the working strength of a rope. Allow a factor of safety of 3 to 1 in computing the working strength of a new rope. For example, to handle 200 pounds, use a rope having a tensile strength of 600 pounds. From table I it will be seen that the following sizes of rope will be needed for this load: ¼-inch manila yacht, or 5/16-inch cotton, or ¼-inch commercial manila, or 5/16-inch sisal, or 5/16-inch wartime, or 5/16-inch jute. When old rope is used, make actual tests to determine its strength. Always bear in mind that rope deteriorates with age, and be guided accordingly. Never overestimate the strength of a rope.

■ 9. STRENGTH OF ATTACHMENT.—The strength of a rope is only as great as the strength of its attachment to another rope or to an object. When a rope is bent sharply around a small pipe, bar, or ring, or even around itself, the individual fibers are strained and the tensile strength of the rope at such a bend is reduced sometimes as much as 40 percent.

■ 10. CUTTING.—Before a rope is cut, a serving always should be placed on each side of the spot where the rope is to be cut. The serving will prevent the rope from unlaying or unraveling. For information on serving, see paragraphs 26 and 27.

■ 11. COILING.—*a. General.*—Certain established techniques must be followed in coiling and uncoiling fiber rope. (See TM 5–225.)

*b. Coiling handling lines.*—Coiling the handling lines on low altitude barrage balloons offers special problems. To coil these lines, proceed as follows:

(1) Grasp the rope in the left hand, thumb toward the free end, and hold the line with the left hand as shown in step *A*, figure 1.

(2) Take the free end of the line in the right hand approximately opposite the right hip. (See step *A*, fig. 1.)

(3) With the right hand, loop the line into a series of coils of the same size and hold the coils in the left hand. Be sure





that the coils and the lay of the rope are in the same direction.

(4) When the full length of the rope has been coiled, pass the right hand through the center of the coil, reach up behind the coil, grasp the standing part of the line above the coil and pull it through the coil, forming a loop. (See step *B*, fig. 1.)

(5) Bring the loop up across the front of the coil, around behind the standing part of the line, and tie it off with an overhand knot. (See step *C*, fig. 1.)

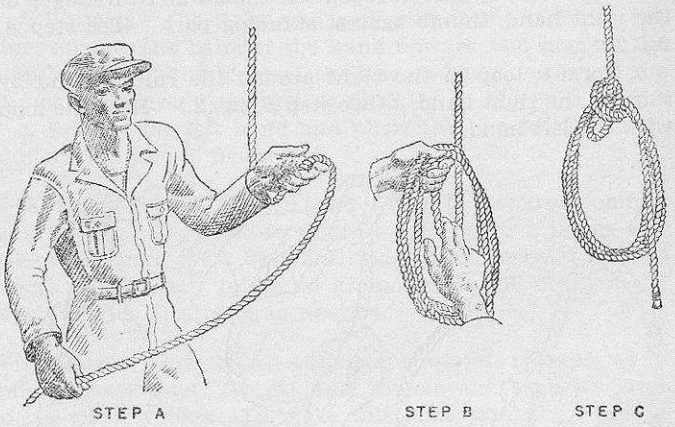



FIGURE 1.—Coiling handling lines.

## SECTION IV

## ROPE AND CORD KNOTS

■ 12. GENERAL.—For a general treatment of knots and hitches, see FM 5–35 and TM 5–225. The rope knots and hitches which are not treated in other manuals, or which are tied in a special way for balloon work, are discussed in this section.

■ 13. BOWLINE.—The bowline is used to attach the rip cord either to the flying cable when the low altitude balloon is

flying or to a point on the bed when the balloon is moored. Because the knot often must be tied by a crewman reaching above his head, the following special method of tying should be learned by all balloon operators:

*a.* Place the forefinger of the right hand along and near the end of the running end of the line. Hold the standing part of the line with the left hand, palm up.

*b.* Place the running end over and at right angles to the standing part beyond the left hand. Grasp the running end and the standing part between the thumb and forefinger of the right hand, thumb against standing part. (See step *A*, fig. 2.)

*c.* Form a loop in the bight around the running end by turning the right hand. (See step *B*, fig. 2.) Hold the loop with the left hand.

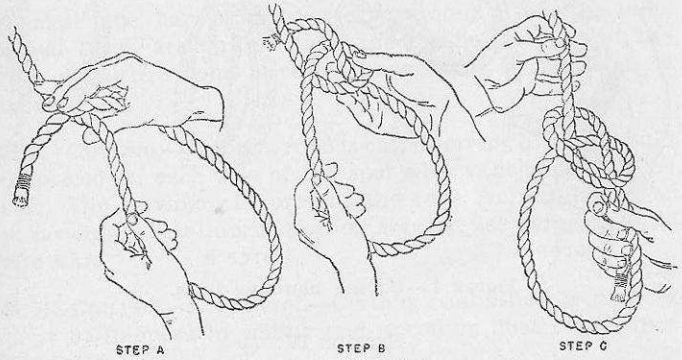



FIGURE 2.—Bowline.

*d.* Pass the running end back and around the standing part, down through the loop. Then pull the two parallel parts of the running end against the standing part until the knot is tight. (See step *C*, fig. 2.)

■ 14. SWAB HITCH.—A swab hitch is a quick-release hitch used in balloon work for tying handling lines to the eyes of the wire spider. To make the swab hitch, proceed as follows:

*a.* Stand facing the spider on the right side of the handling line.





*b.* Pass the running end of the handling line up through the spider eye about 8 inches past the marking on the handling line.

*c.* Double the line back along the standing part with the running end to the right. (See step *A*, fig. 3.)

*d.* Grasp the bight thus formed in the left hand at the spider eye to hold the line in place.

*e.* Then, with palm down, pass the right hand under the running end of the line (see step *B*, fig. 3) over the spider leg, and grasp the running end of the line. (See step *C*, fig. 3.)

*f.* Withdraw the right arm and with it the bight in the line, turning the palm of the hand upward and placing the running end of the bight of the line on the side toward the throat of the eye. (See step *D*, fig. 3.)

*g.* Release the left hand and allow the line to pull tight, as shown in step *E*, figure 3.

■ 15. LARK'S HEAD.—A lark's head is used to fasten a grommet to a line or an eye, and to fasten a soft eye to a larger soft eye or to a hard eye. In balloon rigging it is used at various places, particularly to fasten grommets to the octagon. A lark's head is illustrated in figure 4.

■ 16. SINGLE BOWKNOT.—A single bowknot is used as a quick-release knot, for example to join the sandbag lines to the rigging lines. To make this knot, pass the running end of the line in which the knot is to be tied around the object to which the line is to be attached. Then tie an overhand knot, leaving the loop in the running end. (See fig. 4.)

■ 17. REEF BEND.—A reef bend is used to join two soft eyes of approximately the same size or to join a bight in one rope to a soft eye in another. For example, a reef bend is used to join the mooring-line extensions to the mooring lines. To make a reef bend, pass one eye over the second eye. Then pull the free end of the line in which the first eye is made through the second eye. The completed reef bend looks like a square knot and the pull of each eye is against the walls of the other. (See fig. 5.)

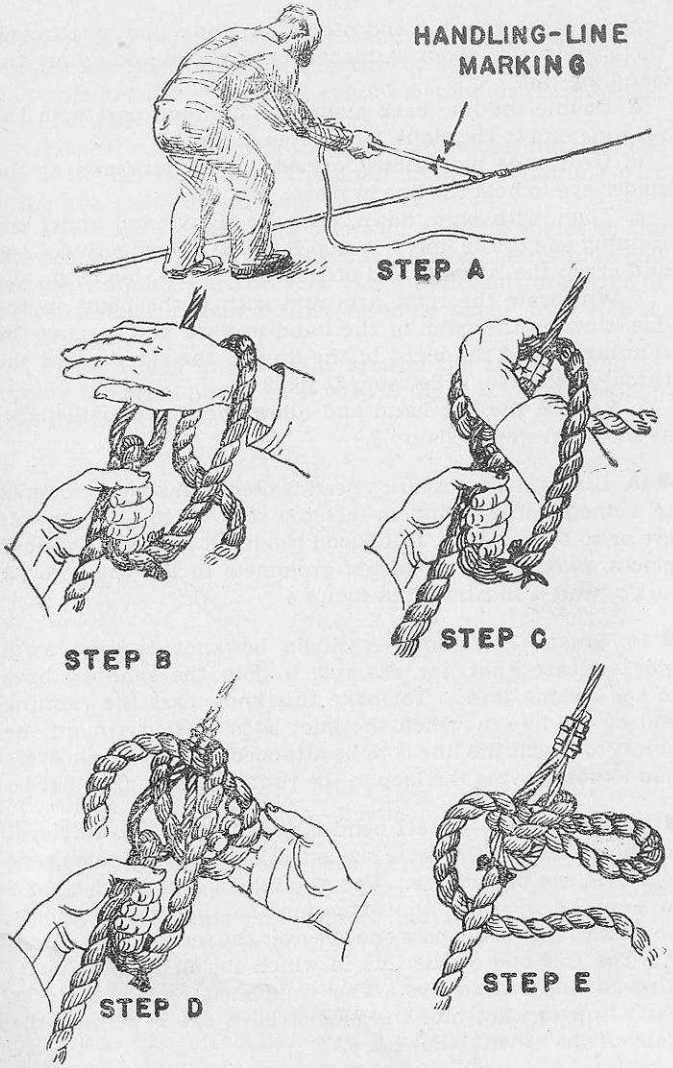



FIGURE 3.—Swab hitch.





■ 18. PICKETING HITCH.—A picketing hitch is used to fasten handling lines to eyes or to screw pickets and to fasten the tail-line strop to the bungee assembly. The standing

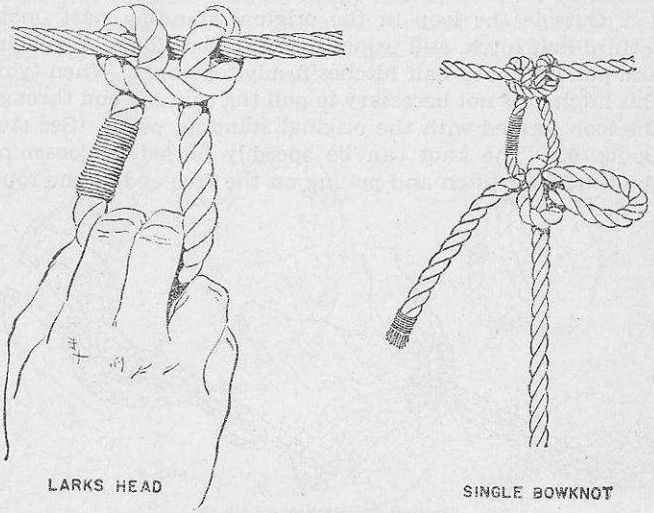



FIGURE 4.—Larks head and single bowknot.

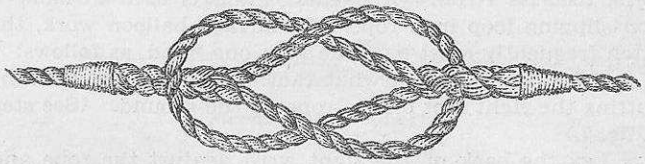


FIGURE 5.—Reef bend.

part of the rope can easily be lengthened or shortened. To make a picketing hitch, proceed as follows:

*a.* Pass the bight in the running end of the line through the eye or screw picket. Pull the slack out of the line and make a half hitch around the standing part of the line, using the tensioned side of the bight.

*b.* Continue using the tensioned side of the bight and lay another half hitch over and above the first half hitch (away from the eye or picket) and within the loop formed with the original standing part. (See step *A*, fig. 6.)

*c.* Outside the loop in the original standing part, make a third half hitch, still using the tensioned side of the bight, and pull the three half hitches firmly together. When tying this hitch, it is not necessary to pull the running end through the loop formed with the original standing part. (See step *B*, fig. 6.) The knot can be speedily untied by loosening the third half hitch and pulling on the free end of the rope.

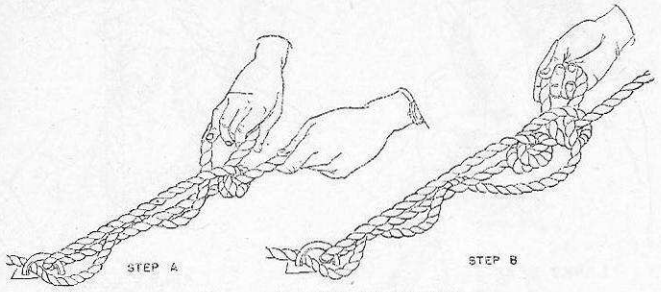



FIGURE 6.—Picketing hitch.

■ 19. HARNESS HITCH.—A harness hitch is used to make a non-slipping loop in a rope. In barrage balloon work, the hitch frequently must be made with one hand, as follows:

*a.* Keep the rope somewhat taut. This may be done by putting the right foot on the rope on the ground. (See step *A*, fig. 7.)

*b.* Lay the back of the right wrist against the rope and reach around and grasp the rope with the fingers of the right hand. (See step *A*, fig. 7.)

*c.* Raise and turn the right hand inward forming a loose loop in front of the standing part of the rope. (See step *B*, fig. 7.)

*d.* Reach around to the right of the standing part of the rope and grasp the left side of the loop. (See step *C*, fig. 7.)

*e.* Now pull the right hand back through the opening





between the standing part of the rope and the other side of the loop. (See step *D*, fig. 7.) Step *E*, figure 7, shows the completed knot.

■ 20. CORD KNOTS.—There are a few knots used in joining cords and small twine. The most common ones used in balloon work are the square knot, silk line tie, and surgeon's knot.

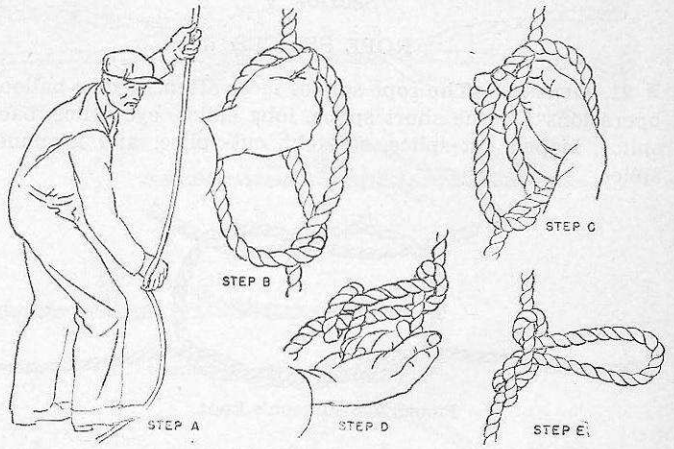



FIGURE 7.—Harness hitch.



FIGURE 8.—Silk line tie.

*a. Square knot.*—Information on the square knot is found in FM 5–35 and TM 5–225.

*b. Silk line tie.*—The gas-valve operating line is joined by a silk line tie. This tie consists primarily of a square knot in the line. After the square knot has been tied, a half hitch is taken with the running ends on the standing part on each side of the square knot and the running ends are sewed or seized to the standing parts. (See fig. 8.)

*c. Surgeon's knot.*—The surgeon's knot, a variation of the square knot, is used in balloon work to tie bulky packages. To tie it, the two running ends are passed completely around each other, as in the first step of making the square knot. Then one additional turn is made around the standing part with either of the two ends, and the knot is finished in the manner of the square knot. (See fig. 9.)

## SECTION V

## ROPE SPLICES

21. GENERAL.—The rope splices most often used in balloon operations are the short splice, long splice, eye splice, back splice, looped cut-splice, straight cut-splice, and grommet splice.

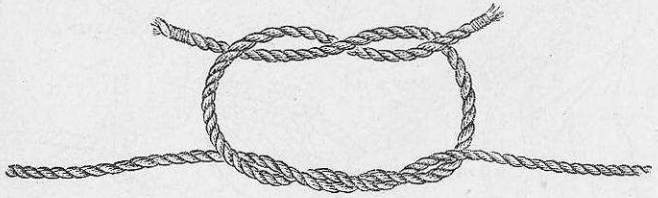


FIGURE 9.—Surgeon's knot.

22. SHORT SPLICE, LONG SPLICE, EYE SPLICE, AND BACK SPLICE.—For directions for making and using the short splice, long splice, eye splice, and back splice, see TM 5–225.

23. LOOPED CUT-SPLICE.—A looped cut-splice is used in a rope to form a permanent eye which will absorb pull parallel to the rope in the direction of the loop. (See fig. 10.) To make a looped cut-splice, unlay each of the two ends of the rope forming the eye (rope 1) for a distance of at least fifteen times the diameter of the rope. (See step *A*, fig. 10.) For making looped cut-splices in balloon mooring and handling lines, the length of the center portion of the rope between the unlaid portions in step *A* is about 9 inches. This will make a looped cut-splice with an internal length of about 5 inches. Place rope 1 into rope 2 as shown in step *B*, figure





10. Then using the same method used in making an eye splice, tuck the strands of rope 1 at both ends into the strands of rope 2. Be sure that both ends of rope 1 are spliced into rope 2 in the same direction. Take three tucks with each strand and serve the splices. (See step *C*, fig. 10.)

24. STRAIGHT CUT-SPLICE.—A straight cut-splice is used in a line to form a permanent eye which will act as a keeper

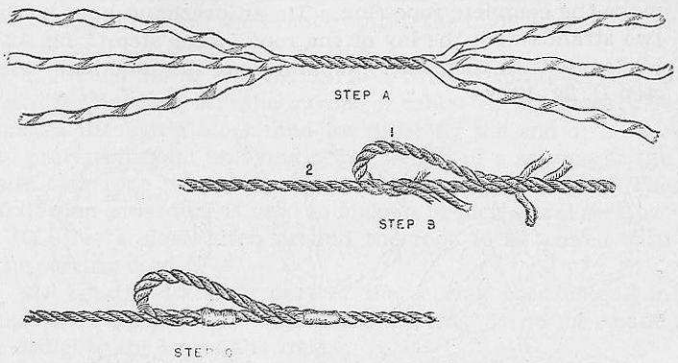



FIGURE 10.—Looped cut-splice.

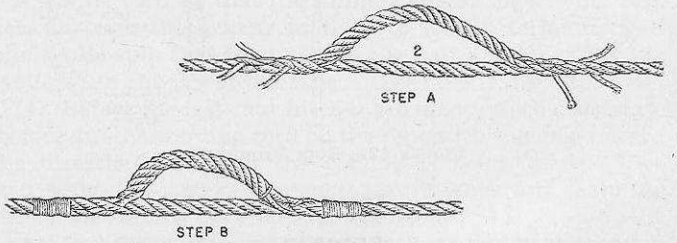



FIGURE 11.—Straight cut-splice.

to prevent lateral movement of any rope, grommet, or cable attached to the standing part of the line at the point of the splice. The straight cut-splice is made in the same way as the looped cut-splice except that rope 1 is spliced into rope 2 in opposite directions. Rope 1 may be smaller in size than rope 2. (See fig. 11.)

25. ROPE GROMMET.—A rope grommet is a rope ring. (See fig. 12.) To make a three-stranded grommet, unlay a rope and take one strand about four and a half times the circumference of the desired grommet. Form a loop of the desired size near one end of the strand. (See step *A*, fig. 12.) Lay the strand around the loop, being sure that it follows the lay of the strand in the loop. (See step *B*, fig. 12.) Then follow around for the third time, fitting in the strand to make the complete rope ring. Tie an overhand knot in the two strands with the lay of the rope. (See step *C*, fig. 12.) Make one tuck with each end, and serve the junction. (See step *D*, fig. 12.)

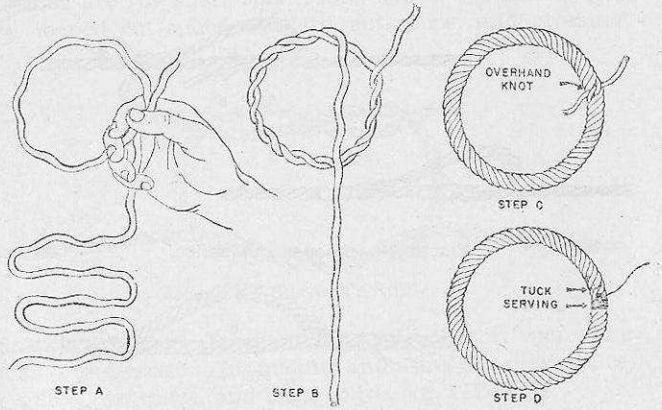



FIGURE 12.—Rope grommet.

## SECTION VI

## SERVING

26. GENERAL.—*a. Definition.*—Serving is the operation of placing a protective covering of cord or wire on the outer surface of rope or cable.

*b. Instructions.*—Apply all servings tightly and lock all ends. In serving an eye splice, or any other junction of rope varying in diameter, be sure to start at the smaller diameter





and serve toward the larger; otherwise it will be impossible to keep the serving tight.

*c. Finishing.*—Finish all servings with two coats of shellac. If shellac is not available, apply a heavy coat of wax to the serving cord before starting the serving.

27. METHODS.—There are several methods of serving rope and cable, but only three are used in rigging barrage balloons. They are the French spiral, the underhand French spiral, and the cockscomb serving.

*a. French spiral* (see fig. 13).—A French spiral serving is used for finishing all splices (rope or cable) except those to be passed through a block, and for finishing the end of a rope to prevent it from unlaying. The length of a serving at the end of a rope should equal the diameter of the rope. The following procedure is used to make a French spiral serving:

(1) Tie a clove hitch around the rope to be served with the serving cord.

(2) Let the standing part of the serving cord extend in the direction toward which the serving is to be made, parallel to the lay of the rope.

(3) Make a series of half hitches around the rope with the serving cord, so that the running end of the serving cord goes through the loop from right to left to form the half hitch. Be sure that the knots of the half hitches follow the "valleys" in the lay of the rope. (See step *A*, fig. 13.)

(4) Before the last four hitches are made, place a separate loop of another serving cord on the rope with the loop toward the direction in which the serving is being made. (See step *A*, fig. 13.) Make four more half hitches, and reeve the end of the serving cord through the loop.

(5) Pull the running end of the serving cord back through the serving by means of the loop.

(6) Cut off all loose ends. (See step *B*, fig. 13.)

*b. Underhand French spiral* (see fig. 14.)—An underhand French spiral serving is used for finishing splices to be passed through a block, and to finish grommets. An underhand French spiral is started exactly like the French spiral. The half hitches are made by passing the running end of the

serving cord through the loop from left to right. In this serving the half hitches are under the serving instead of on top of it.

*c. Cockscomb serving* (see fig. 14).—A cockscomb serving

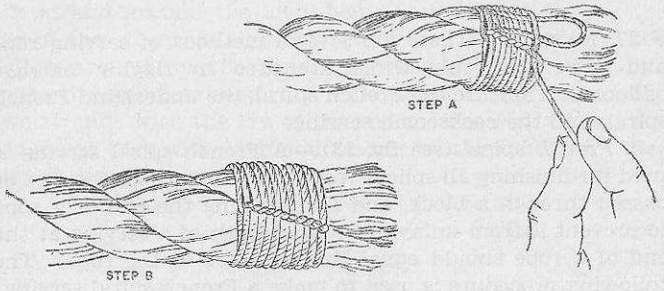



FIGURE 13.—French spiral serving.

