

Cooperative Extension Service
North Dakota State University
Fargo, North Dakota 58102

ROPE and its uses

DARNELL R. LUNDSTROM
Extension Agricultural Engineer

CIRCULAR A-489 Revised

MAY 1977

Some type of rope has been used since pre-historic times. The first ropes were probably vines from trees or strips of animal hide. Rope was necessary to hang food out of reach of animals, to construct nets or traps, and for construction purposes. Later, fibers of different types were braided or wound together to make ropes. Fibers used included water grasses and fibrous bark from various tropical trees. Fine ropes also were braided from horse and goats' hair. Other fibers such as cotton have also been used together with manila and sisal.

Rope Materials

Ropes in use today are made from either natural or synthetic fibers. Natural fiber ropes use mainly manila or sisal fibers. Nylon and polypropylene or polyethylene are the most commonly used synthetic fibers.

Manila rope is made from the fiber of the abaca tree, a species of banana plant which grows almost exclusively in the Philippine Islands. The strands of manila fiber are very strong and from 6 to 10 feet long. Sisal rope is made from leaves of the henequin plant, a plant having long pointed leaves with spiny edges, which grows mainly in Yucatan, Mexico. Sisal fibers average 3 feet in length and are only 3/4 as strong as manila. Ropes commonly use manila or manila-sisal combinations while straight sisal is used for twine. Sisal fibers are stiff and harsh resulting in "splinters" from this rope. These "splinters" indicate the rope is all or partially sisal.

Ropes are also made from jute, cotton, and Italian hemp. These are soft fibers and have only about 50 per cent of the strength of manila.

The man-made fibers used for rope include nylon, polyester (dacron), polyethylene and polypropylene. These fibers all are made from basic raw materials

such as nitrogen, oxygen, hydrogen and carbon. Polyethylene and polypropylene are very similar; both are made from petroleum products. Polypropylene utilizes polypropylene gas and polyethylene utilizes polyethylene gas.

Strength of Ropes

Table 1 lists the breaking strength and working strength of common sizes and types of rope. Notice that the working strength is considerably below the breaking strength. This difference is called the safety factor and must be considered when choosing a rope. The most common safety factor for manila rope is 5; meaning 1/5 of the breaking strength equals the working strength. For example, if a 250-pound block was to be lifted, a 3/8" rope having a 270 pound working strength and 1,350 pound breaking strength could be used. A safety factor of 6 is used for polypropylene and polyethylene and a factor of 9 is used for dacron and nylon.

The rated working load on rope includes this safety factor to allow for some natural wear and

5
544.3
N9
A8

Table 1: Breaking strengths and working strengths of common rope types. Working strengths are based on 20 per cent of breaking strength for manila and sisal; 11 per cent of breaking strength for nylon and dacron; 17 per cent of breaking strength for polypropylene and polyethylene.

| Size (Diameter) | | Type of Rope | | | | |
|--------------------|----------------------|---------------|--------------|--------------|------------------------------|---|
| | | Manila lbs | Sisal lbs | Nylon lbs | Polyester (Dacron) lbs | Polypropylene and Polyethylene lbs |
| 3/16" | Breaking Strength | 450 | 360 | 1,000 | 1,000 | 800 |
| | Working Strength | 90 | 70 | 110 | 110 | 136 |
| 1/4" | Breaking Strength | 600 | 480 | 1,650 | 1,650 | 1,250 |
| | Working Strength | 120 | 96 | 172 | 172 | 210 |
| 3/8" | Breaking Strength | 1,350 | 1,080 | 3,700 | 3,700 | 2,700 |
| | Working Strength | 270 | 220 | 410 | 410 | 460 |
| 7/16" | Breaking Strength | 1,750 | 1,400 | 5,000 | 5,000 | 3,500 |
| | Working Strength | 350 | 280 | 550 | 550 | 600 |
| 1/2" | Breaking Strength | 2,650 | 2,140 | 6,400 | 6,400 | 4,200 |
| | Working Strength | 530 | 430 | 700 | 700 | 710 |
| 5/8" | Breaking Strength | 4,400 | 3,500 | 10,400 | 10,000 | 6,200 |
| | Working Strength | 880 | 700 | 1,140 | 1,100 | 1,050 |
| 3/4" | Breaking Strength | 5,400 | 4,300 | 14,200 | 12,500 | 8,500 |
| | Working Strength | 1,080 | 860 | 1,560 | 1,380 | 1,450 |
| 1" | Breaking Strength | 9,000 | 7,200 | 25,000 | 22,000 | 14,000 |
| | Working Strength | 1,800 | 1,400 | 2,750 | 2,480 | 2,380 |
| 1 1/2" | Breaking Strength | 18,500 | 14,800 | 53,000 | 46,800 | 29,700 |
| | Working Strength | 3,700 | 2,900 | 5,700 | 5,200 | 5,000 |