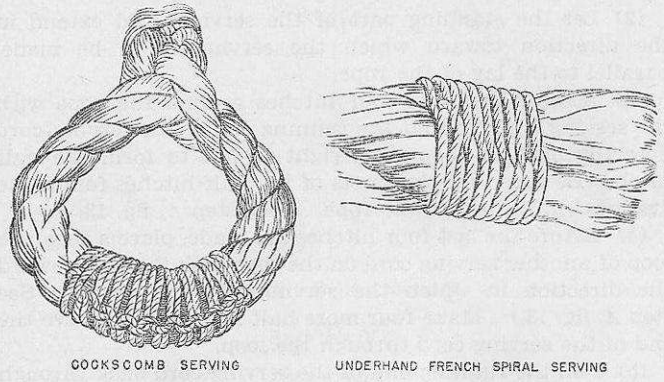



FIGURE 14.—Underhand French spiral and cockscomb serving.

is used for a protective covering on the crown of an eye or on a grommet wherever reinforcement is required. A cockscomb serving is made like a French spiral serving, except that the direction of the half hitches is alternated: one with the lay of the rope, the next against it. Thus, the knots of the half hitches are all on the outer circumference of the eye.



## CHAPTER 2

## CABLE (WIRE ROPE)

Paragraphs

SECTION I. General ..... 28–29
II. Measuring, marking, cutting, and parceling cable .. 30–35
III. Cable splices ..... 36–38

### SECTION I

### GENERAL

■ 28. GENERAL.—In barrage balloon work, the terms "cable" and "wire rope" are used interchangeably. For information concerning the construction and care of wire rope, see TM 5–225.

■ 29. FLYING CABLE.—*a. General.*—The principal use of cable for low altitude barrage balloons is for flying cable. (For information on the use of cable on the VLA balloon, see FM 4–188.)

*b. M2 cable.*—The M2 cable is made of six high tensile steel wires laid around a central hemp core, which is impregnated with a neutral oil or grease to lubricate the cable. The construction of this cable is referred to as 6 by 1, which means that each of the six strands is made of only one wire.

*c. M1 cable.*—The M1 flying cable is made of six steel strands of seven wires each, laid around a core of another strand of seven wires. This construction is known as 7 by 7, which means that each of the seven strands is made up of seven wires.

*d. Care.*—For proper methods of examining and caring for flying cable, see FM 4–187.

*e. Characteristics.*—The characteristics of flying cable used with low altitude balloons are given in table II.

TABLE II.—*Characteristics of flying cable used with LA balloons*

| | M2 | M1 |
|---|---|---|
| Size | 0.24 inches | 7/32 inches. |
| Construction | 6 by 1 | 7 by 7. |
| Core | Hemp | Steel. |
| Tensile strength | 7,600 pounds | 6,800 pounds. |
| Weight per 1,000 feet (approximate) | 90 pounds | 83 pounds. |

## SECTION II

## MEASURING, MARKING, CUTTING, AND PARCELING CABLE

■ 30. MEASURING.—*a. General.*—A knowledge of cable measurement is necessary for determining the length of cable required to make a strop of a given length. (A strop is any piece of cable or rope with an eye in one or both ends.) The piece of cable from which a strop is to be made must be long enough to allow for the eyes and splices.

*b. Finished length.*—The finished length of a strop is the over-all length of the strop when the eyes have been spliced and the strop is measured with the eyes held at their proper width.

*c. Cutting length.*—The cutting length of a strop is the length of cable required to make a strop of the desired finished length.

■ 31. DETERMINING CUTTING LENGTH.—*a. General.*—The method of determining the cutting length of cable to make a strop will be shown by an example. Figure 15 shows a 2-foot spider leg. It has an 8- by 3-inch eye in one end, a 4- by 2-inch eye in the other end, and a finished length of 2 feet. The steps in determining the cutting length of this strop are outlined below.

*b. Steps.*—(1) Determine the length of cable between the throats of the large and small eyes by subtracting the length of the large eye and the length of the small eye from the over-all length.





(2) Determine the circumference of the large eye by using the formula $2L+\frac{1}{2}W$, where $L$ is the length of the eye and $W$ is the width of the eye.

(3) Determine the circumference of the small eye by using the same formula given in (2) above.

(4) To allow for tucking, add 8 inches for each splice to be made.

(5) Add the results obtained in (1) through (4) above to get the cutting length.

*c. Results.*—The steps outlined in *b* above are expressed in figures below:

| | | |
|---|---|---|
| (1) 2′—8″—4″ | =1′ | (Length between throats). |
| (2) (2×8″)+(½×3″)=16″+1½″ | =1′ 5½ | (Circumference of large eye). |
| (3) (2×4″)+(½×2″)= 8″+1″ | = 9″ | (Circumference of small eye). |
| (4) 2×8″ | =1′ 4″ | (Allowance for splicing). |
| (5) Total | 4′ 6½″ | (Cutting length). |

■ 32. METHOD OF MEASURING AND MARKING CABLE.—If a number of strops of the same type are to be made, it will be found convenient to follow a method such as the one outlined below for measuring and marking the cable. This method is illustrated in figure 15 for the 2-foot spider leg described in paragraph 31 above. The method involves the following procedure:

*a.* Drive six nails in the top of a work bench, as illustrated in figure 15. The distances between nails *A* and *B* will be the length of cable required for tucking an eye-splice; the distances between nails *B* and *C* will be the circumference of the eyes, and the distance between nails *C*

and *C* will be the length of the strop between the throats of the eyes.

*b.* Place one end of the cable at nail *A*, and cut the cable at the other nail *A*. Mark the cable with crayon at nails *B* and *C*.

*c.* Make a short serving at the crayon marks by nails *B*, starting at the mark and serving six or eight turns toward the center of the cable. Unlay the cable from the ends back to the servings.

*d.* To make the eyes, start tucking the splices at the crayon marks made at nails *C*.

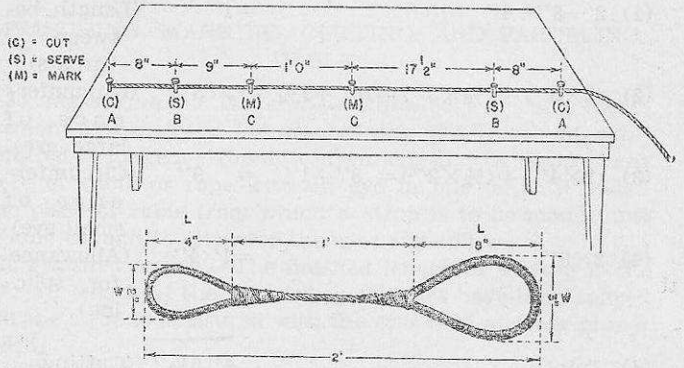



FIGURE 15.—Two-foot spider leg and method of measuring and marking cable.

■ 33. CUTTING.—In cutting cable, observe the following rules:

*a.* Before cutting, place a serving at each side of the place to be cut. The distance between these servings varies with the diameter of the cable and should be a minimum of one diameter. If extra-flexible cable is used, friction tape may be used to make the serving.

*b.* Cut the cable with a sharp tool (cable cutter). When used with nicopress sleeves, cable should be cut with the small welding tip of an acetylene torch.

*c.* Dip the ends of the cable in solder if the cable has been cut with a sharp tool, to prevent the strands from unlaying. If solder is not obtainable, each strand of extra-flexible cable





must be served at its end with cord or a strip of highly adhesive tape. This is not necessary if the cable has been cut with an acetylene torch, since the cutting fuses the ends of the strands.

■ 34. PARCELING.—*a.* Parceling is the operation of wrapping cable with protecting tape or cloth.

*b.* Splices should be parceled to—

(1) Protect fabric and personnel by covering the sharp points where the strands have been cut off.

(2) Give a base for serving.

(3) Prevent corrosion. Parceling should be of oil-soaked tape or cloth. If oil-soaked material is not available, the parceling, after application, should be painted with a noncorrosive metallic paint.

(4) Hold the splice in shape.

*c.* Those eyes to which rope lines are tied (cradle legs and spider legs) must be heavily parceled to prevent rapid wear of the rope lines.

*d.* Parceling should be applied to an eye splice as follows (see fig. 16):

(1) Start parceling ½ inch above the sharp point nearest the eye (point *A*).

(2) Parcel to ½ inch beyond the farthest sharp point (point *B*).

(3) Then parcel back to a point about 1 inch from the throat of the eye (point *C*). The parceling is not carried back completely to the throat of the eye to facilitate inspection of the splice around the throat.

(4) As the parceling is applied, lay the sharp points toward the end of the splice.

*e.* Parceling may be either light, medium, or heavy.

(1) To make a light parceling, cover the area to be parceled by wrapping it with tape or cloth so that the second turn of the wrap just covers the outer edge of the first turn, the third wrap just covers the outer edge of the second turn, and so on until completion.

(2) To make a medium parceling, cover the area to be parceled by a light parceling as described above and repeat

the process once, so that there will be two thicknesses over the part to be covered.

(3) To make a heavy parceling, cover the area to be parceled by a light parceling as described above and repeat the process twice, so that there will be three thicknesses over the part to be covered.

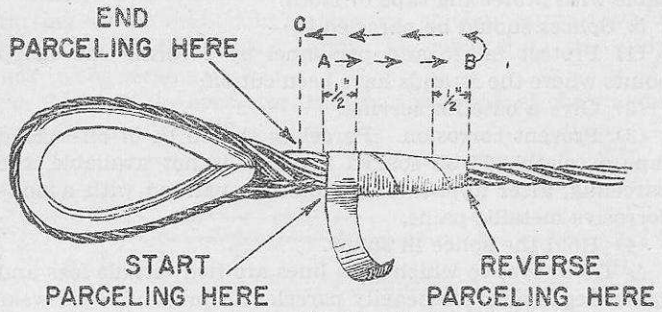



FIGURE 16.—Parceling.

■ 35. ROPE AND CABLE REPAIRING MATERIALS AND TOOLS.—Certain rope and cable repairing materials and tools, the uses of which are not self-explanatory, are listed below:

*a. Cable splicer.*—A cable splicer is an adjustable vise which holds the cable on a thimble while splicing is being done.

*b. End cutting compound nipper.*—The end cutting compound nipper is used for cutting short ends of strands in completing splices.

*c. Nicopress tool and sleeves.*—See paragraph 38.

## SECTION III

## CABLE SPLICES

■ 36. GENERAL.—This chapter discusses the wrapped and soldered splice and the nicopress sleeve splice. For methods of splicing cable by hand, see TM 5–225.

■ 37. WRAPPED AND SOLDERED SPLICE.—The wrapped and soldered splice is used primarily for VLA balloons to make eyes in the flying wire, when socket eyes and wedges are not available, and to make eyes in the foot ropes and stabilizer bracing wires. The method of making this splice is shown in FM 4–188. The solder used should be soft solder, grade A. The soldering flux should be a noncorrosive paste. The wrapping wire should be soft or annealed copper or iron wire, 0.0403 inch in diameter (19 gage).





■ 38. NICOPRESS SLEEVE SPLICE.—*a. General.*—The nicopress sleeve provides a rapid and effective method of splicing cable and may be used on any size cable employed in rigging LA barrage balloons.

*b. Sleeve.*—The sleeve is a length of nickel-copper alloy tubing, approximately oval in shape with its side slightly depressed. The diameter and length of the sleeve vary with the diameter of the cable to be spliced.

*c. Nicopress tool.*—The nicopress tool is used for compressing the sleeve on the cable. Each cable size requires a tool for that size.

*d. Making an eye-splice with nicopress sleeve.*—(1) To make an eye-splice with the nicopress sleeve, insert the cable end to be spliced into the sleeve and bend the cable back on itself, forming an eye of the proper size. (See fig. 17.)

(2) Pass the end back through the sleeve so that it extends ⅛-inch beyond the sleeve before it is pressed. This projection is necessary since the sleeve elongates under pressure.

(3) Compress the sleeve with the nicopress tool, allowing $\frac{1}{16}$-inch space between the presses. The number of presses made will vary with the length of the sleeve. (See fig. 17.) When making the presses, hold the sleeve exactly in line so that the sleeve is compressed along the major axis of its oval. To insure the correct splice, compress the nicopress tool until the handle bumpers meet. When making three presses, make the first one at the center, rotate the sleeve 180°, and press at each end.

*e. Pressure.*—The amount of sleeve pressure must be correct to insure satisfactory splices. A gage is provided for checking the diameter of the compressed sleeve. Hold the gage so that it fits over the compressed portion of the sleeve as shown in figure 17. If the splice is right, the compressed

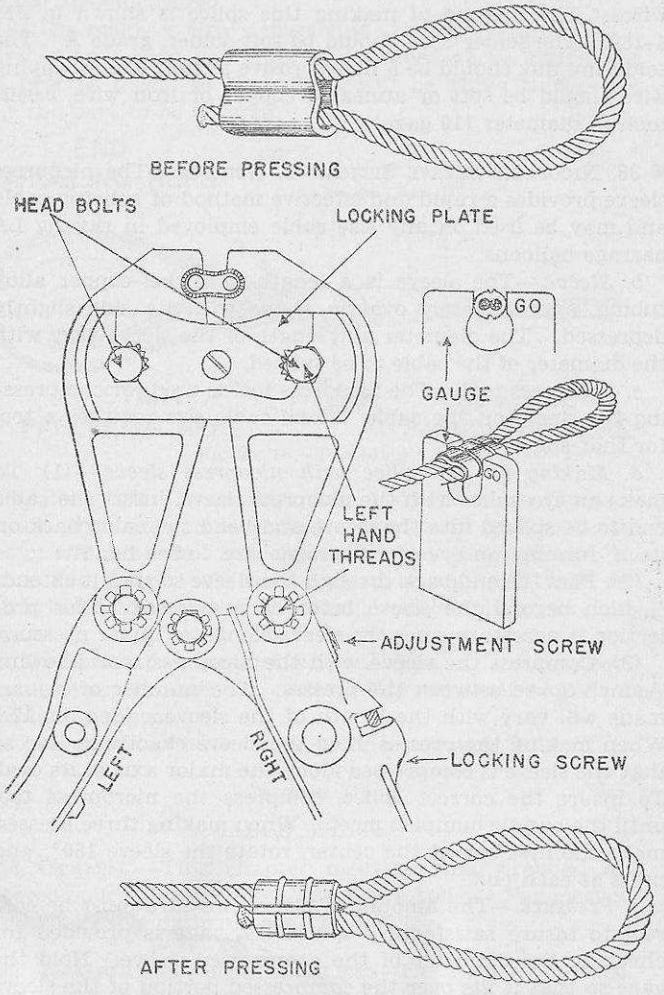



FIGURE 17.—Nicopress tool and method of splicing.





portion of the sleeve should enter the slot marked "Go" on the gage, and there should be no clearance between the sleeve and the sides of the gage.

*f. Adjustment.*—If the sleeve does not fit into the gage, it will be necessary to adjust the nicopress tool. A wrench is provided for this purpose. To adjust the tool, loosen the locking screw one or two turns and then turn the adjustment screw in a clockwise direction a fraction of a turn. Compress a sleeve and make another test with the gage. Continue turning the adjustment screw a little at a time until the sleeve passes easily into the gage. When the correct setting is obtained, turn up the locking screw hard to keep the tool adjusted. Always have the handles of the tool open when turning the screws.

*g. Care of nicopress tool.*—The tool should be inspected frequently during use. Necessary adjustments should be made, and the tool cleaned and oiled. The empty tool should work freely and should have a slight spring at the final closing. If it binds it can be eased by slightly loosening the head bolts. To loosen the head bolts, remove the locking plate, unscrew the head bolts ⅙ or ⅓ turn, and replace the locking plate. Note that when the tool is held as shown in figure 17, the two bolts on the right-hand side have left-hand threads and the other three bolts have right-hand threads.

*h. Removal of sleeve.*—The sleeve may be removed by laying it against an anvil or a similar hard surface and by hitting a chisel placed in a groove of the sleeve. This may be done without injuring the cable, and the eye may be readjusted and a new sleeve pressed on.

*i. Straight splices.*—Two pieces of cable may be spliced together by passing their ends through the sleeve in opposite directions and compressing the sleeve.

# CHAPTER 3

# FABRIC AND FABRIC REPAIR


| | | Paragraphs |
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| SECTION I. | General | 39–42 |
| II. | Care of fabric | 43–46 |
| III. | Fabric repair | 47–55 |
| IV. | Stitching | 56–57 |
| V. | Patching | 58–61 |
| VI. | Replacing panels | 62–64 |
| VII. | Gas and air valves | 65–66 |
| VIII. | Replacing rubber cords on Mk. VI balloon | 67–71 |


## SECTION I

## GENERAL

■ 39. DEFINITIONS.—Certain terms used in connection with barrage balloon fabric are defined below:

*a. Thread.*—Thread is a thin cord of flax, cotton, silk, or other fibrous substance twisted and drawn out. Thread is made in both right and left twist. The direction of the twist may be determined by holding the end of the cord in the left hand and turning it to the left between the thumb and forefinger of the right hand. If it tightens, it is left twist. If it unwinds, it is right twist.

*b. Warp.*—The warp of a cloth consists of the threads which run lengthwise of the cloth as it comes from the loom. (See fig. 18.)

*c. Filler.*—The filler of a cloth consists of the threads which run crosswise of the cloth as it comes from the loom. (See fig. 18.)

*d. Panels.*—Panels are the individual pieces of fabric which are seamed together to make up the envelope and the diaphragm of the balloon.

*e. Gore.*—A gore is a band of panels extending from nose to tail of the balloon.

*f. Ring.*—A ring is a band of panels extending around the balloon at right angles to its long axis.





■ 40. BALLOON FABRIC.—*a. Cloth.*—Cloth from which balloon fabric is constructed is woven from long staple cotton with equal stretch and tensile strength in warp and filler. (See fig. 18.)

*b. Proofing.*—Balloon cloth is made into fabric by proofing it with rubber or neoprene. Neoprene is a synthetic rubber made chiefly from limestone and coal tar products. Aluminum powder may be suspended in the last several coats of neoprene to give the outer surface of the fabric an aluminum coating. The aluminum coating reduces superheat and lessens the deterioration of the neoprene and the cloth.

*c. Single-ply fabric.*—Single-ply fabric is made by proofing a single thickness of cloth. It may or may not be coated with aluminum.

*d. Double-ply fabric.*—(1) *General.*—Double-ply fabric is made by vulcanizing together two pieces of single-ply fabric. Double-ply fabric may be made by vulcanizing a gas film between the two plies, in which case the fabric is known as gastight fabric. If the gas film is omitted the fabric is known as airtight fabric.

(2) *Double-ply parallel fabric.*—Double-ply parallel fabric is constructed by placing the two plies together so that the warp of one is parallel to the warp of the other, and the filler of one is parallel to the filler of the other. The total tensile strength of the double-ply fabric is approximately the sum of the tensile strengths of the single pieces in any one direction. (See fig. 18.)

(3) *Double-ply bias fabric.*—Double ply bias fabric is constructed by placing the two plies together so that one ply of cloth is secured to the other ply at an angle of 45°. The bias ply is said to be right- or left-handed according to the way the laps go from left to right or right to left when the finished fabric is viewed in the direction of the warp of the straight ply. This construction offers greater resistance to tearing than the double-ply parallel fabric, and the stretch of the fabric is minimized and is more uniform than that of double-ply parallel fabric. However, the tensile strength of double-ply bias fabric is not materially greater than that of single-ply fabric. (See fig. 18.)

41. CONSTRUCTION OF BALLOON.—*a. Envelope.*—(1) *Fabric.*—The envelope is made of gastight double-ply bias fabric, aluminum coated on the outside. This fabric is used because it offers a much greater resistance to tearing and to distortion and strain than single-ply or double-ply parallel fabric. The ballonet portion of the envelope may be made from airtight double-ply bias fabric.

(2) *Gores, rings, and panels.*—The construction of the balloon envelope varies with the width of the balloon fabric. See figures 19 and 20 for the construction of balloons with both 39-inch fabric and 42-inch fabric.

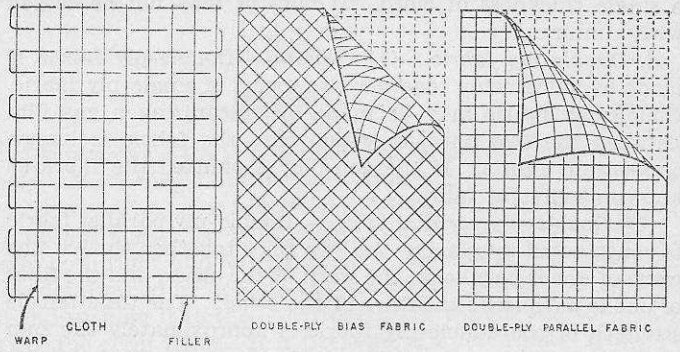



FIGURE 18.—Construction of cloth and fabric.

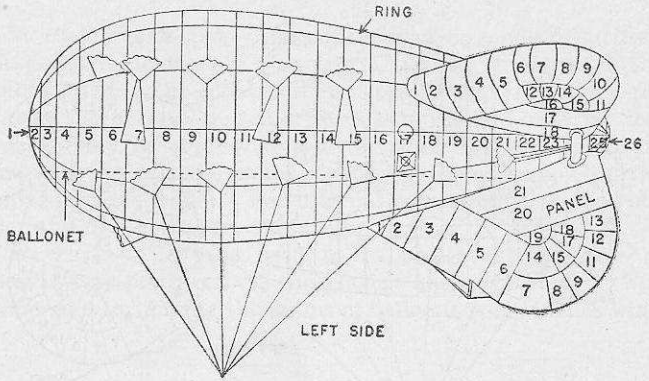
(3) *Bias.*—The bias of the panels on the D–8 balloon alternates along the gores and runs in the same direction in the rings. The bias on the Mk. VII and D–7 balloons alternates along the rings and runs in the same direction in the gores.

(4) *Overlap.*—In all three balloons the rings overlap from nose to tail and the gores overlap from top to bottom. (See fig. 21.)

*b. Diaphragm.*—The fabric used in the construction of the diaphragm is gastight double-ply parallel fabric. The fabric has no aluminum coating.







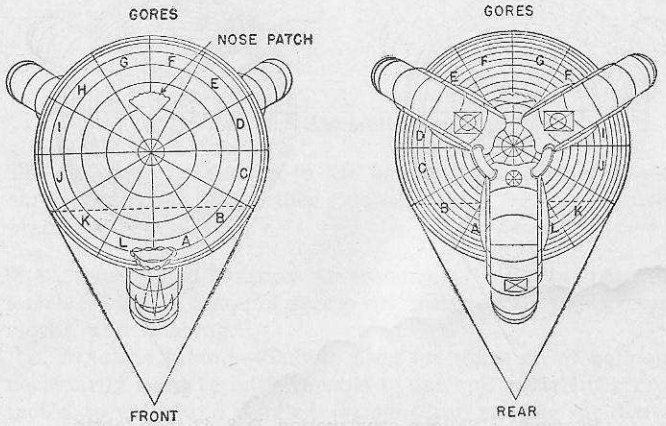
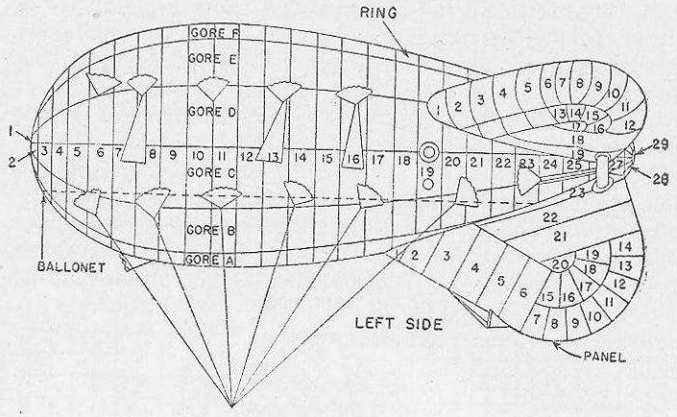




FIGURE 19.—Balloon construction, D–8, 39-inch fabric.



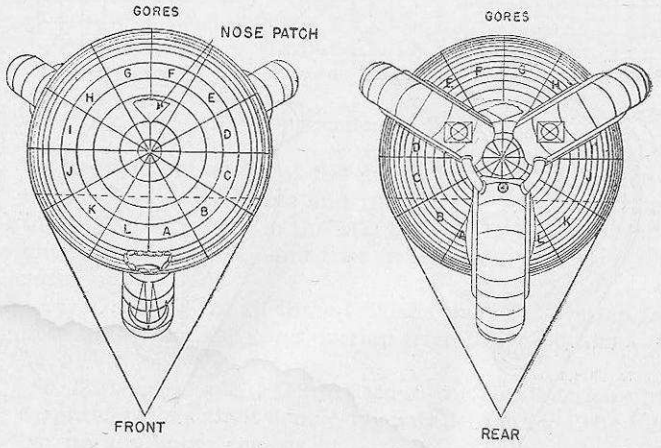




FIGURE 20.—Balloon construction, D–8, 42-inch fabric.





*c. Rudder and fins.*—The rudder may be made of airtight or gastight double-ply bias fabric, aluminum coated. The fabric used in the construction of the fins may be single-ply fabric, aluminum coated. The cloth used in making this fabric may be somewhat heavier than the cloth used in making the fabric for the double-ply construction of the envelope and rudder. For internal construction of the rudder and fins, see figure 22.

*d. Tape.*—The tape used in balloon construction is of Single-play cloth cut on the bias at an angle of 45°. The tape used for joining the seams of balloons is 1⅛ inches wide.

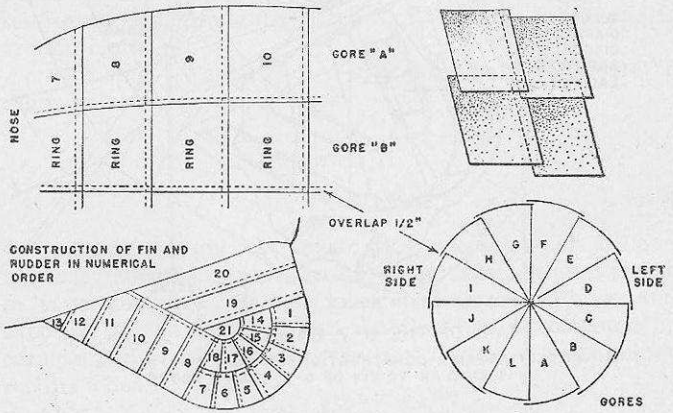
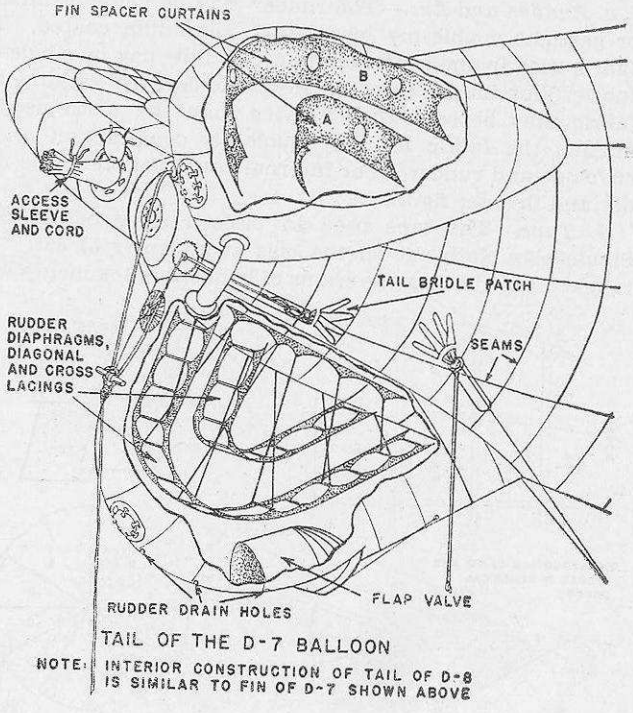



FIGURE 21.—Assembling panels.

The side to be cemented to the balloon is proofed with uncured neoprene. The other side is proofed with cured neoprene.

■ 42. FABRIC FOR BALLOON ACCESSORIES.—The principal balloon accessories made of fabric are inflation tubing, ground cloths, and webbing.

*a. Inflation tubing.*—Tubing used for inflation of balloons necessarily must be impermeable to gas and sufficiently protected to withstand rough treatment and chafing incidental to operation. The fabric of inflation tubing is constructed



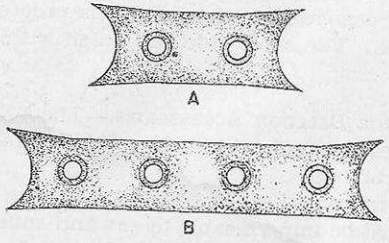




FIGURE 22.—Internal construction of rudder and fins.





of two plies: an inner ply of envelope fabric of the type described above, and an outer ply of 8-ounce khaki duck. The duck is proofed with neoprene. The two plies of tubing are thoroughly cemented together and vulcanized. The fabric used in the construction of the "wye" connections is identical with that used for inflation tubing.

*b. Ground cloths.*—Ground cloths are 20 by 20 feet. The fabric is 10-ounce Army, double-filled duck, waterproofed and dyed. The cloths are equipped with twelve ¾-inch iron grommets, one at each corner of the cloth and the others evenly spaced two to a side on each side of the cloth. The points at which the grommets are inserted in the cloth are reinforced with triangular patches of the same fabric as the ground cloths.

*c. Webbing.*—Webbing, used in making patches, should be 6-ply, herringbone woven duck.

## SECTION II

## CARE OF FABRIC

■ 43. DETERIORATION OF FABRIC.—Deterioration of balloon fabric is indicated by a weakening of the fabric or an increase in its permeability. Balloon fabric deteriorates with age and exposure to the elements, but deterioration is hastened by careless handling, faulty storage, and failure to make minor repairs when needed.

■ 44. DETERIORATION OF NEOPRENE.—The neoprene used in gas proofing balloon fabric is subject to different rates of deterioration depending on the conditions of manufacture and the elements of weather to which it is exposed.

*a. Conditions of manufacture.*—(1) *Overcuring.*—Neoprene that is overcured (hard case) deteriorates more rapidly than neoprene properly cured. Overcuring is produced by the use of an excessive amount of accelerator in curing the neoprene gum. Deterioration caused by overcuring is indicated by the appearance of dark greasy spots on the surface of the balloon fabric. Such areas may be reproofed.

(2) *Light spots.*—The black pigment used in the neoprene frequently may be unevenly distributed in the proofing, caus-

ing light spots in the fabric. These light spots are actually gastight, but when viewed from the interior of the balloon they may be mistaken for pinholes in the fabric. Light spots may be distinguished from actual pinholes by the use of a magnifying glass, under which the fabric across the light spots is plainly visible.

*b. Elements of weather.*—(1) *Sunlight.*—Neoprene deteriorates rapidly in bright sunlight. Aluminum coating the exterior surface of balloon fabric reduces this deterioration.

(2) *Cold.*—When fabric is subjected to low temperatures, it loses its pliability. Balloon fabric which has become brittle should be handled as little as possible. Bends, folds, or blows will crack cold, brittle balloon fabric.

■ 45. HANDLING.—Balloon fabric is delicate and must be handled carefully. It should not be permitted to come in contact with sharp or uneven objects. The following precautions must be *scrupulously* observed:

*a. A deflated balloon must be laid only on linoleum, a smoothly-troweled cement floor, or ground cloths. Any surface upon which a balloon is laid must always be kept clean.*

*b. Under no circumstances should anyone step on balloon fabric unless in stocking feet or in special cotton footees. Walking on the balloon must be kept to a minimum.*

*c. Abrasive substances must not be allowed to come in contact with a balloon. A muddy balloon should be washed before it is walked upon.*

*d. Care must be exercised in the handling of tools to prevent puncturing the balloon.*

*e. All oily or greasy material must be kept from contact with balloon fabric.*

*f. Folding, rolling, stretching, and handling of a deflated balloon must be kept at a minimum.*

*g. During icy conditions care must be taken to prevent the ice from puncturing the fabric.*

■ 46. INSPECTION.—The balloon should be inspected regularly and carefully to make certain that no defects exist. Defects must be repaired immediately. All points at which the fabric is under particular strain or chafing should receive close attention and careful checking. Rough handling by the crew





and improper tension on any point in flying or mooring must be avoided. For the proper methods of inspecting balloons and fabrics, see FM 4–182.

## SECTION III

## FABRIC REPAIR

■ 47. GENERAL.—The principles of fabric repair set forth in this chapter apply to both LA and VLA balloons. However, certain equipment on the VLA balloon varies from that of the LA balloon and special mention of this equipment is made below.

■ 48. CLASSES OF REPAIR.—*a. Minor repairs.*—Minor fabric repairs to balloons are made in the field by platoon personnel. Minor fabric repairs consist principally of cementing temporary patches over scuffed places, pinholes, and small tears.

*b. Major repairs.*—Major fabric repairs to balloons are made by battery or headquarters battery personnel. Major fabric repairs consist of repairing large tears and holes; replacing whole panels, patches, and parts of the balloon such as fins; and proofing the balloon to decrease permeability.

■ 49. MATERIALS.—The materials used to repair balloon fabric consist of fabric, cement, thread and needles, and fabric repair tools.

■ 50. MATCHING FABRIC.—When repairing a balloon, the following rules must be observed.

*a.* Patch rubberized fabric with rubberized fabric.

*b.* Patch neoprened fabric with neoprened fabric.

*c.* Match bias of patch with bias of balloon fabric.

■ 51. CEMENT.—*a. General.*—Cement comes from the manufacturer either in three parts (a cement base, an activator, and a thinner), or in two parts (a cement base and a thinner). The ingredients must be mixed according to the manufacturer's instructions accompanying them. Never use cement that has been mixed longer than the time specified by the manufacturer.

*b. Rules for applying.*—The following rules will be observed in applying cement:

(1) All surfaces to which cement is to be applied must be thoroughly cleaned with benzol. Care must be taken not to use too much benzol, since an excess will break down the neoprene. Old cement is removed by erasing it with a piece of raw rubber. All aluminum is removed from aluminized fabrics where cement is to be applied. Steel wool is used for this purpose.

(2) Rubber cement is used with rubberized fabric, and neoprene cement is used with neoprened fabric.

(3) Dust, moisture, and sunlight cause cement to lose its adhesive qualities. Cement must be used in clean, dry places, out of the direct rays of the sun.

(4) The number of coats and method of application should follow the manufacturer's directions.

(5) After cementing, the surfaces which are cemented together must be thoroughly rolled with a vulcanizing roller or seam stitcher (see par. 53) to eliminate air bubbles and flatten the fabric.

(6) All spilled cement must be removed at once. Areas around cemented repairs are dusted with powdered soapstone or talc to cover the excess cement.

(7) In the construction of accessory patches, cement is allowed to dry for at least 12 hours before the patch is sewed with a sewing machine. At least 24 hours must be allowed for a cemented repair on a balloon to dry before the balloon is inflated.

*c. Precautions.*—The following precautions will be observed in using cement:

(1) Cement is highly inflammable and must be kept away from sparks and flames.

(2) The fumes of cement are dangerous to breathe. Cement must not be used in improperly ventilated places for prolonged periods of time.

■ 52. THREAD AND NEEDLES—*a. Thread.*—The thread used for hand sewing in the repair of balloons is linen, left-twist, unbleached, No. 16, three-cord; or linen, left-twist, unbleached, No. 30, three-cord. The thread used for machine sewing should be cotton, machine, soft finish, bleached, white, No.





12, four-cord. The terms "machine," "machine-twist," and "left-twist" appearing in thread nomenclature all indicate a left-twist thread. The shuttle and rotary hook of sewing machines will unwind a right-twist thread, causing thread breakage and weak seams.

*b. Needles.*—Both machine and hand needles are used in making repairs to balloon fabric.

(1) The following sizes of needles and thread are recommended for machine sewing:

| *Sizes of needles* | *Cotton thread No.* |
|---|---|
| 16 | 30 |
| 18 | 24 |
| 20 | 20 |
| 22 | 16 |
| 23 | 12 |
| 24, 25 | 8 |

(2) The hand needle commonly used for making the baseball stitch in repairing balloons is a 2½-inch upholsterer's needle, 17 gage. The hand needle commonly used for making the harness stitch in repairing balloons is a straight needle. A No. 2 needle is the most satisfactory for general use. (See fig. 24.)

■ 53. REPAIR TOOLS.—Certain repair tools, the uses of which are not self-explanatory, are listed below:

*a. Pinking shears* (see fig. 23).—Pinking shears are used for cutting patches. The shears make a saw-toothed edge which helps to prevent the patches from peeling and curling at the edges.

*b. Raw rubber.*—Raw rubber is used for removing old cement. The rubber acts on fabric as art gum does on paper.

*c. Vulcanizing roller* (see fig. 23).—The vulcanizing roller is a compressor to roll out air bubbles and flatten fabric when fabric is being cemented.

*d. Seam stitcher* (see fig. 23).—The seam stitcher is also a compressor to roll out fabric. The stitcher is used for the same purpose as the vulcanizing roller, but for more precise work, since it is smaller and can work along edges and irreg-

ularly shaped joints. The stitcher is also used to work out any air bubbles left by the larger roller.

■ 54. PRECAUTIONS WHEN WORKING INSIDE BALLOON.—When work is to be done inside the balloon, the following precautions should be observed:

*a. Only small quantities of neoprene cement will be taken into the balloon.*

*b. Men will work inside the balloon for extremely short periods of time unless a current of air is passed through the balloon from a blower located in a position where it draws in fresh air.*

*c. Personnel inside the balloon will maintain frequent verbal contact with someone outside the balloon.*

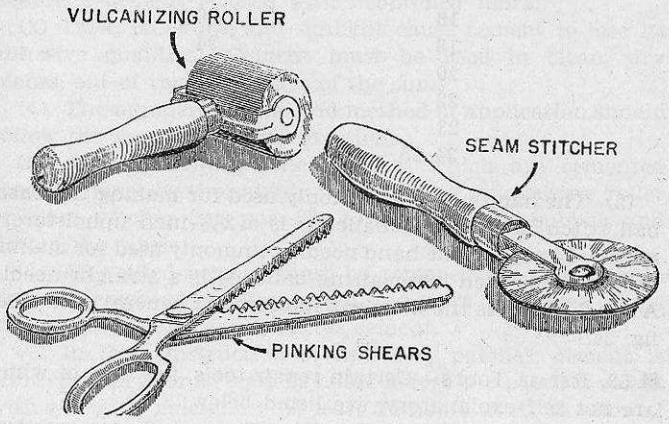



FIGURE 23.—Fabric repair tools.

■ 55. REPAIR BUILDING.—The building in which major repairs to the balloons are to be made should be sufficiently large to permit balloons to be spread on the floor and inflated. No sharp projections or other abrasive surfaces should be permitted where they will come in contact with the balloons.





## SECTION IV

## STITCHING

■ 56. HAND-STITCHING.—*a. General.*—Stitching by hand requires a correctness of execution which can be attained only by patience, care, and constant practice. The baseball stitch and the harness stitch are the hand stitches used in barrage balloon work.

*b. Baseball stitch.*—(1) *General.*—Stitching may be required to hold the edges of a tear together so that a patch can be placed over the tear. The baseball stitch is used for this purpose. The stitch does not repair the fabric; it merely holds it in place and makes it easier to apply a patch. Stitching will not be used when the edges of the tear can be matched and the patch applied without stitching.

(2) *Procedure.*—In making the baseball stitch, the needle is inserted through the fabric not less than ¼ inch from the edge of the tear, and the individual stitches are made a minimum of ¼ inch apart. The method of making this stitch is shown in figure 24 and described below:

(*a*) To begin the stitch pass the needle between the two edges of the tear and bring it out a minimum of ¼ inch beyond the end of the tear, as shown at point 1, figure 24.

(*b*) Pass the needle again between the two edges of the tear and bring it out to one side opposite the end of the tear as shown at point 2, figure 24.

(*c*) Again pass the needle between the two edges of the tear, underneath the first stitch, and bring it out at point 3, figure 24.

(*d*) Again pass the needle between the two edges of the tear, underneath the first stitch, and bring it out at point 4, figure 24. Continue the stitching as shown in figure 24.

(*e*) The method of turning a corner when using the baseball stitch is also illustrated in figure 24. One point is used as a pivot, and several stitches are begun from this point until the corner is turned.

(*f*) The baseball stitch is finished by reversing the procedure with which it was begun.

*c. Harness stitch.*—The harness stitch is used for stitching pieces of webbing in making patches, but is not used

in repairing the balloon envelope. The method of making this stitch is shown in figure 24.

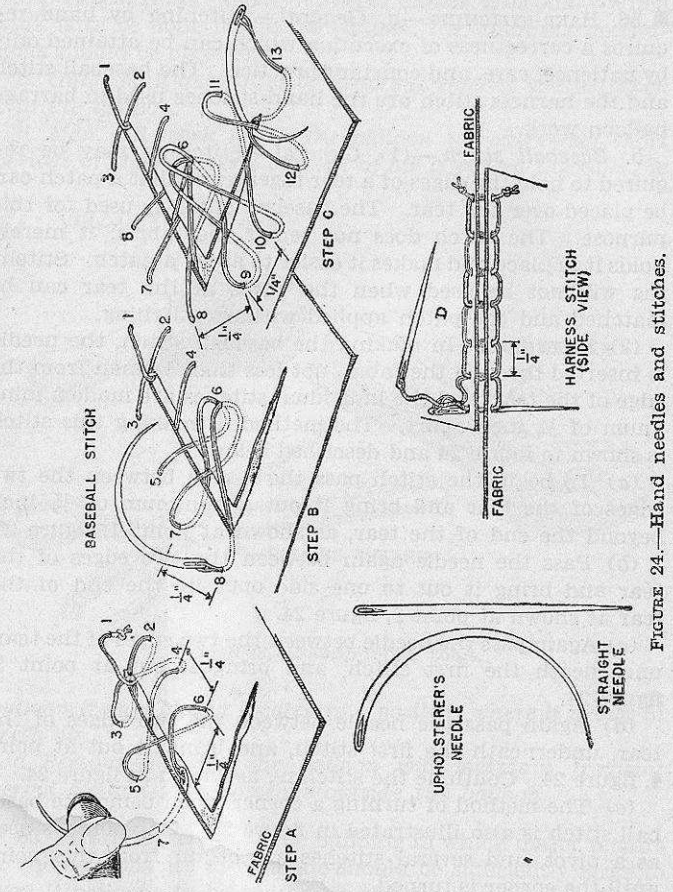



FIGURE 24.—Hand needles and stitches.

■ 57. MACHINE STITCHING.—*a. General.*—Machine stitching is used principally in working on accessories to the balloon, and never in working on the balloon itself.





*b. Type of stitch.*—The type of stitch made by machine sewing is a lock stitch. In operating the machine it is advisable to work slowly and carefully, making between five and eight stitches to the inch so that the stitches will not be too close together. Eight is the maximum number of stitches per inch, but five or six stitches per inch are more desirable.

*c. Type of machine.*—A single needle lock-stitch machine is used. The machine feeds itself and the operator needs only to guide the material. Each sewing machine is accompanied by the manufacturer's manual of instructions for care, use, and adjustment. The manufacturer's manual should be kept for reference. For further detailed information see TM 1–440.

## SECTION V

## PATCHING

■ 58. TYPES OF PATCHES.—*a. Accessory patches.*—Accessory patches are part of the designed construction of the balloon and include the following:

(1) Circular.
(2) Finger.
(3) Delta.
(4) Handling (Mk. VI balloon).
(5) Rigging (Mk. VI balloon).

*b. Repair patches.*—Repair patches are used to repair holes and tears in the balloon fabric.

■ 59. MEASUREMENTS OF PATCHES.—When parts are to be replaced on the balloon, exact measurements will be taken from blueprints, if available, or from the parts to be replaced. The size of repair patches will vary with the extent and type of damage to the balloon fabric. For specifications, see paragraph 61.

■ 60. ACCESSORY PATCHES.—Double-ply parallel fabric is used in constructing all accessory patches. The use and construction of accessory patches are outlined below:

*a. Circular patch* (see fig. 25).—Circular patches may be used to form a point for the attachment of lines and ropes, for example, as a tail-line bridle guide patch on the D–7

balloon. Instructions for making this particular circular patch follow. Other patches are made in a similar manner but with different dimensions.

(1) Cut three circular pieces of fabric 8⅝ inches, 6 inches, and 5 inches in diameter. Cut a small slit in the center of the 8⅝-inch and 5-inch pieces.

(2) Cut a piece of ¼-inch rope 9¼ inches long. Serve each end of the rope at a point 2½ inches from the end. Fray each end of the rope from the serving outward. Seize the 4¼-inch center portion of the rope into a loop.

(3) Apply cement to the frayed ends of the rope and the fabric pieces, and spread the frayed ends of the rope uniformly on the 6-inch piece.

(4) Now put the loop through the slit in the 5-inch piece, and cement together the 6-inch and 5-inch pieces with the frayed rope in between. Press the two pieces firmly together, permit the cement to dry for at least 12 hours, and sew.

(5) Finally pass the loop through the slit in the 8⅝-inch piece and cement it to the assembled 5- and 6-inch pieces. Seize a thimble into the loop.

*b. Finger patch* (see fig. 26).—Finger patches are used on some balloons as handling patches and rigging patches. The proper method of making a finger patch follows:

(1) Cut out eight finger strips. The four inner finger strips are smaller than the four outer ones. Cut out the back piece, reinforcement webbing, center piece, and front piece.

(2) Cut two lengths of rope, and serve each length at two points which are equally distant from the ends. Fray each end and saturate the frayed ends in cement.

(3) Cement the frayed ends of the ropes to the inner finger strips. The frayed ends of the rope should be rolled flat after cementing.

(4) Cement the outer finger strips over the ropes and the inner finger strops. Roll out air bubbles with a vulcanizing roller. Allow to dry for at least 12 hours.

(5) Sew the inner and outer finger strips together with a figure 8 pattern, or some similar cross-over design.

(6) Overlap and cement the four completed fingers together at the same angle as those of the patch being replaced.





(7) Cement the center piece onto the fingers. Cement and sew the reinforcement webbing over the center piece.