deterioration of the rope. The safety factor also takes care of some shock loading. For example, the 250-pound block in the above example might be dropped slightly and the rope be forced to absorb the shock. The shock loading may easily be three times the block weight or 750 pounds.

A higher factor of safety is used for synthetic ropes than for manila. Synthetic ropes are more subject to cuts and because of their smaller size for a certain strength, a cut will reduce their strength more than the same cut on a manila rope.

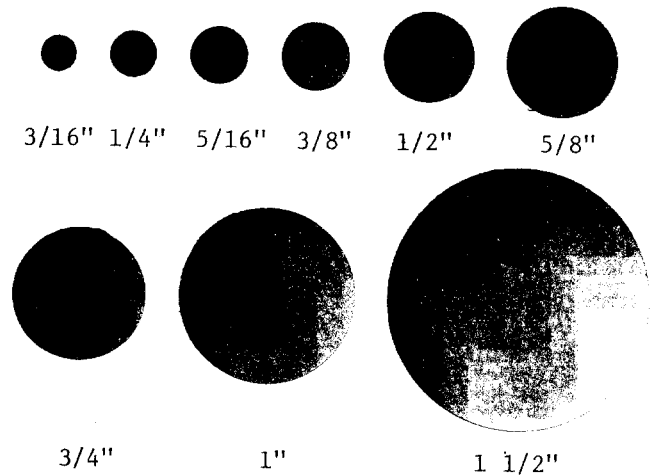


Figure 1. Rope size is important, but more than just size must be considered.

Rope Characteristics

The type of usage will determine which rope will fit the job. More than just the strength of the rope must be considered. The following summarizes individual rope characteristics which will affect its application.

Manila is the most commonly used rope. This is the standard other types of rope are compared to. Manila rope has good abrasion resistance. It has a high water absorption and is attacked by mildew and dry rot. Manila has very little stretch and does not have high resistance to impact loading.

Sisal has similar characteristics to manila but is weaker, having 80 per cent of manila's strength. Sisal is more subject to mildew than manila rope.

Nylon is the strongest rope material, having over 2 1/2 times the strength of manila pound for pound. Nylon is light, has good abrasion resistance and excellent resistance to shock loading. Mildew and dry rot do not attack, however, nylon is affected by high temperatures, having a melting point of 480°F. Nylon has a lot of stretch and elasticity. This is good for shock loading, but may be dangerous if the rope breaks because the rope will "snap back" and may cause damage or personal injury.

Polyester or dacron rope has excellent characteristics, high abrasion resistance, good impact resistance, very low water absorption, no rot or mildew problem and high strength. Polyester, however, is the most expensive rope material and high temperatures are harmful. Polyester is heavier than nylon, weighing the same as manila. Polyester ropes stretch but do not "snap back" like nylon.

Polypropylene and polyethylene are the most common synthetic rope materials. They are light, have high strength, high impact resistance and are highly resistant to rot and mildew. However, they are not very resistant to abrasion. Polypropylene and polyethylene have a low tolerance to heat, melting at about 330°F. Both materials are lighter than water and are widely used for water ski tow lines.

GENERAL INFORMATION

Relaying Strands. The process of building up a rope from single strands is called laying a rope and the process of twisting together strands that have become untwisted, relaying. The most satisfactory method of relaying strands is that illustrated in Figure 1. The rope should be held firmly in the left hand and the thumb placed upon one of the strands, as shown in the illustration. Strand No. 1 is then twisted tightly with the right hand and pulled snugly into its place in the rope. Before loosening the hold upon the strand with the right hand, the thumb of the left is pressed upon this twisted strand at x. The next step is to grasp strand No. 2 with the right hand, twist it tightly, lay it in place above No. 1, and hold it with the thumb of the left hand just above the point x on No. 1. Strand No. 3 is treated in the same manner as Nos. 1 and 2, and the process is continued until the desired length of rope is relayed. If the work is properly done the rope may assume its original condition.

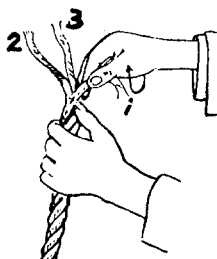
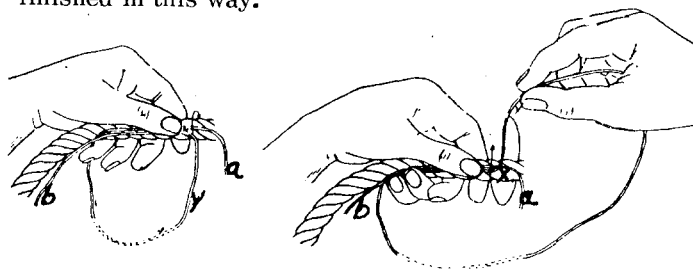


Figure 1. Relaying strands

Whipping. Binding the end of a rope with twine so that it will not unravel is called whipping. Ropes that are to be passed through pulley blocks, halter ropes and the ends of strands used in making splices, are usually finished in this way.



Figures 2 (left) and 3 (right). Beginning of the "Whipping"



Figure 4. The finished whipping

Secure a piece of string about 3 feet long and place it on the rope, allowing the end a to hang loosely over the end of the rope about two inches. Now make a loop by passing the other end of the string b down the rope and allowing a loose end of about two inches. Grasp the rope with the left hand in such a manner that the thumb can be placed on both strings as at x in Figure 2. Then with the right hand, grasp the loop of the string at y and wrap it down the rope over itself and the other strand (Figure 3). Continue the wrapping as far as desired (one-half inch or more) then draw up the loops and tighten the tie by pulling on the ends a and b (Figure 4). If the string is wrapped firmly and closely, when complete it should appear as in Figure 4.

KNOTS

Square or Reef Knot. The commonest knot for joining the ends of two ropes, and probably the knot that is most often made, is the sailor's true knot or reef knot. In making it, care should be taken not to make a granny knot. (See description of granny, Figure 6.)

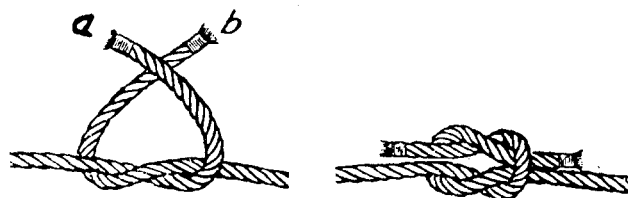


Figure 5. Square knot

First tie the righthand form of the overhand knot (Figure 5, top), then cross the strands (a in front of b) and tie the lefthand overhand knot. Notice that the ropes leave the loops together (Figure 5, bottom). The square knot can be easily and quickly tied, it is easily untied and is secure and reliable except when made with ropes of different sizes. The ease with which the knot can be tied and untied makes it very useful in reefing sails,

and its smoothness and secure character make it of use to the farmer in fastening the ends of binder twine when threading the binder.