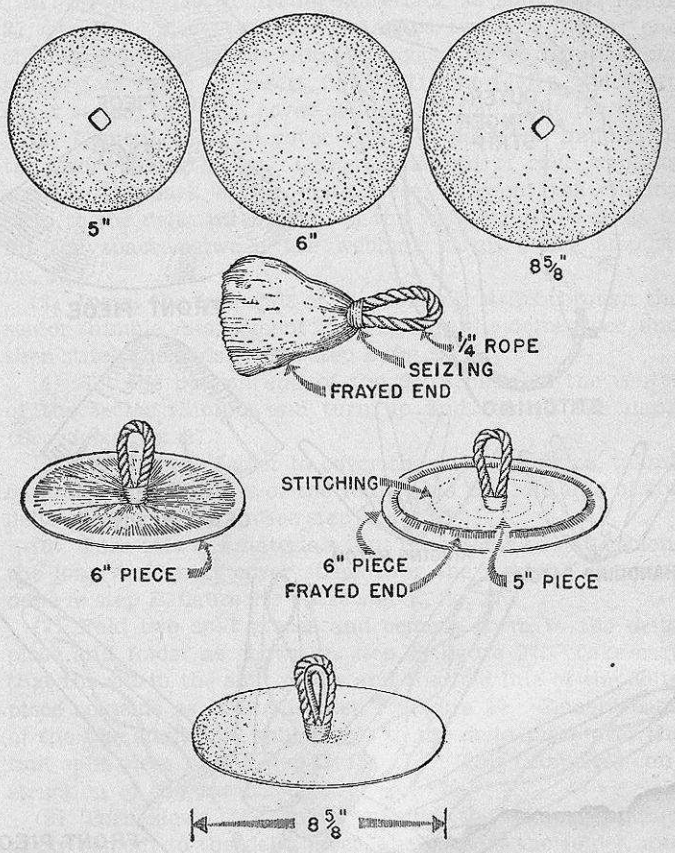



FIGURE 25.—Circular patch.

Cement the front piece in place, and finally cement the back piece in place.

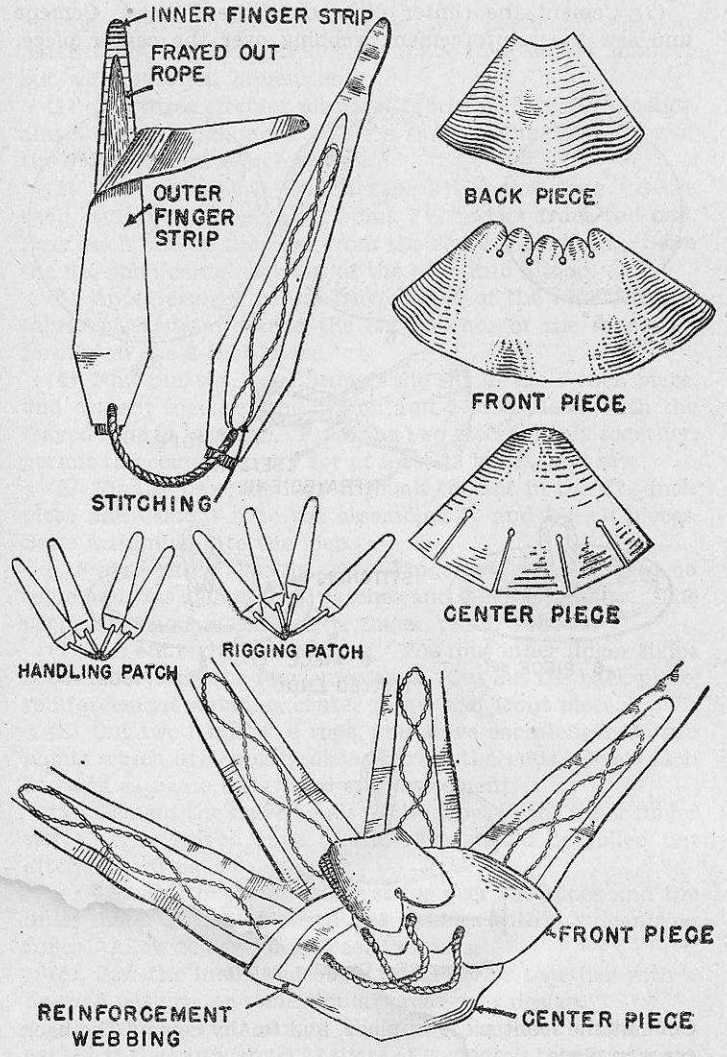



FIGURE 26.—Finger patch.





*c. Delta patch.*—Delta patches are used on some balloons as handling patches and rigging patches. The proper method of making a delta patch follows:

(1) Prepare the following materials, as shown in figure 27: one delta piece, two webbing strips, two cover strips, one chafing strip, one sector thimble (rigged for either handling line or foot rope; see insert, figure 27), one folder, two short cover strips, two long cover strips, and four split pieces.

(2) Cement the two cover strips around the middles of the two webbing strips. Cement one end of each webbing strip to the back of the delta piece. Cement the chafing strip to the delta piece between the webbing strips so as to fill the space between the webbing strips. (See step *A*, fig. 27.)

(3) Insert the free ends of the webbing strips through the sector thimble slits, cement these ends to the delta piece, and then stitch the ends. (See step *B*, fig. 27.)

(4) Slit the bottom end of the delta piece to the center of the sector thimble and turn up and cement the flaps. (See step *C*, fig. 27.)

(5) Cement the folder to cover the webbing strips, taking care that the fold line of the folder and the fold line of the delta piece coincide. (See step *D*, fig. 27.)

(6) Turn over the materials thus far assembled and cement the long and short cover strips over the webbing stitching done in step *B*, figure 27. (See step *E*, fig. 27.)

(7) Fold two split pieces and cement them to the delta piece and folder as shown in step *F*, figure 27. Take care that the slit in the split pieces and the fold line of the delta piece coincide as shown in step *F*, figure 27. Cement each of the two additional split pieces to the delta piece over the first split piece. (See step *G*, fig. 27.) This completes construction of the patch.

(8) Turn down the folder behind the sector thimble, apply cement to the delta piece, the back of the folder, and the projecting portions of the split pieces, and cement the patch to the balloon envelope.

*d. Handling patch (Mk. VI balloon).*—(See fig. 28.) The handling patch for the Mk. VI balloon is a circular patch into which are set three strips of webbing which form an

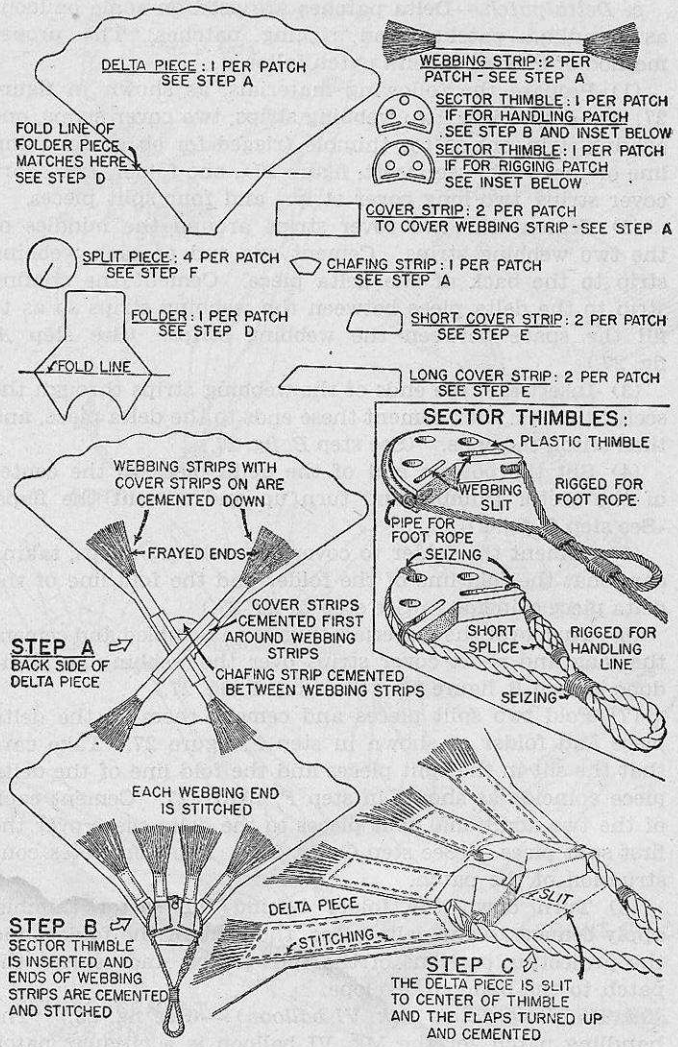



FIGURE 27.—Delta patch.





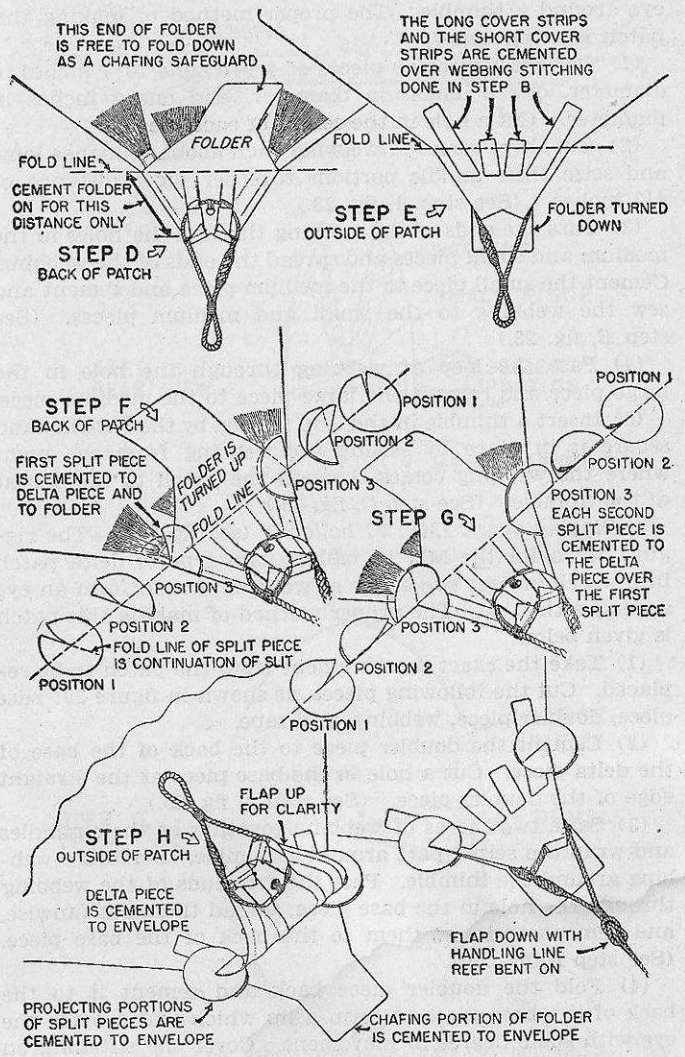



FIGURE 27.—Delta patch—Continued.

eye around a thimble. The proper method of making this patch is given below.

(1) Cut three circular pieces of fabric, one 10¼ inches in diameter, one 8 inches in diameter, and one 2 inches in diameter. Cut a hole in the center of each piece.

(2) Cut three strips of webbing each about 11 inches long, and seize their middle portions together for a distance of 4¼ inches. (See step *A*, fig. 28.)

(3) Pass the ends of the webbing through the holes in the medium and small pieces and spread the ends of the webbing. Cement the small piece to the medium piece and cement and sew the webbing to the small and medium pieces. (See step *B*, fig. 28.)

(4) Pass the loop of webbing through the hole in the large piece and cement the large piece to the medium piece.

(5) Insert a thimble in the loop formed by the webbing and secure it in place by seizing the webbing from the point where the webbing comes through the patch to the throat of the thimble. (See step *C*, fig. 28.)

*e. Rigging patch (Mk. VI balloon)* (see fig. 29).—The rigging patch for the Mk. VI balloon is a type of delta patch into which are set two strips of webbing, which form an eye around a thimble. The proper method of making this patch is given below.

(1) Take the exact measurement from the patch to be replaced. Cut the following pieces, as shown in figure 29: base piece, doubler piece, webbing, and tape.

(2) Cement the doubler piece to the back of the base of the delta piece. Cut a hole in the base piece at the straight edge of the doubler piece. (See step *A*, fig. 29.)

(3) Seize two pieces of webbing together at their middles and wrap the seized part around a thimble. Serve the webbing around the thimble. Pass the free ends of the webbing through the hole in the base piece, spread them out fanwise, and cement and sew them to the back of the base piece. (See step *B*, fig. 29.)

(4) Fold the doubler piece back and cement it to the back of the base piece to form a lip which will provide the eye with some degree of movement. Cover the stitching on the front of the patch with tape. (See step *C*, fig. 29.)





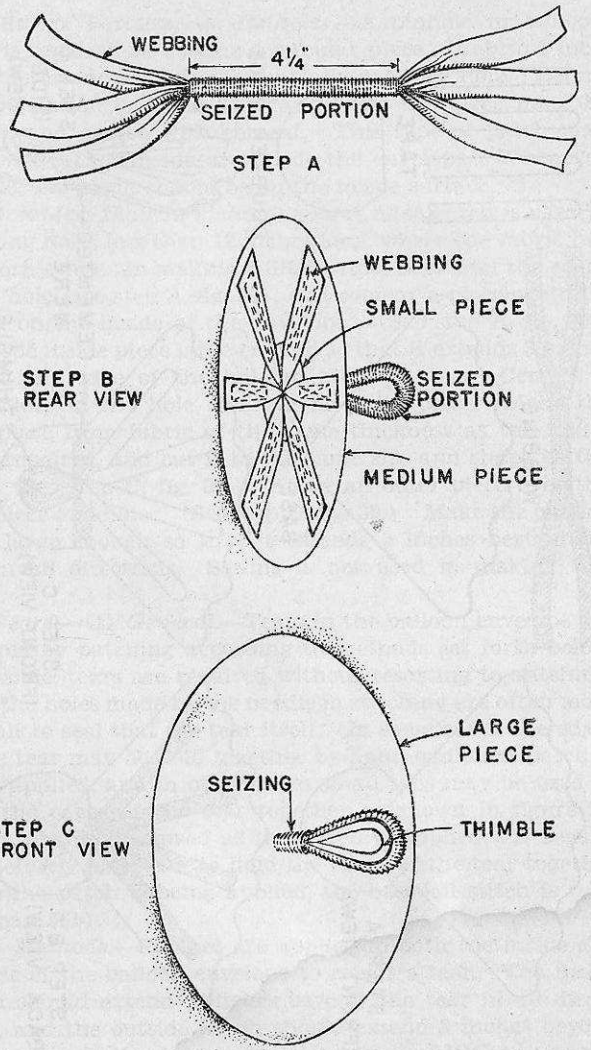



FIGURE 28.—Handling patch (Mk. VI balloon).

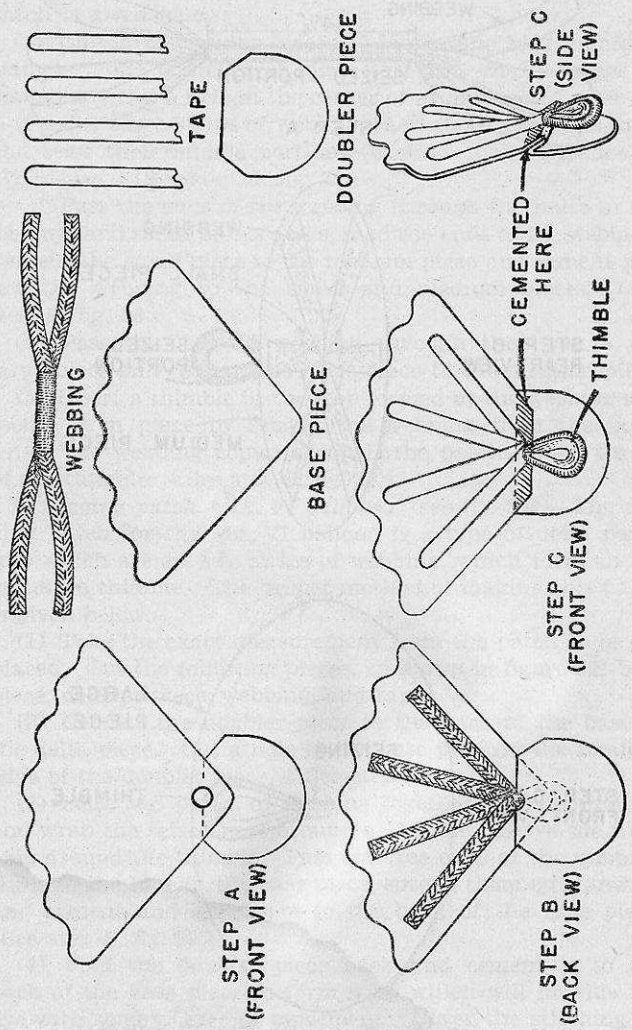



FIGURE 29.—Rigging patch (Mk. VI balloon).





■ 61. REPAIR PATCHES.—*a. Pinholes.*—A pinhole in balloon fabric is repaired by cutting a circular piece of fabric 1 inch in diameter and applying it centrally over the hole. Before the application is made, the fabric and the piece must be cleaned and coated with cement. This type of patch may be applied either inside or outside the envelope. Whenever possible, the patch should be on the inside surface.

*b. Holes less than 12 inches long.*—A filler patch is used in repairing holes less than 12 inches long, where the fabric has been torn away. In making a filler patch, first trim the edges of the hole (see step *A*, fig. 30), and cement a piece centrally over it on the inside of the envelope. (See step *B*, fig. 30.) Make the inside piece large enough so that it extends 3 inches beyond the edge of the hole in all directions. Cement a filler piece in the hole against the inner piece. Make the filler piece from fabric of the same thickness as the fabric being repaired, and cut it to the same size and shape as the hole. (See step *C*, fig. 30.) Apply an outer piece over the filler piece and hole. (See step *D*, fig. 30.) Make the outside piece large enough so that it extends 2 inches beyond the hole in all directions. Sewing is not used in making this patch.

*c. Tears.*—(1) *General.*—Tears in the balloon envelope are repaired by patching according to methods set forth below. If possible, tears are repaired without resorting to stitching, since the holes made by the needle in stitching are often more difficult to seal that the tear itself. In some cases, the edges of the tear may be held together by hand while the patch is being applied, and in other cases small tabs may be used to hold the edges of the tear together as shown in figure 31. These tabs are removed as the patch is applied. If sewing is absolutely necessary to hold the edges of the tear together while the patch is being applied, the baseball stitch is used (see par. 56*b*).

(2) *Methods.*—Patches are applied to both the inside and outside of the balloon envelope to repair a tear. The inside patch should extend 3 inches beyond the tear in all directions, and the outside patch should extend 2 inches beyond the tear in all directions. If the required width of the inner patch is not more than 8 inches, the entire tear is covered

by two pieces of fabric, one on the inside and one on the outside, as shown in figure 31. Tears which would require an inner patch more than 8 inches wide are repaired by applying a series of inner and outer patches following the direction of the tear, as shown in figure 31.

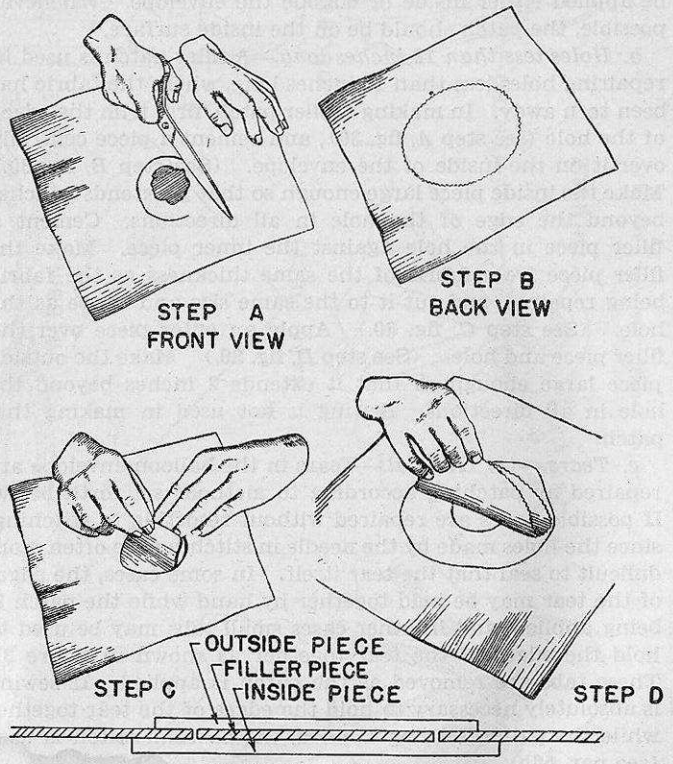



FIGURE 30.—Filler patch.

*d. Holes greater than 12 inches long.*—To repair a hole greater than 12 inches long, where the fabric has been torn away, first trim the edges of the hole so that they will be straight. Then cut strips of fabric 6 inches wide, mark a line down the center of each strip, and cement these strips





around the edge of the hole on the inner surface of the envelope so that the center lines of the strips correspond with the edges of the hole. Cut a piece of fabric, of the same kind as the envelope fabric, to the exact dimensions of the hole. Place this piece of fabric in the hole and cement it to the projecting portions of the inner fabric strips. Cut strips of fabric 4 inches wide, mark a line down the center of each strip, and cement the strips on the outside of the envelope so that the center lines of the strips correspond with the edges of the hole.

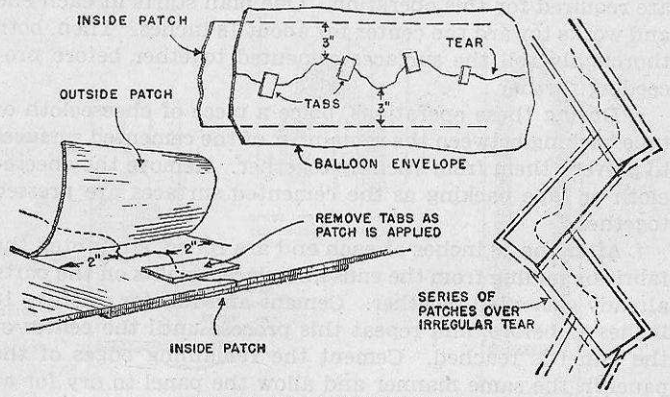



FIGURE 31.—Patching tears.

## SECTION VI

## REPLACING PANELS

■ 62. ENVELOPE PANEL.—In replacing a panel, first remove the old panel by soaking the cement loose with benzol and working the edges of the panel away from the adjoining panels. The benzol is applied sparingly, using an oiler with a very small spout opening. Cut the replacement panel ½ inch larger than the old panel on all sides, using the old panel as a pattern. Then proceed as follows:

*a.* Remove the cement remaining on the envelope with a piece of raw rubber and wash lightly with benzol the surfaces of the envelope where cement is to be applied.

*b.* Apply the required number of coats of cement (according to the manufacturer's directions) to one of the long edges of the hole and to the corresponding edge of the new panel. Work the cement thoroughly into the fabric; apply it to only one edge at a time and cement the panel on this edge before additional cement is applied. See figure 21 for overlap of panels.

*c.* After the cement is applied, mark a line on the envelope 1 inch from the edge of the hole, to be used as a guide line.

*d.* Cement the edge of the panel to the envelope. Two men are required for this operation. One man starts at each end and works toward the center for about 18 inches. Then, both thoroughly roll the surfaces cemented together before proceeding further.

*e.* During these operations, place a piece of cheesecloth or tape backing between the remainder of the cemented surfaces to prevent them from sticking together. Remove the cheesecloth or tape backing as the cemented surfaces are pressed together.

*f.* After the 18 inches at each end are rolled, straighten the fabric by pulling from the ends and place weights on the parts already cemented together. Cement and roll for another 18 inches as before, and repeat this process until the center of the panel is reached. Cement the remaining edges of the panel in the same manner and allow the panel to dry for at least 12 hours before tape is applied.