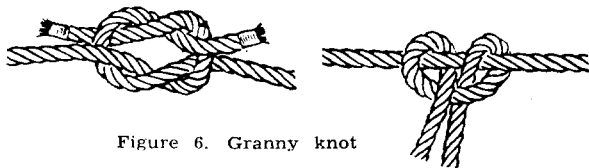


Figure 6. Granny knot

Granny or Lubber's Knot. This knot is often improperly used for the square knot and is of little value because it slips easily. The first step in making the knot is similar to that in making the square knot (Figure 5) but in completing it, the strand a passes behind the strand b before it is passed through the loop. Notice in Figure 6 that the ropes are on opposite sides of the loop. When the knot is drawn out of its correct form it assumes the shape of a hitch as shown in Figure 6 bottom. This kind of hitch slips easily.

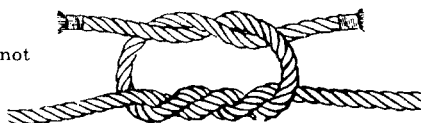
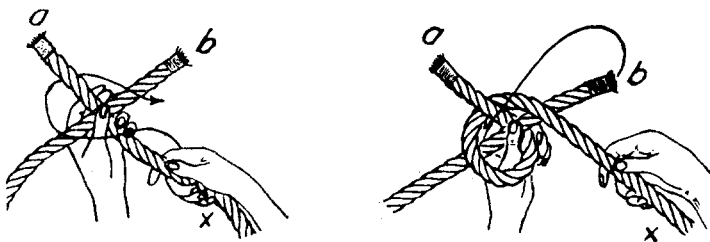


Figure 7. Surgeon's knot

Surgeon's Knot. The surgeon's knot is a modified form of the square knot. But instead of making but one twist as in Figure 5, the left end b is wrapped twice about the other rope (Figure 7). The string or rope is then pulled up tight and the wraps are jammed closely together by swinging the hands until the wrists cross while still pulling. This holds the knot securely until the second part can be tied. The surgeon's knot is used in surgical operations.



Figures 8 (left) and 9 (right). Making the weaver's knot

Weaver's Knot or Sheet Bend. This knot is easily made, is easily untied and never draws tight. Place the two ends of the rope together, the right a under the left b (Figure 8). Hold the two in place with the left hand, and with the right hand holding the rope at x, pass it around the end a, as shown in Figure 9. Release the right rope at x (Figure 9) and with the right hand, pass the end b through the loop as shown in Figure 10, left. The knot is completed by pulling on the ropes. By inserting a wooden stick or "toggle" into the knot it may be more easily untied.

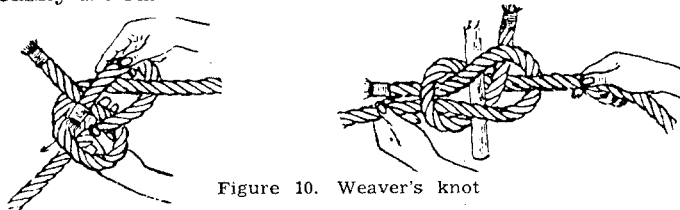


Figure 10. Weaver's knot



Figure 11. Figure "8" knot

Figure "8" Knot. This knot is made by making a loop in the rope by passing the end a over the standing part b at x, as shown in Figure 11. The end a is then passed beneath the standing part b and is brought back through the loop y. It is drawn taut by pulling on the standing part. The knot is used to prevent ropes from slipping through pulleys or holes.