*g.* Mark guide lines $\frac{9}{16}$ inches wide on the envelope before applying the tape. Next wash the cemented edges of the panel and the uncured neoprene side of the tape with benzol. Now apply the required number of coats of cement to the seams and put the tape on a few inches at a time. Do not apply cement to the tape, but be sure that the tape is rolled thoroughly. Allow the cement to dry for 24 hours.

*h.* Air-inflate the balloon to permit repairmen to enter it to apply tape to the insides of the seams. After the cementing, powder the cementing area with powdered soapstone or talc.

■ 63. PEEL-OFF TYPE RIP PANEL.—In replacing the peel-off type rip panel, follow the dimensions given on the manufacturer's blueprints or take the exact measurement from the old panel. Then proceed as follows:





*a.* Remove the old panel completely. Place the part of the envelope which is covered by the rip panel on a perfectly flat surface, preferably a board, to be sure that it does not wrinkle, and clean off all the old cement and other foreign matter with benzol.

*b.* Cement and tape the lower end of the panel to the envelope, and unroll the panel over the grommeted holes. Draw guide lines on the envelope 1 inch from the edge of

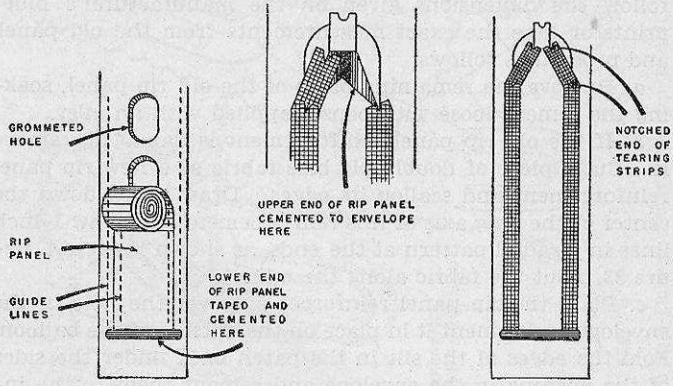



FIGURE 32.—Peel-off type rip panel.

the panel and draw similar lines on the panel 1 inch from its edges. (See fig. 32.)

*c.* Cut four tearing strips of parallel fabric, two long and two short, and notch the ends of the tearing strips so that they will tear along their lengths. Cement the long tearing strips on so that they will join the rip panel to the envelope, leaving the top 4 inches uncemented. (See fig. 32.) Apply the cement in the same manner as in the replacement of any other panel. Be careful to prevent the formation of bubbles or folds.

*d.* Cement the uppermost end of the rip panel to the envelope to prevent the escape of gas. Apply this cement so that it will be flush with the ends of the short tearing strips

along a center line, and tapered off at the sides as shown in figure 32. Cement the short tearing strips over the upper end of the rip panel. Finish cementing the long tearing strips.

■ 64. CHEESE-CUTTER TYPE RIP PANEL.—The cheese-cutter type rip panel is constructed as shown in figure 33. When the rip panel is ripped, it is unlikely that the rope stiffener or balloon envelope will be damaged, and replacement of the stiffener (made of No. 84 cotton seine twine or 3/16-inch rope) ordinarily will not be required. In replacing the rip panel, follow the dimensions given on the manufacturer's blueprints or take the exact measurements from the old panel, and proceed as follows:

*a.* Remove the remaining parts of the old rip panel, soaking the cement loose with benzol applied with an oiler.

*b.* If the old rip panel reinforcement is damaged, remove it. Cut a piece of double-ply bias fabric as a new rip panel reinforcement and scallop its edges. Draw a line down the center of the long axis of this reinforcement and draw 1-inch lines in a radial pattern at the ends, as shown in step *A*, figure 33. Cut the fabric along these lines.

*c.* Place the rip-panel reinforcement over the hole in the envelope and cement it in place on the outside of the balloon. Fold the edges of the slit in the patch back under the sides of the opening in the envelope and cement them to the inside of the envelope. (See step *A*, fig. 33.)

*d.* Cut out the rip panel, which is made of double-ply parallel fabric, and mark a line down the center of its long axis. Cement a strip of webbing (ripping tape) along the center of the panel, passing its looped upper end through the slit in the upper end of the panel. Cement the tape reinforcement over the slot through which the ripping tape passes. Cement the assembled rip panel over the hole in the balloon. (See step *B*, fig. 33.)

*e.* Cement the end reinforcements over both ends of the panel to strengthen its junction to the rip panel reinforcement. (See step *C*, fig. 33.)

*f.* Cement the ripping strip in its proper position on the envelope. (See step *D*, fig. 33.)





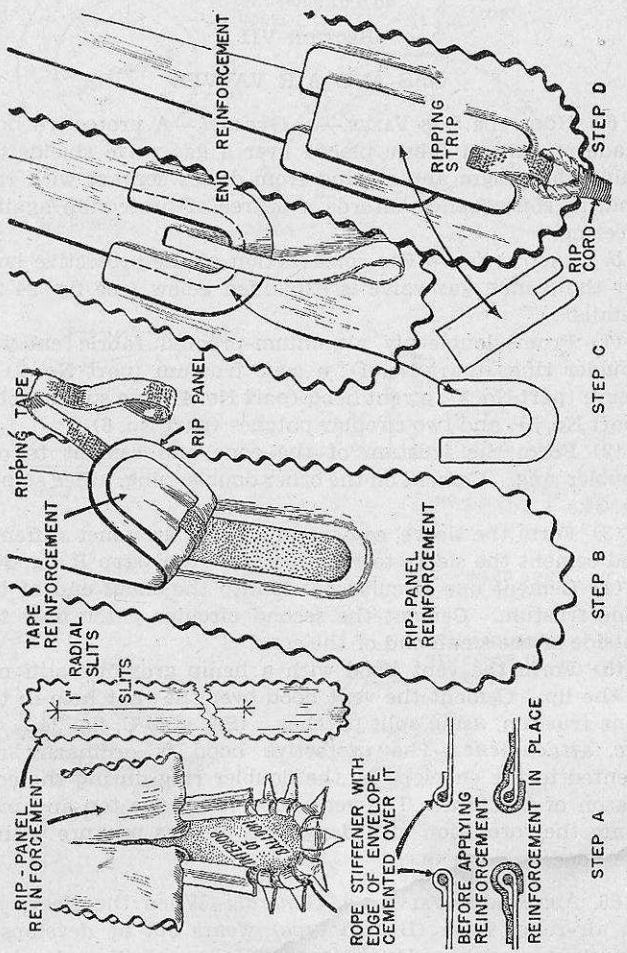



FIGURE 33.—Cheese-cutter type rip panel.

*g.* Eye-splice the rip cord into the loop sewed into the end of the ripping tape.

## SECTION VII

## GAS AND AIR VALVES

■ 65. HOOD FOR GAS VALVE.—*a. General.*—A protective hood made of balloon fabric placed over a gas valve shields the valve diaphragm and seating from direct contact with rain and, in consequence, affords a degree of protection against freezing.

*b. Construction.*—The construction of the protective hood for the 8-inch gas valve is explained below (see fig. 34 for details):

(1) From double-ply aluminum-proofed fabric cut two doubler rings (part No. 1), a cone frustum (part No. 2), a sleeve (part No. 3), a vent hood (part No. 4), two split patches (part No. 5), and two circular patches (part No. 6).

(2) Form the frustum of the cone and cement to one doubler ring. Cement on the other doubler ring. (See step *A*, fig. 34.)

(3) Form the sleeve, cement in a hemp grommet stiffener, and cement the sleeve to the frustum. (See step *B*, fig. 34.)

(4) Cement one circular patch into the small end of the cone frustum. Cement the second circular patch over the outside of the small end of the cone.

(5) Form the vent hood with a hemp grommet stiffener in the lip. Cement the vent hood over the vent hole in the cone frustum, using split patches. (See step *C*, fig. 34.)

*c. Attachment.*—The protective hood is ordinarily cemented to the envelope by the doubler ring during the cold season of the year. The vent hood its at the top and prevents the formation of a dangerous air-gas mixture within the hood.

■ 66. AIR-RELIEF VALVE.—*a. General.*—When the sleeve on an air-relief valve (British type) wears out or develops a tendency to stick under the conical collar, or otherwise fails to function properly, a replacement valve assembly is constructed and substituted as outlined below.





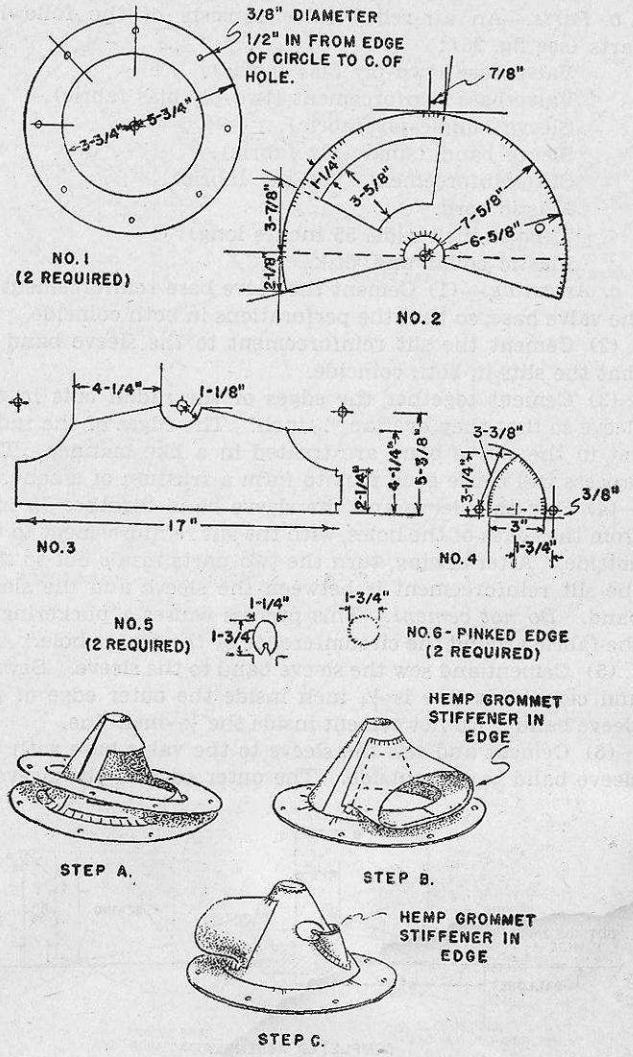



FIGURE 34.—Hood for gas valve.

*b. Parts.*—An air-relief valve consists of the following parts (see fig. 35):

Valve base (two-ply bias fabric).
Valve base reinforcement (two-ply bias fabric).
Sleeve (single-ply fabric).
Sleeve band (single-ply fabric).
Slit reinforcement (two-ply fabric).
Elastic cord.
Tape (1 inch wide, 55 inches long).
Plastic collar and disk.

*c. Assembly.*—(1) Cement the valve base reinforcement to the valve base, so that the perforations in both coincide.

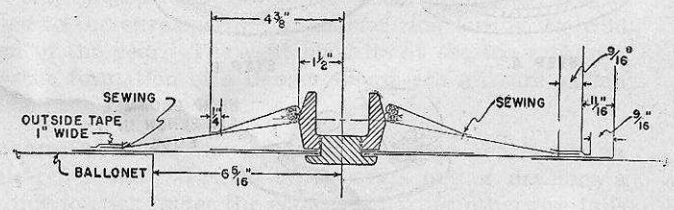
(2) Cement the slit reinforcement to the sleeve band so that the slits in both coincide.

(3) Cement together the edges of the radial cuts in the sleeve so that they overlap 9/16 inch. The edges of the radial cut in the sleeve band are treated in a like manner. This process will cause each part to form a frustum of a cone.

(4) Sew the sleeve and the sleeve band together 3/8 inch from the edges of the holes, with the slit reinforcement to the outside. After sewing, turn the two parts inside out so that the slit reinforcement is between the sleeve and the sleeve band. *Do not cement.* This process causes a puckering of the fabric around the circumference of the center hole.

(5) Cement and sew the sleeve band to the sleeve. Sewing and cementing line is 1/4 inch inside the outer edge of the sleeve band. Do not cement inside the 1/4-inch line.

(6) Cement and sew the sleeve to the valve base with the sleeve band to the outside. The outer edge of the sleeve is




COMPLETED ASSEMBLY

FIGURE 35.—Air-relief valve.





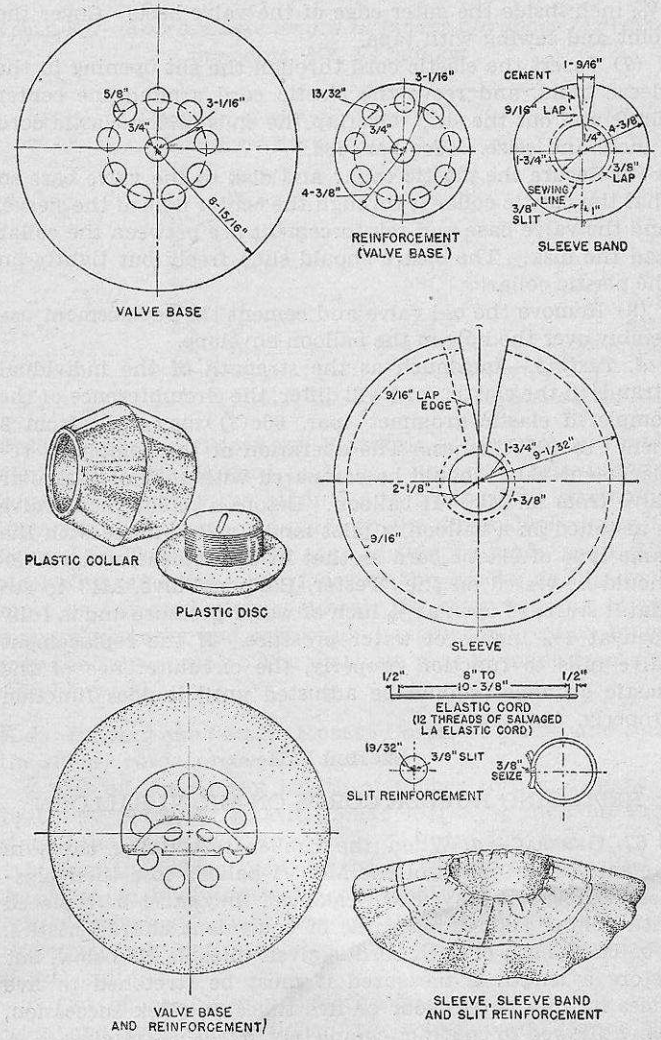



FIGURE 35.—Air-relief valve.—Continued.

11/16 inch inside the outer edge of the valve base. Cover the joint and sewing with tape.

(7) Insert the elastic cord through the slit opening in the sleeve band, and reeve the elastic cord around the center circle and out the slit. Overlap the ends of the elastic cord 1 inch, and seize. (See par. 66*d*.)

(8) Secure the plastic collar and disk to the valve base so that the plastic collar is through the center hole of the sleeve, and the valve base and reinforcement are between the collar and the disk. The sleeve should slide freely but tightly on the plastic collar.

(9) Remove the old valve and cement the replacement assembly over the hole in the balloon envelope.

*d. Testing.*—Inasmuch as the strength of the individual strands in the elastic cord will differ, the circumference of the completed elastic grommet (par. 66c(7)) may vary from 8 inches to 10⅜ inches. The operation of the completed replacement valve should be compared with that of a similar valve from an Mk. VII balloon. Before a replacement valve is installed on a balloon, a pilot model valve (made with the same type of elastic cord as that in the replacement valve) should be tested on the "Tester, Balloon Valve, M1" to see that it starts to open at ⅛ inch of water pressure and is fully open at 1⅛ inches of water pressure. If the replacement valve fails to function properly, the circumference of the elastic grommet should be adjusted until it does function properly.

## Section VIII

## REPLACING RUBBER CORDS ON MK. VI BALLOON

■ 67. General.—*a.* When the rubber restraining cords in the expansion system of the Mk. VI balloon lose their elasticity or become frayed or weakened, they must be replaced with rubber restraining cords of equivalent characteristics.

*b.* The length of each cord is given in table III below, but before a length is measured it must be stretched to five times its free length four or five times in quick succession, being allowed to contract completely between stretches.





TABLE III.—*Approximate length in inches of rubber restraining cords, Mk. VI balloon*

| Cord No. | Length | Cord No. | Length | Cord No. | Length |
|---|---|---|---|---|---|
| 1 | 20⅞ | 11 | 52¾ | 43 | 37¾ |
| 2 | 29⅛ | 12 | 53½ | 44 | 34⅝ |
| 3 | 34⅝ | 13 | 53¾ | 45 | 31½ |
| 4 | 39 | 14 to 36 | 54 | 46 | 28⅜ |
| 5 | 42⅛ | 37 | 52¾ | 47 | 24⅜ |
| 6 | 44⅞ | 38 | 50¾ | 48 | 20⅞ |
| 7 | 47¼ | 39 | 48 | 49 | 17⅜ |
| 8 | 49¼ | 40 | 45⅝ | 50 | 13 |
| 9 | 50⅜ | 41 | 43 | 51 | 9 |
| 10 | 52 | 42 | 40½ | 52 | 5⅛ |

■ 68. Stretching Tools and Platform.—The ends and middle of each rubber cord must be bound and seized under tension. To effect the binding and seizing, two stretching tools and a platform are made to the dimensions shown in figure 36. The stretching tools should be made from stiff steel wire, and the inner faces of the crooks on the tools must be trimmed with a smooth file after bending to remove vise marks and any other irregularities which might fray the rubber cord. The platform may be made from any suitable wood.

■ 69. Binding and Seizing Rubber Cords.—To bind and seize the rubber cords, proceed as follows:

*a.* Cut off the correct length of rubber cord and mark it half way along its length. Make marks ¼ inch on each side of the center mark.

*b.* Jam the rubber cord on the stretching tools so that a crook on each of the tools coincides with one of the off-center markings. Hook one of the tools onto nail *A* of the stretching platform, then pull the other tool and hook it over nail *B*.

*c.* Cut off an 8½-inch length of adhesive tape, ½ inch wide, and wrap the portion of the rubber cord between the stretching tools. Wrap two complete turns of tape on one end of the stretched portion of the cord, and continue the

wrapping across the stretched portion so that each turn of tape overlaps the preceding turn by half the width of the

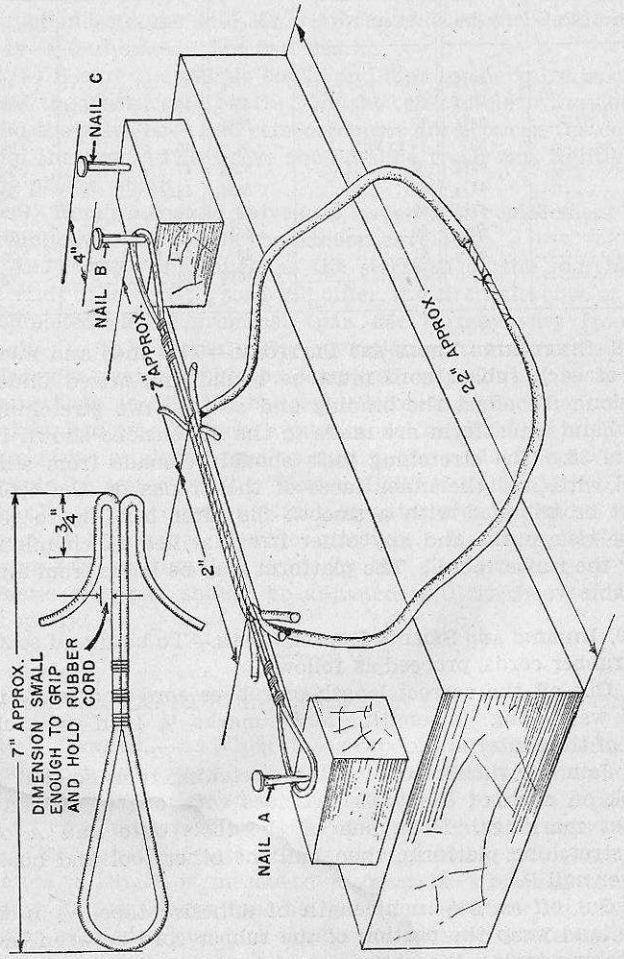



FIGURE 36.—Stretching tools and platform.

tape. When the opposite end of the stretched portion of cord has been reached, make two complete turns of the tape





and again wrap back toward the middle of the stretched portion. If the wrapping is done properly, the return wrapping should overlap about half of the first wrapping.

*d.* Tie a clove hitch around the middle of the stretched portion, using a 4-ounce cord 21 inches long (No. 16 blocking cord is satisfactory). Be sure that the free ends of the cord are the same length after the clove hitch is tied. Pull the hitch tight, pass both ends of the cord to the reverse side of the wrapped rubber cord, and tie a square knot. Then pass the free ends of the cord back to the front of the wrapped rubber cord.

*e.* Unhook one of the stretching tools from its nail, allowing the bound rubber cord to contract slowly, then free it from the stretching tools. Do *not* allow the rubber cord to contract rapidly, or the wrapping may burst.

*f.* Make two marks on each end of the rubber cord, one at a point ½ inch from one end, and the other at a point 1 inch from the same end, so that the two marks will be ½ inch apart. Stretch and wrap each end of the rubber cord between the marks as described in *b* and *c* above.

*g.* Jam the two ends of the rubber cord, side by side but facing opposite directions, in the double crooks of the stretching tools so that the marks made in *f* above will coincide with the crooks of the tools. Hook one of the tools to nail *A* and the other tool to nail *B*, as shown in figure 36.

*h.* Tie a clove hitch around the two wrapped cords at the middle of the stretched portion, using a 4-ounce cord, 21 inches long. Pull the hitch tight, being sure that the free ends of the 4-ounce cord are the same length. Pass the free ends of the cord to the reverse side of the wrapped rubber cords, cross them, and pass them back between the wrapped rubber cords. Tie a square knot over the clove hitch. Then pass the ends of the cord back between the wrapped rubber cords to the reverse side. (See fig. 37.)

*i.* Unhook one of the stretching tools from its nail, allow the wrapped rubber cords to contract slowly, and free them from the stretching tools. Cut off the stub ends of the rubber cord, leaving approximately ¼ inch between each end of the cord and the corresponding end of the wrapping.

■ 70. BINDING AND SEIZING CONTINUOUS RUBBER CORD.—When a long piece of rubber cord is available, it is desirable to prepare several lengths from the same piece. To take advantage of a long piece of rubber cord, proceed as follows:

*a.* Start at one end and mark off the correct length for the first cord. Then from the end of the first cord mark the correct length for the second cord, and continue the process until the required number of separate cords have been marked off, or until the long cord is used up.

*b.* Mark, stretch, wrap, and tie the center of each cord as described in paragraph 69.

*c.* Mark, stretch, and wrap the end of each cord, as described in paragraph 69.

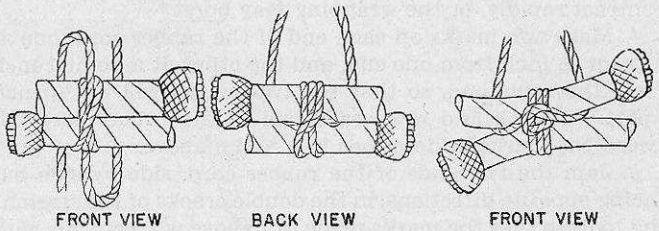



FIGURE 37.—Seizing rubber cords.

*d.* Starting at each line marking the end of one rubber cord and the beginning of another, make marks *A*, *B*, *C*, and *D* as shown in step *A*, figure 38. Jam the rubber cord on the stretching tools so that mark *A* coincides with a crook on one of the tools and mark *D* with a crook on the other. Hook one of the tools over nail *A* and the other tool over nail *C*. The distance between marks *A* and *D* should be approximately 6 inches. (See step *B*, fig. 38.)

*e.* Wrap the rubber cord between marks *A* and *B* with adhesive tape in the manner prescribed above, and repeat the performance between marks *D* and *C*. Unhook one of the stretching tools from its nail, allowing the cord to contract slowly, and cut the cord half-way between the taped portions. Seize the two ends of the rubber cord with the 4-ounce cord as described in paragraph 69*g* and *h* above.





■ 71. ATTACHING RUBBER CORD TO ENVELOPE.—To secure the restraining cord to a pair of links on one of the securing bands, proceed as follows:

*a.* Pass one free end of the 21-inch, 4-ounce cord under and through one of the links forming a pair. Then pass the other free end of the 4-ounce cord under and through the other link. Cross the two free ends of the cord, then pass them around the rubber cord, and again pass each end under and through its respective link. (See step *A*, fig. 39.)

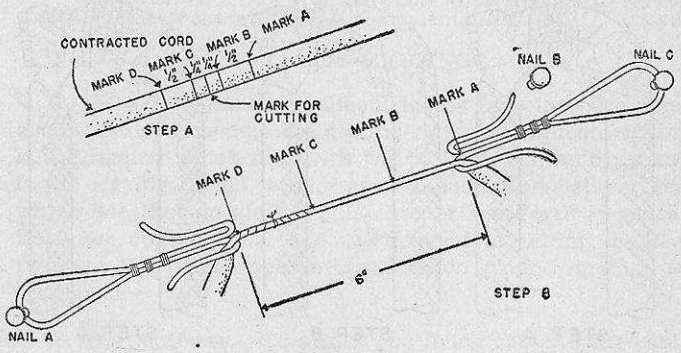



FIGURE 38.—Wrapping continuous rubber cord.

*b.* Pull the two ends of the cord tight and tie them off with a square knot across the front of the links. Now pass the two ends of the cord back through the links and cross them on the under side of the links. (See step *B*, fig. 39.)

*c.* Pass the ends of the cord around the seizing and tie them off with a square knot. (See step *C*, fig. 39.)

*d.* Repeat the whole procedure in tying off the other end of the doubled rubber cord.

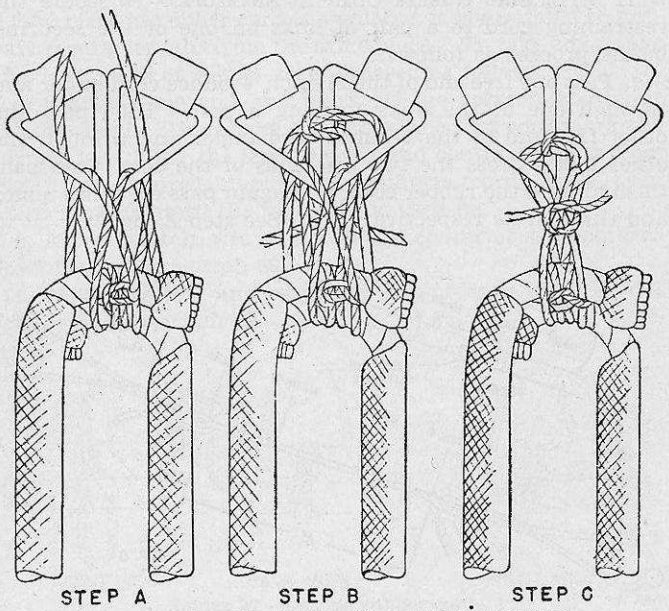



FIGURE 39.—Attaching rubber cord to envelope.



# CHAPTER 4

# RIGGING

## SECTION I

Paragraphs

SECTION I. Balloon rigging ..... 72–88
II. Construction of ground rigging (wire rope) ..... 89–101
III. Construction of ground rigging (fiber rope) ..... 102–124
IV. Construction of fabric equipment ..... 125–128

## BALLOON RIGGING

■ 72. GENERAL.—Barrage balloon rigging falls into two categories: balloon rigging and ground rigging. Balloon rigging is the rigging which flies with the balloon. Ground rigging is the rigging which is necessary to moor the balloon, but which does not go aloft. This chapter sets forth specifications for constructing, and methods of attaching, balloon rigging. For comparable information on ground rigging, see section II.

■ 73. FLYING CABLE.—To attach the flying cable to the cable terminal, proceed as follows:

*a.* Serve the end of the cable for about 1 inch with No. 9 linen cord.

*b.* Starting at a point 24 inches from the end of the cable, serve for a distance of 12 inches. Skip 8 inches and serve for 12 more inches. (See step *A*, fig. 40.)

*c.* Pass the free end of the cable once around the cable terminal starting from the strap side and following the groove all the way around. Then make a second turn around the cable terminal with the free end, passing the second turn underneath the turn already made. (See step *B*, fig. 40.)

*d.* Secure the free end of the cable with clamps spaced and alined as shown in step *C*, figure 40.

*e.* Be careful to observe the following:

(1) The uncovered 8-inch portion of the cable is to make metallic contact with the cable terminal, insuring electrical contact between the cable terminal and the cable.

(2) A loop is to be formed in the free end of the cable between the two clamps. Closing of the loop during flight

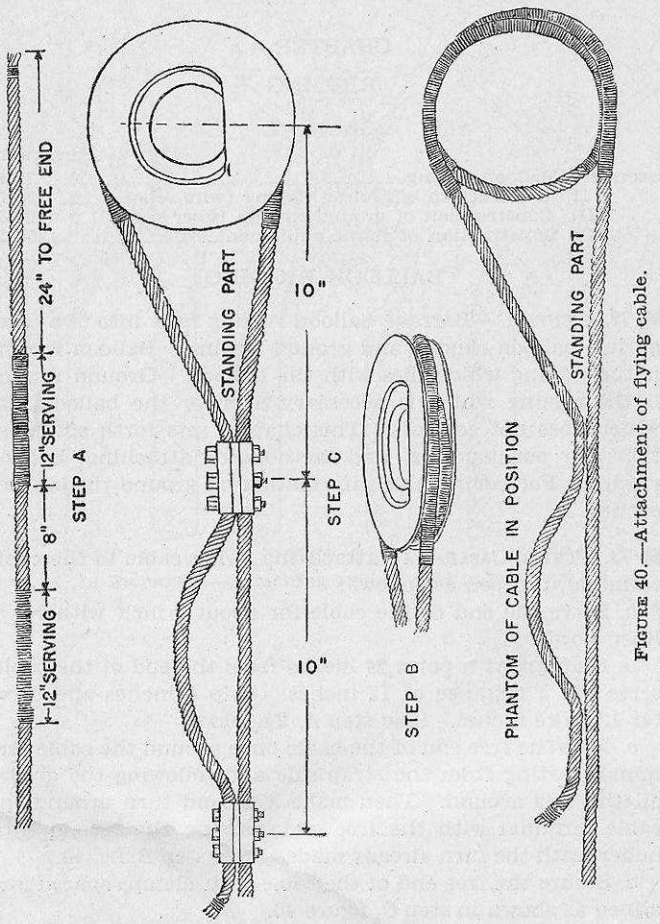



FIGURE 40.—Attachment of flying cable.

indicates that the cable has slipped through the top clamp and that adjustment is needed.





■ 74 HANDLING LINES.—*a.* Each handling line comes on the balloon as one continuous line. Principal wear is on the lower end of the line, which is passed through blocks on the bed and is otherwise submitted to strain. When it is necessary to replace the lower end of a handling line, the line is cut off 2 feet 10½ inches below the looped cut-splice, and a 5-inch soft eye is made 1 foot 6 inches below the looped cut-splice. The lower end of the line which was cut off is replaced with a line made of ⅝-inch rope with a 5-inch soft eye in one end. For the D–7 and Mk. VII, the cutting length of this line is 51 feet 7 inches; for the D–8, 59 feet 1 inch. For the D–7 and Mk. VII, the finished length is 50 feet; for the D–8, 57 feet 6 inches. This line is reef-bent to the eye made below the looped cut-splice of the upper part of the handling line.

*b.* If it becomes necessary to replace the upper part of a handling line, this part is made of ⅝-inch rope with a 5-inch soft eye in each end and a looped cut-splice 1 foot 6 inches from the crown of the lower eye. For the D–7 and Mk. VII, the cutting length is 18 feet 4½ inches; for the D–8, 19 feet 4½ inches. For the D–7 and Mk. VII, the finished length is 15 feet 6 inches; for the D–8, 16 feet 6 inches. The handling lines are lark's-headed into the loops on the handling patches.

■ 75. MOORING LINES.—Mooring lines are of the same dimensions and rope-size as the replacement handling lines described in paragraph 74*b* above. The mooring-line extensions are made of ⅝-inch rope with a 5-inch soft eye in one end. For the D–7 and Mk. VII, the cutting length is 26 feet 4½ inches; for the D–8, 31 feet 4½ inches. For the D–7 and Mk. VII, the finished length is 25 feet; for the D–8, 30 feet. Mooring lines are lark's-headed to the appropriate patches on the balloon, and mooring-line extensions are reef-bent to the lower ends of the mooring lines. Mooring-line extensions are attached only as storm precautions.

■ 76. FOOT ROPES.—*a. Finished lengths.*—Replacement foot ropes, made of new 5/32-inch cable, are made to the following finished lengths:

| | *D–7, Mk. VII* | *D–8* |
|---|---|---|
| No. 1 | 27′ 2″ | 27′ 9″ |
| No. 2 | 25′ 1″ | 26′ 2¼″ |
| No. 3 | 23′ 8″ | 25′ 5⅛″ |
| No. 4 | 24′ 4″ | 26′ 5⅜″ |
| No. 5 | 26′ 6″ | 29′ 6¾″ |
| No. 6 | 32′ 4″ | 35′ 8⅜″ |

*b. Attachment.*—On a balloon with delta type rigging patches, replacement foot ropes are attached as shown in

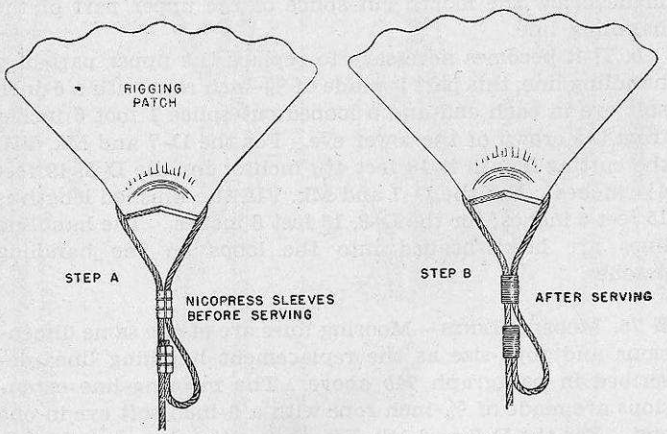



FIGURE 41.—Attachment of foot ropes.

figure 41. On a balloon with finger type rigging patches, the free ends of the replacement foot ropes are threaded into the hollow metal suspension rings and are attached to the standing part with a nicopress sleeve.

■ 77. RIGGING LINES.—*a. Dimensions.*—Replacement rigging lines are made of 5/16-inch rope. Cutting and finished lengths for the D–7 and Mk. VII are 55 feet; for the D–8, 70 feet. The lengths of the rigging line between patches are given below:





| | *D–7, Mk. VII* | *D–8* |
|---|---|---|
| Between No. 1 and No. 2 patches | 6′ | 8′ 6″ |
| Between No. 2 and No. 3 patches | 7′ | 9′ 6″ |
| Between No. 3 and No. 4 patches | 8′ | 11′ 6″ |
| Between No. 4 and No. 5 patches | 9′ | 12′ 6″ |
| Between No. 5 and No. 6 patches | 11′ 3″ | 15′ 6″ |

*b. Attachment.*—On balloons with delta type rigging patches, the rigging lines are tied into the loops on the foot ropes. The lines are attached to the front and rear loops by a sheet-band and half hitch, and have their running ends seized to the standing part. At each of the other four loops, they are secured by a sheet-bend through the loop and a half hitch above the loop, as shown in figure 42. On balloons with finger type rigging patches, the rigging lines are tied into the front and rear suspension rings by a clove hitch and half hitch, and have their running ends seized to the standing part. At each of the other four patches a clove hitch is tied around each side of the suspension ring, as shown in figure 42.

■ 78. BEDDING STROPS.—*a. Dimensions.*—Dimensions of the bedding strops, made of 3/8-inch rope with a 5-inch soft eye in each end, are given below.

(1) For D–7 and Mk. VII balloons.

| *Number required* | *Cutting length* | *Finished length* |
|---|---|---|
| 4 (at No. 1 patches) | 4 feet 5 inch | 2 feet 6 inch |
| 4 (at No. 2 patches) | 4 feet 5 inch | 2 feet 6 inch |
| 4 (at No. 3 patches) | 4 feet 5 inch | 2 feet 6 inch |
| 4 (at No. 4 patches) | 4 feet 5 inch | 2 feet 6 inch |
| 4 (at No. 5 patches) | 5 feet 8 inch | 3 feet 9 inch |
| 4 (at No. 6 patches) | 7 feet 11 inch | 6 feet |

(2) For the D–8 balloon, the bedding strops for the No. 5 patches are made to a finished length of 5 feet (cutting length, 6 feet 11 inches), and the strops for the No. 6 patches are made to a finished length of 8 feet (cutting length, 9 feet 11 inches). All other bedding strops are the same lengths as those for the D–7 and Mk. VII balloons.

*b. Attachment.*—(1) On balloons with delta type rigging patches, the bedding strops are lark's-headed to the foot ropes as shown in figure 42. On balloons with finger type

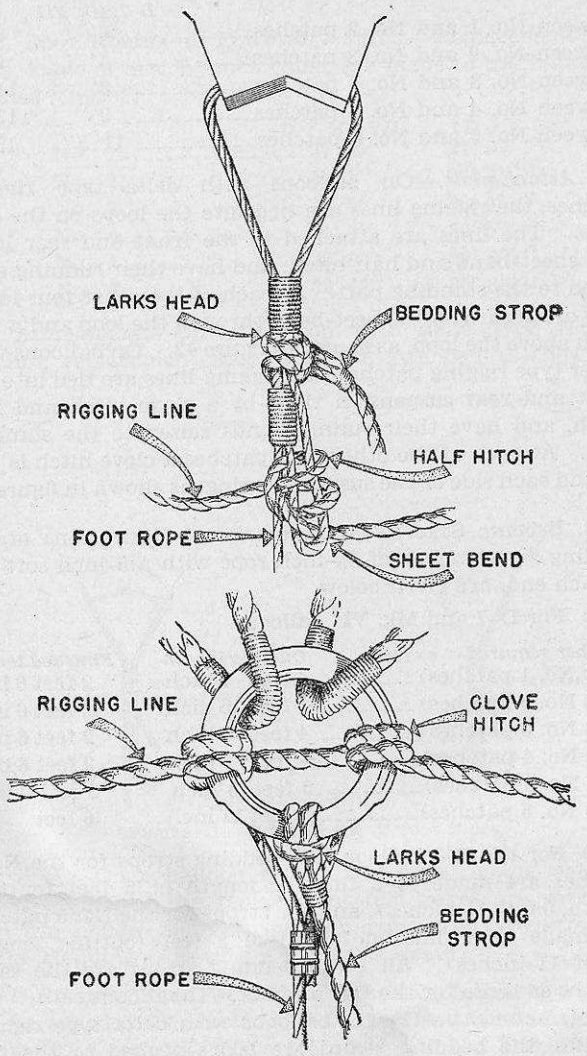



FIGURE 42.—Attachment of rigging lines and bedding strops.





rigging patches, the bedding strops are lark's-headed into the suspension rings, as shown in figure 42.

(2) Two bedding strops are attached to each No. 5 rigging patch and one strop is normally attached to each of the remaining patches. For storm precautions, an extra bedding strop is attached to every rigging patch except No. 5.

■ 79. RIP CORD.—The rip cord is made of ⅜-inch rope; cutting length for the D–7 and Mk. VII is 66 feet 6 inches; for the D–8, 75 feet 7 inches. Finished length for the D–7 and Mk. VII is 65 feet 11 inches; for the D–8, 75 feet. For peel-off type rip panels, the rip cord is eye-spliced around the toggle in the end of the rip panel. (See fig. 43.) The rip cord is attached to the cheese-cutter type rip panel as shown in figure 33. On balloons having circular patches, the rip cord is secured to the loops of the circular patches with breakable cord having a breaking strength of 10 pounds. The cord is clove-hitched to the rip cord, passed through the circular patch loops, and tied off with a square knot. On balloons equipped with snatch rings, the cord is clipped to the snatch rings on the envelope by snatch clips.

■ 80. GAS-VALVE OPERATING LINE.—*a. Dimensions.*—The cutting length of the gas-valve operating line for the D–7 and Mk. VII is 64 feet 7 inches; for the D–8, 69 feet 7½ inches. The finished length for the D–7 and Mk. VII is 61 feet 11 inches; for the D–8, 66 feet 11¼ inches.

*b. Attachment.*—The gas-valve operating line extends from a bridle attached to the nose spider patch, through a bull's-eye (plastic thimble) on the ballonet strop, to the gas valve. (See fig. 44.) It is attached as follows:

(1) The line is attached to the nose of the balloon by an adjustable webbing strap and a nose bridle and spider patch. The bridle is soft eye-spliced into grommets in the nose spider patch. The bridle supports a plastic buckle through which the adjustable webbing strap passes. The line is tied to a loop in the end of the adjustable webbing strap by a double sheet-bend, and the running end of the line is sewed to the standing part.

(2) Near its center, the line passes through a bull's-eye in the ballonet strop. The ballonet strop is secured to a

bridle, which in turn is attached to the ballonet diaphragm by a spider patch. The bridle is made by soft eye-splicing the ends of two lengths of rope into grommets on the spider patch. A 3-inch loop is made in the center of each of these ropes by seizing. These two loops are then seized together. The ballonet strop is made of 3/16-inch rope, with a loop formed in one end by tying a bowline and then seizing the running end to the loop. The loop in the ballonet strop is

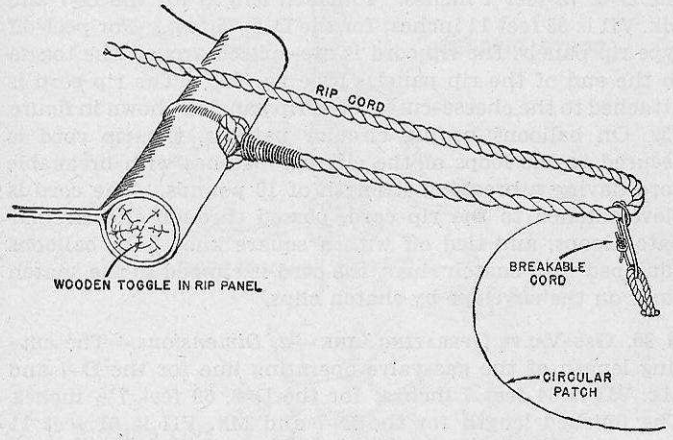



FIGURE 43.—Attachment of rip cord, peel-off type panel.

lark's-headed into the bridle loop. The bull's-eye is eye-spliced into the other end of the ballonet strop.

(3) The line is attached to the valve by forming a loop in its end and reef-bending this loop to an eye in the valve-line strop. The loop in the end of the valve line is 19 inches long, and is made by tying a bowline and sewing the running end to the loop.

(4) When the valve is removed, the reef bend is freed by passing the entire valve through the loop in the end of the valve line. The bowline should not be untied. When the valve is removed from the balloon, the valve line is secured to its securing strop to make it readily accessible when the valve is replaced.





■ 31. JUNCTION STROP.—There are two types of junction strops, one for use with the bell crank and one for use with the British type concentration fitting. Both have a finished length of 1 foot 9 inches. Since replacements must be made by the using troops, methods of constructing both types are given below.

*a. Bell-crank junction strop* (see fig. 45).—The junction strop for use with the bell crank is made as follows:

(1) Cut a piece of 7/32-inch cable 4 feet 3 inches long.

(2) Form the cable into a loop by joining the two ends with a nicopress sleeve.

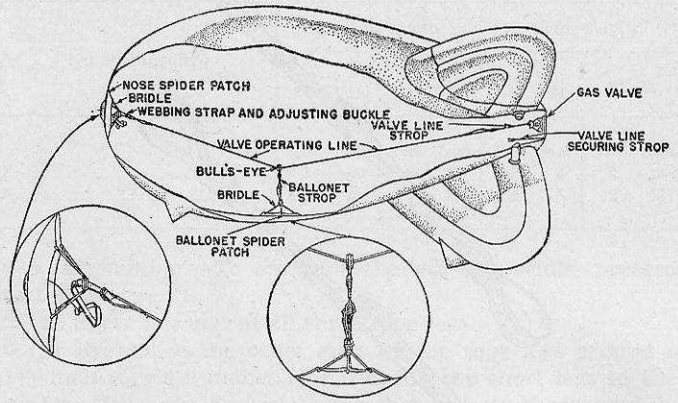



FIGURE 44.—Attachment of gas-valve operating line.

(3) Secure a thimble in each end of the loop by clamping the cable together at the throat of each thimble with a nicopress sleeve.

(4) Seize the strop at three equidistant points.

*b. British type junction strop* (see fig. 46.)—The junction strop is constructed on the triangular plate of the British type concentration fitting as follows:

(1) Cut a piece of 7/32-inch cable 5 feet 11 inches long.

(2) Form a 4- by 2-inch eye in each end, using tapered splices.

(3) Parcel the splices, but do not serve them.

(4) Parcel the entire strop and heavily parcel the two eyes. (See step *A*, fig. 46.)

(5) Parcel and cockscomb serve the two eyes together. (See step *B*, fig. 46.)

(6) Lay the grooved triangular plate in the bight of the strop. Mark the strop on each leg about 5 inches from the throat holding the triangular plate.

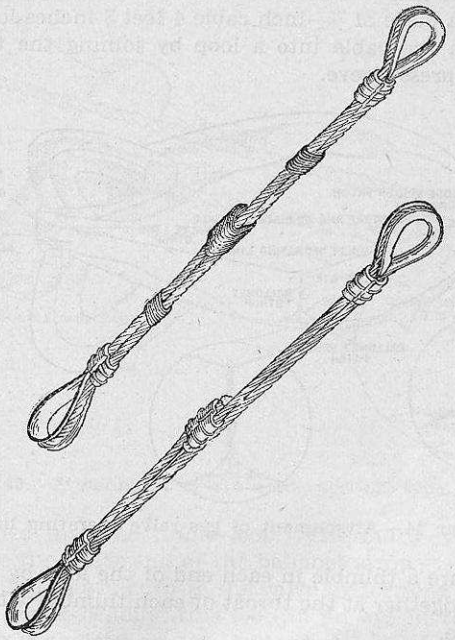


FIGURE 45.—Bell-crank junction strop.

(7) Remove the triangular plate and cockscomb serve between the marks.

(8) Put the triangular plate back into the strop, being careful that its legs are of equal length. Parcel the two legs together from throat of eye to throat of triangular plate. (See Step *C*, fig. 46.)