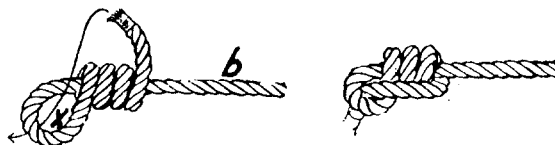


Figure 12. Stevedore knot

Stevedore Knot. The stevedore knot, like the figure eight, is used to prevent ropes from pulling through pulleys or holes. It is made in the same manner as the figure eight, but instead of making one turn around the standing part b, three turns are made as shown in Figure 12. The end is then passed back through the loop as shown by the direction of the arrow. The standing part of the rope b is then drawn until the loop x is taut.

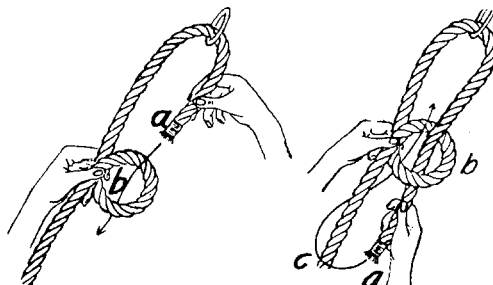


Figure 13. Beginner's bowline knot

Bowline Knot. The bowline is without question the most useful and most important of the different knots. It is easily tied, will not slip nor draw tight and may be easily untied. It is used in fastening animals, in the hay field or stacking outfits, in tying hay ropes, and the like.

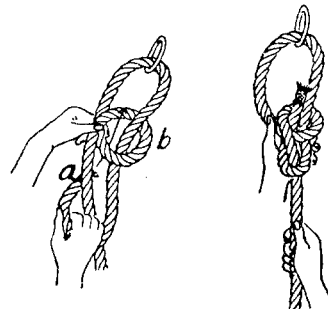


Figure 14. Beginner's bowline finished

(1) **BOWLINE - BEGINNER'S METHOD.** The knot is made by passing the end of the rope as a through a ring or around a post. A loop or half hitch is then made in the standing part of the rope about 2 feet from the end a (Figure 13, left). The end a is then brought through the loop b from the upper side (Figure 13, right). Next the end a is passed over the standing part of the rope at

c, as in Figure 14, and is then passed back through the loop b. Figure 14 also shows the completed knot drawn taut.

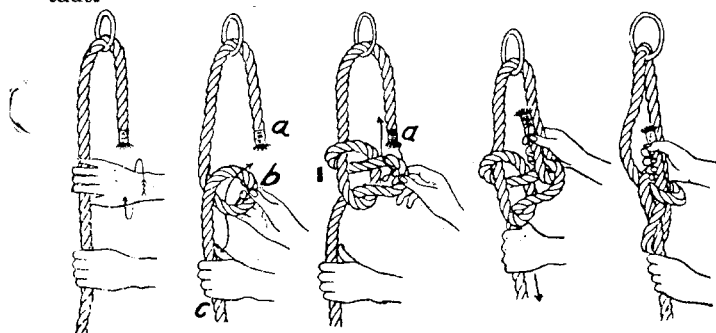


Figure 15. Boy's bowline knot

(2) **BOWLINE - BOY'S METHOD.** Placing the rope through a ring or around the object to which it is to be tied, lay both hands, palms down, on the standing part of the rope (Figure 15, left). With a twist of the right hand, make a loop or half hitch b. Now, with the left hand, pull the standing part of the rope c through the half hitch b, making a loose slip knot (Figure 15, center). Bring the end a through the loop of the slip knot d and fold it back upon itself, holding it firmly with the right hand. With the left hand on the standing part of the rope, give a quick jerk in the direction indicated by the arrow and the knot is completed (Figure 15, right).