(9) Start a seizing 2 inches from the throat of the triangular plate and seize tightly up to the throat.

(10) Parcel over this seizing and start another seizing 3 inches from the throat and seize tightly up to the throat.

(11) Parcel over this last seizing and serve the entire strop, from throat of eye to throat of triangular plate, with a French-spiral serving. (See Step *D*, fig. 46.)

■ 82. TAIL-LINE BRIDLE.—*a. Dimensions.*—See figure 47. The tail-line bridle, made of ⅝-inch rope, consists of three legs attached to a toggle. Dimensions of the legs are as follows:

| Number required | Cutting length | | | | Tying length | | | |
|---|---|---|---|---|---|---|---|---|
| | D-7, Mk. VII | | D-8 | | D-7, Mk. VII | | D-8 | |
| | *Feet* | *Inch* | *Feet* | *Inch* | *Feet* | *Inch* | *Feet* | *Inch* |
| 1 | 13 | 6 | 12 | 10 | 10 | 6 | 9 | 10 |
| 2 | 16 | 5 | 15 | 10 | 13 | 5 | 12 | 10 |

*b. Assembling.*—To assemble the tail-line bridle, proceed as follows:

(1) Serve one end of all three rope legs.

(2) Eye-splice the other ends of the rope legs around a 1½-inch toggle 9 inches long, placing the short legs in the center. Seize the three legs together to hold them securely against the toggle.

(3) Put the legs under a tension of 15 pounds and mark them at their tying lengths (points at which they will be tied to the tail-line bridle patches). This marking may be done with a small strip of fabric inserted between the strands of the rope.

*c. Attaching.*—On balloons with delta patches, the three bridle legs are secured to their respective tail-line bridle patches (short leg on top) by a double sheet-bend tied into the soft loop on each patch. The running end of each rope is seized to its standing part. On balloons with finger patches, the bridle legs are tied to the tail-line bridle patches

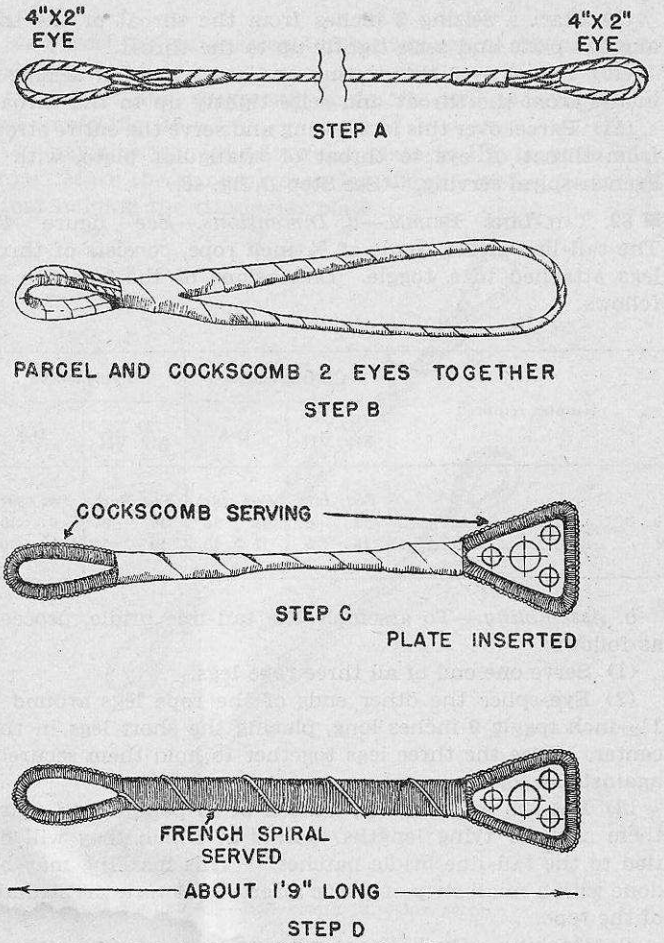



FIGURE 46.—British-type junction strop.

by a clove hitch; a half hitch is taken, and the running end of each rope is seized to its standing part.

■ 83. TAIL-LINE.—*a. Dimensions.*—The tail line is made of ⅝-inch rope with a 5-inch soft eye, cockscomb served, in one





end and an 8-inch soft eye, cockscomb served, in the other end. For the Mk. VII and D–7, cutting length is 26 feet 1 inch; for the D–8, 30 feet 7 inches. Finished length for the D–7 and Mk. VII is 23 feet 6 inches; for the D–8, 28 feet. The tail line also may be made of ⅜-inch rope, with two strops being made and seized together.

*b. Attachment.*—To attach the tail line, pass the 5-inch eye over the tail-line bridle toggle.

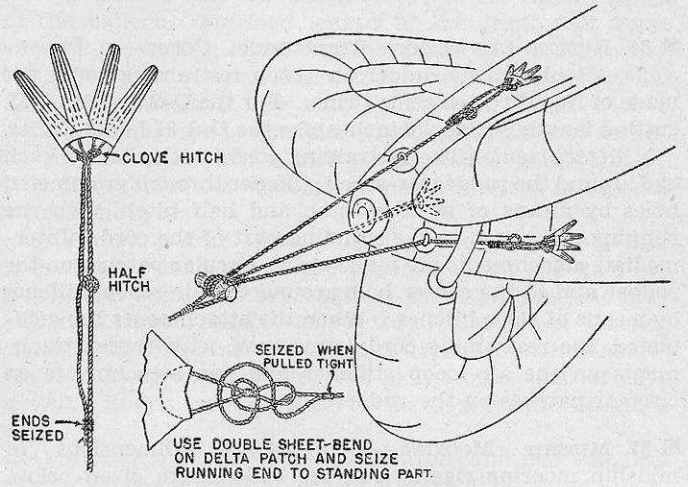



FIGURE 47.—Tail-line bridle.

■ 84. TAIL-LINE EXTENSION.—The tail-line extension is made of ½-inch rope. When used with the ⅝-inch single strop tail line, the tail-line extension is short-spliced into the tail line 1 foot above the 8-inch eye (splice toward the center of the tail line). When used with the double strop tail line made of ⅜-inch rope, the tail-line extension has a 6-inch eye in one end and is lark's-headed onto the tail line just above the 8-inch eye. Cutting length is 25 feet 8 inches in either case.

■ 85. RUDDER PROTECTION SHEET LINES.—*a. Dimensions.*—Rudder protection sheet lines are made of ¼-inch rope.

Cutting and finished length for the D–7 and Mk. VII is 23 feet; for the D–8, 30 feet.

*b. Attachment.*—Each rubber protection sheet line is tied into a series of circular patches extending along the envelope above the rudder. The line is fastened to the loop on the circular patch at each end by a clove hitch, and the running end is seized to the standing part of the line. The line is attached to the intermediate circular patches by single sheet-bends.

■ 86. RUDDER AIR-SCOOP RESTRAINING CORDS.—*a. Dimensions.*—Replacement rudder air-scoop restraining cords are made of No. 72 cotton seine twine. For the D–7 and Mk. VII, cutting length is 33 feet 6 inches; for the D–8, 31 feet 6 inches.

*b. Attachment.*—The restraining cord is attached at each end around the rudder air-scoop stiffener through grommeted holes by means of a clove hitch and half hitch, with the running end seized to the standing part of the cord. Intermediate attachments are made to two circular patches on the rudder and to the center hole around the air-scoop stiffener by means of clove hitches. When the attachments are completed, the restraining cord forms a W, with three attachments on the air-scoop stiffener and two attachments on circular patches on the rudder.

■ 87. MIDSHIP MOORING.—*a. Dimensions.*—Dimensions of midship mooring rigging for the balloon are given below. Cutting lengths shown are for nicopress sleeves.

(1) *Midship bridles.*—The two midship bridles are made of 3/16-inch or 7/32-inch cable. Cutting and finished lengths for the D–7 and Mk. VII are 25 feet; for the D–8, 26 feet.

(2) *Midship bridle grommets.*—The two midship bridle grommets are made of 3/16-inch or 7/32-inch cable. Cutting length for the D–7, Mk. VII and D–8 is 1 foot 8 inches; finished length is 9 inches.

(3) *Midship running line.*—The midship running line is made of 3/16-inch or 7/32-inch cable. Cutting length for the D–7 and Mk. VII is 40 feet; for the D–8, 42 feet. Finished length for the D–7 and Mk. VII is 39 feet 5 inches; for the D–8, 41 feet 5 inches.





*b. Attachment.*—For details of attaching midship mooring rigging to the balloon, see FM 4–184.

■ 88. MK. VI RIGGING.—*a. Dimensions.*—Dimensions of rigging for the Mk. VI balloon follow:

(1) *Footropes.*—Replacement footropes are made of .067-inch cable (500-pound breaking strength), with a 2-inch soft eye in each end. The eyes are made by means of a wrapped and soldered splice. (See par. 37.) The upper eye is made directly into the thimbled eye of the rigging patch on the balloon. Finished length of the front foot ropes is 11 feet 9¾ inches; of the rear foot ropes, 15 feet 6¾ inches.

(2) *Grommet strops.*—The 6-inch grommet strops for the flying wire assembly are made of ⅛-inch cable, with a ¾-inch thimble eye in one end. Cutting length is 57 inches. For method of making a wire grommet, see paragraph 97. After the grommet is made, the thimble is seized in one end to form the eye.

(3) *Handling lines.*—Handling lines are made of ¼-inch rope with a 3-inch eye in the upper end and a 6-inch eye in the lower end. Cutting length of the front handling lines is 41 feet 7 inches; finished length is 39 feet 6 inches. Cutting length of the rear handling lines is 17 feet 1 inch; finished length is 15 feet. The small eye at the upper end of each handling line is lark's-headed to the appropriate handling patch.

(4) *Stabilizer bracing wires.*—The front and rear stabilizer bracing wires are made of .055-inch cable (300-pound breaking strength), with a 1-inch soft eye in each end. The eyes are made by means of a wrapped and soldered splice. (See par. 37.) Finished length of the front bracing wires is 6 feet 10¾ inches; of the rear bracing wires, 5 feet 2 inches.

(5) *The 25-foot strop.*—The 25-foot strop is made of ⅛-inch cable, with a cutting length of 26 feet 11 inches. It has a 1¼-inch thimbled eye in one end and a 2¼-inch soft eye in the other.

(6) *The 100-foot strop.*—The 100-foot strop is made of ⅛-inch cable with a 3-inch soft eye in each end. Cutting length is 102 feet 4 inches.

(7) *Winch leg.*—The winch leg is made of ⅛-inch cable, with a 3-inch soft eye in one end. It varies in finished length from 25 to 100 feet, depending on the distance from the winch to the fair-lead. The cutting length is the finished length plus 14½ inches.

*b. Installation.*—For details of installing Mk. VI balloon rigging, see FM 4–188.

## SECTION II

## CONSTRUCTION OF GROUND RIGGING (WIRE ROPE)

■ 89. GENERAL.—This section gives details of construction of ground rigging made of wire rope. (See par. 72).

■ 90. CRADLE.—*a. Dimensions.*—See figure 48. The cradle is made of salvaged flying cable according to the dimensions given below. If nicopress sleeves are used instead of hand splices, the cutting lengths given are reduced by 13 inches.

| Number required | Cutting length | | Finished length | | Circumference large eye | Circumference small eye | Cut-splice (cutting length) | |
|---|---|---|---|---|---|---|---|---|
| | *Feet* | *Inches* | *Feet* | *Inches* | | | *Feet* | *Inches* |
| Legs Nos. 1 and 6 (4 each). | 14 | 7 | 12 | 6 | 10½ in. | 6½ inches | | |
| Legs Nos. 2 and 5 (4 each). | 13 | 1 | 11 | | 10½ in. | 6½ inches | 1 | 11 |
| Legs Nos. 3 and 4 (4 each). | 10 | 1 | 8 | | 10½ in. | 6½ inches | | |
| Inner strops (2 each). | 3 | 5 | 1 | 6 | No large eye. | 2 small eyes; 6½ inches. | | |
| Extra strops for D–8 (4 each). | 3 | 2 | 1 | 2 | 2 eyes; 9 inches. | | | |

*b. Cut-splices.*—The straight cut-splices are put in the Nos. 2 and 5 legs with the inner throat of the large eye-splice and the outer throat of the straight cut-splice 1 foot 6 inches apart.

*c. Installation.*—The cradle is installed as shown in figure 48.





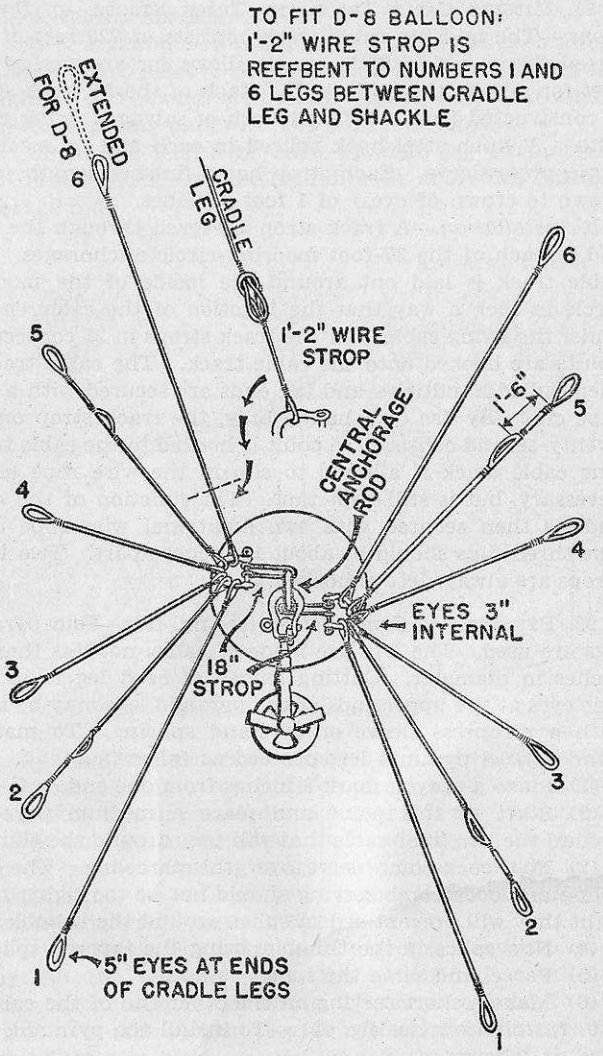



FIGURE 48.—Cradle.

■ 91. MIDSHIP CABLE TRACK AND TRACK STROPS.—*a. Dimensions.*—The midship cable track consists of 229 feet of salvaged flying cable. This length allows for an overlap of 3 feet for joining the cable ends. Each of the 24 track strops is constructed from a 2-foot length of salvaged flying cable, with a ¼-inch steel hook spliced in each end by means of a nicopress sleeve. Each strop has a finished length (from crown to crown of eyes) of 1 foot 6 inches.

*b. Installation.*—A track strop is reeved through the bent rod of each of the 37-foot mooring-circle anchorages. The cable track is laid out around the inside of the mooring circle in such a way that the junction of the cable ends is under the flying cable, and the track strops in 21 consecutive points are hooked onto the cable track. The cable track is then pulled handtight, and the ends are secured with a wire rope clip. By use of a handy-billy, the track strop on the twenty-second consecutive point is hooked to the cable track. The cable track is allowed to slip in the wire rope clip if necessary, but is still kept taut. The junction of the cable ends is then secured with two additional wire rope clips. The three clips should be about 12 inches apart. Two track strops are always left unhooked.

■ 92. PYRAMID.—*a. Construction* (see fig. 49).—Four pyramid legs are used. The legs are made of cable, not less than 7/32 inches in diameter. Cutting length of each leg is 19 feet. The eyes at the upper ends of the pyramid legs may be made with a nicopress sleeve or by hand splicing. To make a hand-spliced pyramid leg, proceed as follows:

(1) Place a crayon mark 8 inches from one end.

(2) Start at this point and place a medium parceling around the length of cable that will pass around the thimble.

(3) Now cockscomb serve over the parceling. The parceling and cockscomb serving should not be too tight; if too tight they will prevent a firm splice around the thimble.

(4) Now splice in the thimble, using the tapered splice.

(5) Parcel and serve the splice.

(6) Make a short serving on the other end of the cable.

*b. Installation* (see fig. 49).—To install the pyramid, proceed as follows:





(1) Reeve the upper eyes of the pyramid legs directly onto the quick-release shackle.

(2) Force a thimble onto the inner flop ring of each alternate main point. Reeve the lower end of each pyramid leg through its corresponding thimble, and secure the running end to the standing part with two wire rope clips.

(3) Adjust the length of each pyramid leg so that the quick-release shackle will be held directly above the central-anchorage rod.

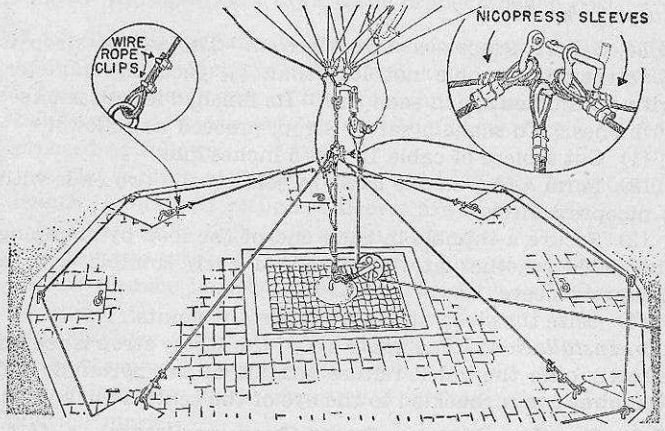



FIGURE 49.—Pyramid.

■ 93. PYRAMID REINFORCING STROP.—*a. Construction.*—The pyramid reinforcing strop is made of salvaged flying cable, with an 8- by 3-inch parceled and served soft eye in each end. The eyes may be made either by hand-splicing or with a nicopress sleeve. Cutting length for hand-splicing is 32 feet, which may be reduced by 13 inches if nicopress sleeves are used. Finished length is 29 feet.

*b. Installation.*—The pyramid reinforcing strop is used to strengthen the pyramid when the balloon is at tail-line mooring or at midship mooring. It may be used to add strength to a weak pyramid leg, to replace a broken pyramid leg, or to act as a fifth pyramid leg. If the wind is blowing

from the direction of one of the main points between those to which the pyramid legs are attached, the strop may be installed at that main point to reinforce the pyramid. To install the pyramid reinforcing strop, proceed as follows:

(1) Reeve one end of the strop through the quick-release shackle.

(2) Reeve the other end through the flop ring on the main point from which it is desirable to set up the reinforcement.

(3) Bring the two ends nearly together and lash them with at least three turns of ½-inch rope, and tie off the rope with a square knot.

■ 94. SAFETY STROP.—*a. Construction.*—The safety strop is constructed of cable not less than 7/32 inch in diameter, with a thimbled eye in each end. Its finished length is 5 feet 10 inches. To make a safety strop, proceed as follows:

(1) Cut a piece of cable 12 feet 5 inches long.

(2) Form a loop in the cable by joining the two ends with a nicopress sleeve.

(3) Secure a thimble in each end of the loop by clamping the cable together at the throat of each thimble with a nicopress sleeve.

(4) Seize the strop at three equidistant points.

*b. Installation.*—The upper eye of the safety strop is reeved directly onto the quick-release shackle of the pyramid, and the lower eye is shackled to the eye of the central anchorage.

■ 95. TAIL-LINE MOORING-CIRCLE CABLE AND STROPS.—*a. Construction.*—The tail-line mooring-circle cable consists of 570 feet of salvaged flying cable. Each of the 25 tail-line mooring-circle strops is made from a 6-foot 10-inch length of flying cable, with a small ground rigging hook spliced in each end by means of a nicopress sleeve. Each strop has a finished length (from crown to crown of eyes) of 6 feet. When a site is uneven it is necessary to make these strops of varying lengths. The battalion engineer will determine the lengths.

*b. Installation.*—To install the tail-line mooring-circle cable, proceed as follows:

(1) Reeve two tail-line mooring-circle strops through the bent rod of the tail-line mooring-circle anchorage nearest the winch position. Reeve a strop through the bent rod of each of the remaining 23 anchorages.





(2) Lay the tail-line mooring-circle cable as nearly as possible in position so that the ends will come in front of the winch anchorage.

(3) Hook 22 strops onto the tail-line mooring-circle cable and support the strops on their wooden posts.

(4) Draw the tail-line mooring-circle cable hand taut, and secure the ends with three wire rope clips placed 12 inches apart.

(5) Secure the twenty-third strop, using the handy-billy to draw the cable back toward the proper wooden post.

■ 96. TRANSVERSE STROP.—The transverse strop is 25 feet long with an 8- by 3-inch eye in each end, and a straight cut-splice 5 feet from each end. The strop can be made with either hand splices or nicopress sleeves. To make a transverse strop proceed as follows:

*a.* Cut a piece of flexible flying cable 28 feet long (reduce length 13 inches if nicopress sleeves are to be used).

*b.* Splice an 8- by 3-inch eye in each end.

*c.* Cut two pieces of cable 23 inches long to make the cut-splices (reduce length 13 inches if nicopress sleeves are to be used).

*d.* Measure 5 feet from the crown of the eye in one end of the strop and place a chalk mark.

*e.* From this mark, measure 5 inches more and make another mark.

*f.* Take one of the 23-inch pieces of cable and place a serving 8 inches from each end (for hand-splicing).

*g.* Splice the 23-inch cable into the strop to make a straight cut-splice, matching the servings to the marks on the strop.

*h.* Repeat steps *d, e, f,* and *g* above to make the cut-splice on the other end of the strop.

■ 97. WIRE GROMMETS (See fig. 50).—Thirteen wire grommets of 2-foot circumference are needed for each LA bed. Wire grommets can be made either by hand-splicing or with nicopress sleeves. To make a wire grommet with nicopress sleeves, cut a piece of flexible cable 2 feet 2 inches long and join the ends with a nicopress sleeve. To make a wire grommet by hand-splicing, proceed as follows:

*a.* Cut a length of flexible cable 15 feet long.

*b.* Unlay all strands.

*c.* Near the middle of each strand make two crayon marks 2 feet part.

*d.* Match these crayon marks, forming a ring.

*e.* Form a grommet of six turns.

*f.* Tie a thumb knot with the lay of the cable.

*g.* Secure the two ends with two tucks in each end.

*h.* Parcel and cockscomb serve, or parcel and wrap with wire, between exposed ends.

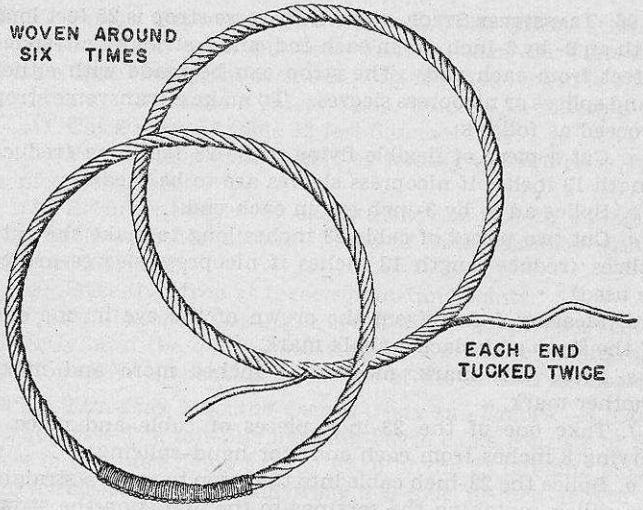



FIGURE 50.—Wire grommet.

98. WIRE SPIDER.—*a. Dimensions* (see fig. 51).—The wire spider is made of salvaged flying cable. The eyes can be made either by hand-splicing or with nicopress sleeves. Dimensions of the spider for hand-splicing are given below. Reduce cutting lengths given by 13 inches if nicopress sleeves are used.





| Number required | Cutting length | | Finished length | Large eye | Small eye |
|---|---|---|---|---|---|
| | *Feet* | *Inch* | *Feet* | | |
| 2 | 4 | 6½ | 2 | 8 feet by 3 inches | 4 feet by 2 inches. |
| 2 | 10 | 6½ | 8 | 8 feet by 3 inches | 4 feet by 2 inches. |
| 2 | 19 | 6½ | 17 | 8 feet by 3 inches | 4 feet by 2 inches. |

*b. Construction.*—When the spider legs are completed to the dimensions given above, the large eyes are heavily parceled and cockscomb served to prevent undue wear on the handling lines which are tied into the eyes. As an alternative to parceling and serving, the eyes may be covered with ¾-inch or 1-inch rope. The rope is applied by unlaying the strands and relaying them around the spider's-eye, with the spider's-eye as a core. The coverings on the eyes must be checked frequently, since—if they are allowed to wear off—the bare cable will chafe and cut the handling lines. The small eyes of the spider are lightly parceled and then served. The spider hand rope is made of ⅜-inch rope, and has a cutting length of 4 feet and a finished length of 3 feet. (See fig. 51.) The free end of the rope is finished by a back splice, and the other end is attached to the shackle by a 3-inch soft eye. The spacer rope is made of ⅜-inch rope and is 3 feet long. (See fig. 51.) It is cross wrapped to the spider legs with serving cord, and the free ends of the rope are served.

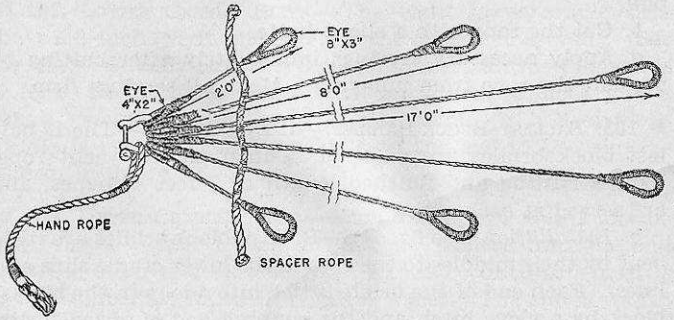



FIGURE 51.—Wire spider.

■ 99. OCTAGON.—The octagon, made of salvaged flying cable, has a cutting length of 113 feet to allow for the overlap when the ends are clamped together. The cable is reeved through the outermost flop rings of the main-point anchorages, and is secured with three wire rope clips. The clips and cable ends should be covered with friction tape.

■ 100. HAULING CABLE.—The hauling cable is made of salvaged flying cable 200 feet long. It is solder-dipped and served at one end and eye-spliced around a thimble at the other end.

■ 101. MK VI RIGGING.—*a. Dimensions.*—Dimensions of Mk. VI ground rigging made of cable are as follows:

(1) *Eight-way bed cable.*—A total of 390 feet of ¼-inch cable is required for the eight-way bed.

(2) *Two-way bed cable.*—A total of 100 feet of ¼-inch cable is required for the two-way bed.

*b. Installation.*—For details of installing Mk. VI rigging, see FM 4–188.

## SECTION III

## CONSTRUCTION OF GROUND RIGGING (FIBER ROPE)

■ 102. GENERAL.—This section gives details of construction of ground rigging made of fiber rope. Care should be taken that no rope is wasted. Follow these suggestions:

*a.* Measure fiber rope while it is under a 15- to 20-pound pull.

*b.* Cut the rope with a sharp knife.

*c.* Apply necessary servings immediately after cutting to prevent the rope from unlaying. Make all servings firm.

■ 103. BALLAST-BLOCK BRIDLES.—*a. Dimensions.*—The 12 ballast block bridles are made of ⅜-inch manila yacht rope, have a cutting and finished length of 3 feet 4 inches, and are served at each end.

*b. Installation* (see fig. 52).—Ballast-block bridles are reef-bent by their middles to the eyes in the lower cradle slips and lines. Each end of the bridle is tied into a loop in the ballast block by a clove hitch and the running end is seized to the





standing part. The distance between the loops on the blocks and the reef bend is 15 inches.

■ 104. LOWER CRADLE LINES.—The four lower cradle lines are made of ⅜-inch manila yacht rope, and have a 3-inch eye in one end and the other end served. Cutting length is 6 feet 10 inches; finished length is 6 feet. These cradle lines are

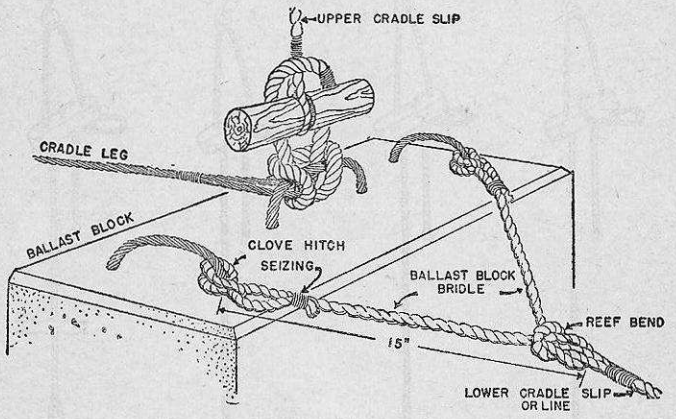



FIGURE 52.—Attachments to ballast block.

reef-bent to the bridles on the ballast blocks at Nos. 1 and 6 cradle legs as shown in figure 52.

■ 105. LOWER CRADLE SLIPS.—The eight lower cradle slips have a 3-inch eye in one end and the other end served. (See fig. 53.) Cutting length is 9 feet 8 inches; finished length is 9 feet. Each slip is rigged with an adjusting block and a small ground rigging hook in the bight. A ballast-block bridle is reef-bent by its middle to the eye in the slip, as shown in figure 52.

■ 106. UPPER-CRADLE SLIPS.—Each of the 24 upper cradle slips has a toggle, 1 inch in diameter, spliced into one end and the other end served. (See fig. 53.) Cutting length is 9 feet 10 inches; finished length is 9 feet. The slip is rigged with an adjusting block and a small ground rigging hook in

the bight. The toggle is attached to a rope grommet on the middle eye of the ballast block, as shown in figure 52.

■ 107. TENSIONING SLIPS.—Each of the 10 tensioning slips is made of 12 feet of ⅜-inch manila rope, and is served at both

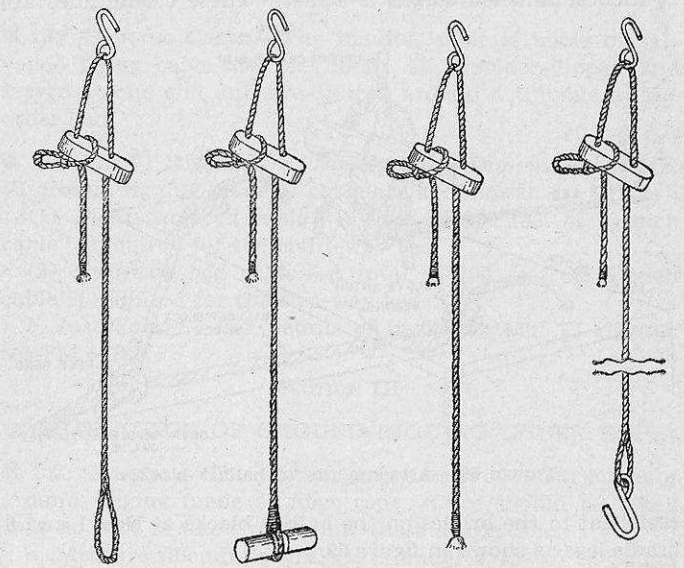



FIGURE 53.—Slips.

ends. The slip is rigged with an adjusting block and a small ground rigging hook in the bight. (See fig. 53.)

■ 108. MOORING SLIPS.—Each of the eleven mooring slips is made of ⅝-inch manila rope with one end served and a large ground rigging hook spliced into the other end. Cutting length is 25 feet 8 inches; finished length is 25 feet. Each slip is rigged with an adjusting block and a small ground rigging hook in the bight. (See fig. 53.)





■ 109. BALLAST-BLOCK GRAPPLE.—The ballast-block grapple is made of ½-inch rope 2 feet 6 inches long. The rope is spliced and served around a 1½-inch toggle at one end, and a sandbag hook at the other end. The grapple measures about 1 foot from the crown of the eye splice on the hook to the inside of the toggle. (See fig. 54.)

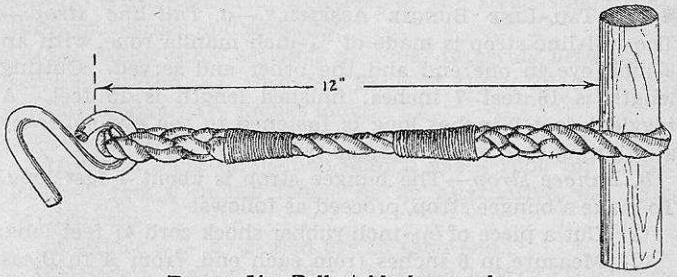



FIGURE 54.—Ballast-block grapple.

■ 110. FIN-FURLING LINES.—The two fin-furling lines are made of No. 72 cotton seine twine. Each line is 38 feet long and has a 1-inch soft eye in each end. A line of this length will serve the D–7, Mk. VII and D–8 balloons. (See fig. 55.)

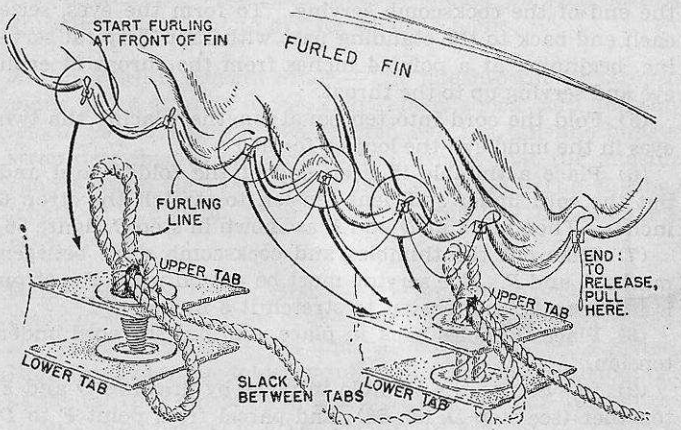



FIGURE 55.—Fin-furling line.

■ 111. HANDY-BILLY.—The handy-billy is a block and tackle made with one single-sheave steel block and one double-sheave steel block, each block having a hook clamped to it. The tackle consists of 25 feet of ⅜-inch rope, which is eye-spliced to the single-sheave block and served at the other end.

■ 112. TAIL-LINE BUNGEE ASSEMBLY.—*a. Tail-line strop.*—The tail-line strop is made of ¾-inch manila rope, with an 8-inch eye in one end and the other end served. Cutting length is 16 feet 7 inches; finished length is 15 feet. A toggle 1 foot 2 inches long is fastened to the eye splice by a retaining cord of No. 72 seine twine.

*b. Bungee strop.*—The bungee strop is about 4 feet long. To make a bungee strop, proceed as follows:

(1) Cut a piece of 5/16-inch rubber shock cord 41 feet long.

(2) Measure in 6 inches from each end, from *A* to *B*, as shown in step *A*, figure 56.

(3) Cockscomb serve 3½ inches on each end, from *B* to *C*, as shown in step *A*, figure 56.

(4) Join the two ends of the cord together by forming the served portions of the cord into eyes and interlocking the eyes as shown in step *B*, figure 56. The throat of each eye is at the end of the cockscomb serving. To form the eyes, seize each end back to the standing part with French spiral serving, beginning at a point 4 inches from the throat of each eye and serving up to the throat.

(5) Fold the cord into ten equal lengths, placing the two eyes in the middle of the loop so formed.

(6) Place a thimble in each end of the folded cord and put the cord under sufficient tension to stretch the strop 6 inches. Then mark at *D* and *E* as shown in step *C*, figure 56.

(7) Take out the thimbles and cockscomb serve between marks *D* and *E*. The serving must be put on while the strop is under sufficient tension to stretch it 6 inches.

(8) Place thimbles back in place, and put the cord under tension.

(9) (*a*) Secure the thimble in place by drawing *D* and *E* together (see step *D*, fig. 56), and parcel from point *F* to *D* and *E* (2 inches).





(*b*) Next seize this area with French spiral serving.

(10) Start at point *G* (3 inches from throat) and parcel and serve up to the throat.

(11) Start at point *H* (4 inches from throat) and parcel and serve to throat.

(12) Make all parcelings and servings on both ends of the strop. When finished, each end of the strop should have three parcelings and servings.

(13) Make three servings at equal intervals between the servings at the two throats. Each of these three servings should be about 1½ inches long.

*c. Check strop.*—To make a check strop, proceed as follows:

(1) Cut a piece of ½-inch manila yacht rope (or equivalent), 7 feet 6 inches long. As an alternative, use extra flexible cable.

(2) Splice a 3- by 2-inch eye in each end.

(3) Secure the completed strop (6 feet long) to the bungee strop. To do this, place the eyes of the check strop on the eyes of the bungee strop, and serve between the crown and the throat of the eyes. Do not serve over the crown.

(4) Seize the center of the check strop to the center of the bungee strop.

*d. Shellacking.*—Put two coats of shellac on each serving and allow each coat to dry for 10 to 12 hours.

■ 113. MIDSHIP RUBBER STROP.—The midship rubber strop is made of 14 strands of 5/16-inch rubber shock cord (cutting length 29 feet) and is constructed like the tail-line bungee strop described in paragraph 112*b*, except that the midship rubber strop has 14 strands instead of 10. The finished length of the strop, from crown to crown of the thimbles, is 24 inches.

■ 114. MIDSHIP CHECK STROP.—The midship check strop is made of 5 feet 2 inches of ½-inch rope with a 2- by 4-inch soft eye in each end. Its finished length is 3 feet 4 inches. It is attached to the midship rubber strop in the same manner as the tail-line check strop is attached to the tail-line bungee strop. (See par. 112*c*.)

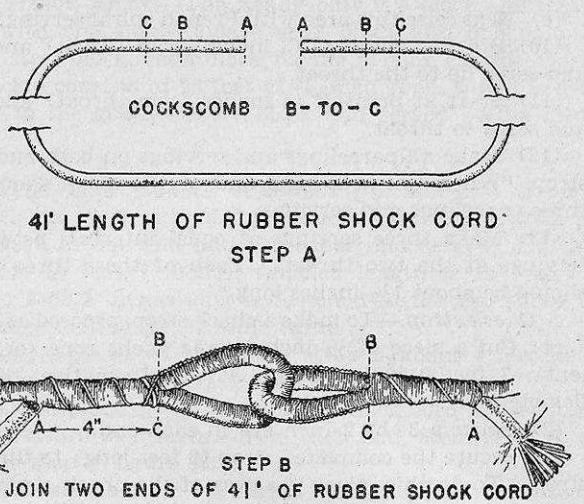



FIGURE 56.—Bungee strop.





■ 115. MIDSHIP TENSIONING STROP.—The midship tensioning strop is made of ¾-inch rope with a 2- by 4-inch soft eye in one end and with the other end served. The strop has a cutting length of 7 feet 11 inches and a finished length of 7 feet. The soft eye of the tensioning strop is lark's-headed into the eyes of the rubber and check strops. The other end of the tensioning strop is passed through the shackle on the trolley block and is tied to its standing part by a picketing hitch.

■ 116. RUNNING NOSE LINE.—The running nose line is made of ½-inch rope with a 3-inch soft eye in one end and a serving on the other end. The cutting length is 26 feet and finished length is 25 feet.

■ 117. RIP-CORD STROP.—Cutting length of the rip-cord strop is 7 feet 6 inches; finished length is 5 feet 6 inches. The strop has a 3-inch soft eye in each end. One eye is attached to the eye of the central anchorage, and the other is left standing free to receive the rip cord when the balloon is at tail-line mooring, mooring-circle close-haul, or midship mooring. The rip-cord strop is seized to the safety strop at four points: at the throat of the eye at the central anchorage, at the throat of the eye at the upper end, and at two points equally distant between the two.

■ 118. RUNNING TENSIONING SLIP.—The running tensioning slip is 36 feet long, with a hook on the running end as well as in the bight. To make a running tensioning slip, cut a 37-foot length of ½-inch rope, splice a hook into one end, and rig the other end with an adjusting block and hook.

■ 119. SANDBAG LINES.—Each of the 12 sandbag lines is spliced around a toggle at one end and the other end is served. Cutting length is 7 feet 10 inches; finished length is 7 feet.

■ 120. SANDBAG SPIDERS.—Each of the two sandbag spiders consists of two straps 4 feet and 3 feet long, seized together, with a toggle spliced into each end. To make a sandbag spider, proceed as follows:

*a.* Cut two lengths of rope, 5 feet 2 inches and 4 feet 2 inches long.

*b.* Splice a 4- by 2-inch toggle in each end of both ropes, and serve properly so that the toggles will be tightly secured.

*c.* Find the center point of each strop, place the strops together at their centers, and cockscomb serve 3 inches each way from the center.

*d.* Seize the four legs of the spider together by putting a 1-inch French spiral serving 1 foot from the crown formed in *c* above.

*e.* From the serving described in *d* above, measure 6 inches toward the crown and place another serving of the same kind.

*f.* Midway between the two servings described in *d* and *e* above, place another serving of the same kind.

■ 121. SNUBBER SLIPS.—The two snubber slips are constructed in the same way and to the same dimensions as the tensioning slips. (See par. 107.)

■ 122. SNUBBER STROPS.—Each of the two snubber strops is eyespliced around a hook at one end and a toggle at the other end. Cutting length is 24 inches and finished length is 9 inches. Construction is like that of the ballast-block grapple. (See par. 109.)

■ 123. HAULING ROPE.—The hauling rope should be ¾-inch manila rope if it is to be used for both mechanical and manual haul-downs. The rope should be 200 feet long. A thimbled eye-splice is made in one end and the other end is served. A wire hauling cable (see par. 100) is used if possible, but it is necessary to use a hauling rope with winches which have gipsy-heads that turn in one direction only.

■ 124. MK. VI RIGGING.—*a. Construction.*—Specifications for Mk. VI ground rigging made of fiber rope follow:

(1) *Heaving lines.*—The two heaving lines are made of ¼-inch rope, 30 feet long, served at each end.

(2) *Side-hook ropes.*—Two side-hook ropes are made of ¼-inch rope, with a ground rigging hook eye-spliced in one end. Cutting length for each rope is 75 feet 10½ inches; finished length is 75 feet.

*b. Installation.*—For details of installing Mk. VI rigging, see FM 4–188.

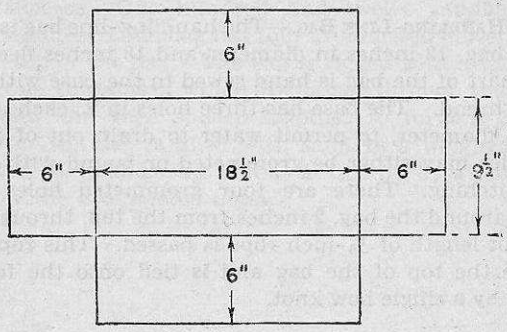




## SECTION IV

## CONSTRUCTION OF FABRIC EQUIPMENT

■ 125. BALLAST-BLOCK COVER.—Covers for concrete ballast blocks may be made of used sandbags, salvaged envelope



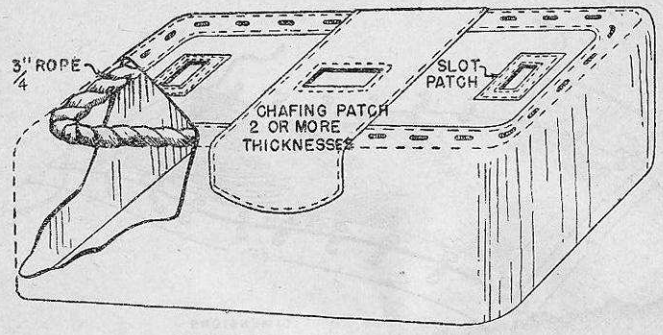




FIGURE 57.—Ballast-block cover.

fabric, or heavy canvas. The most convenient way to make these covers is to cut the fabric in the form of a cross to the dimensions shown in figure 57. The 6-inch flaps are folded

over 54 inches of ¾-inch rope, stitched to hold the rope in place, and then stitched together. Three slots are cut in the top of the cover at the proper points to allow the loops in the block to protrude through the cover. The top of the cover should be reinforced around the slots with at least two thicknesses of material. (See fig. 57.)

■ 126. HANDLING-LINE BAG.—The handling-line bag is a heavy canvas bag, 12 inches in diameter and 18 inches deep. The upper part of the bag is hand sewed to the base with double No. 30 thread. The base has three holes in it, each about an inch in diameter, to permit water to drain out of the bag. The holes may either be grommeted or bound with buttonhole stitching. There are four grommeted holes equally spaced around the bag, 2 inches from the top, through which a 10-foot length of ¼-inch rope is passed. This rope serves to close the top of the bag and is tied onto the foot-rope shackle by a single bow knot.

■ 127. RUDDER PROTECTION SHEET.—The rudder protection sheet is made of heavy canvas and measures approximately 7 by 26 feet. It has an eyelet at each front corner, into which is tied an 8-foot length of No. 72 cotton seine twine. It has

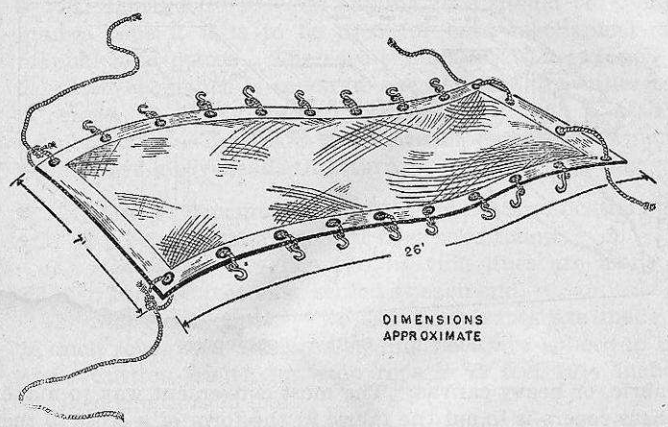



FIGURE 58.—Rudder-protection sheet.





four eyelets along the rear edge through which a 15-foot length of twine is laced. There are also eight eyelets equally spaced along each of the long edges. A small hook is fastened to each of the sixteen eyelets by a short length of twine tied off with a square knot. (See fig. 58.)

■ 128. SANDBAGS.—One hundred and twelve sandbags are needed at a site. Each bag has four grommeted holes ½ inch from the top of the bag. The bag is rigged with a length of ¼-inch rope, the ends of which are passed through the grommeted holes and then spliced together to form a 24-inch ring. After the bag is filled with sand to a weight of approximately 40 pounds, the throat is tied off by a length of rope below the grommeted holes.

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