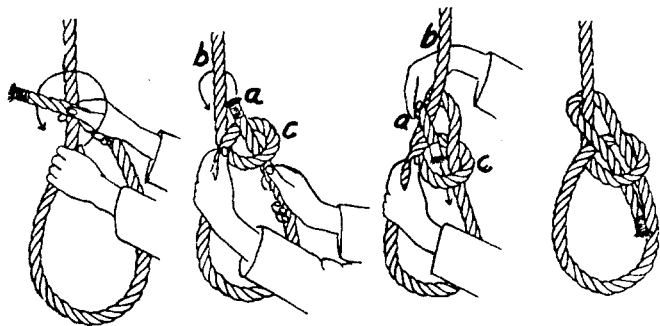


Figure 16. Overhand bowline knot

(3) **BOWLINE - OVERHAND METHOD.** With the right hand on the end of the rope and the left on the right in the position as shown in Figure 16, left, make a loop by bringing the left hand around the end of the rope as indicated by the direction of the arrow. Now, with the left hand hold the loop in place. Grasping the end of the rope a with the right hand, bring it around beneath the standing part b and back through the loop c. This is the quickest and easiest method of making the bowline knot.

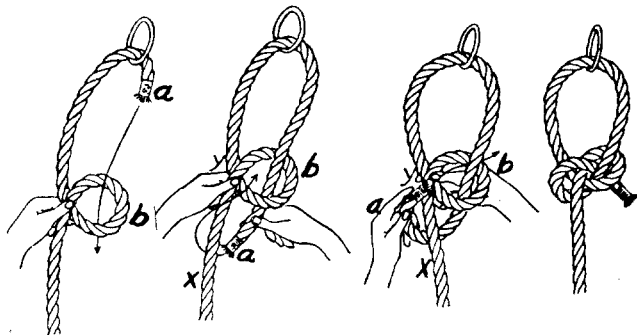


Figure 17. Teamster's hitch

Teamster's Hitch. The teamster's hitch is a modified form of the bowline and is given here because it is often misused for that knot. Unlike the bowline, it draws tight and is difficult to untie. Fasten the rope to the object to which it is to be tied. Then make a loop or half hitch in the rope (Figure 17, left) and bring the end a through the loop from the upper side as in starting the bowline. But instead of bringing the end over the standing part of the rope at x as in the case of the bowline, it is passed under the rope x. In other words it is passed around the loop where the ropes cross, as at y. The end a is then passed down through the loop b, as indicated by the arrow. The completed knot is shown at the right in Figure 17.

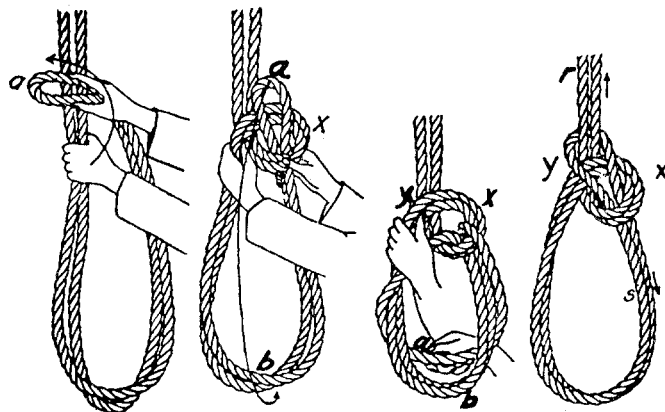


Figure 18. Bowline on the bight

Bowline on the Bight. This knot is made in the middle of a long rope, or at the end of a rope when it has been doubled. The steps in the beginning are the same as those used in making the bowline (see description of bowline, overhand method, Figure 16) except that a double rope is used. Figure 18, left, shows the first step. A loop is then made about the end a with the left hand. The end a should now be pulled through the loop x far enough so that it may be drawn downward as indicated by the arrow. The loop a is now slipped over the large loose loop b, and then carefully moved back until it is in position of a in Figure 18, right. In tying the knot, care should be taken to prevent the half hitch or loop x from losing its form. This can be done by holding the ropes together where they cross at y. To tighten the knot, pull carefully on the ropes at r and s in the direction of the arrows. The bowline on the bight, while not as important as many other knots, is especially useful in throwing horses and cattle. It is safe because it will not slip or draw tight and is easily untied. Its use is further described under "tackles for throwing horses and cattle."

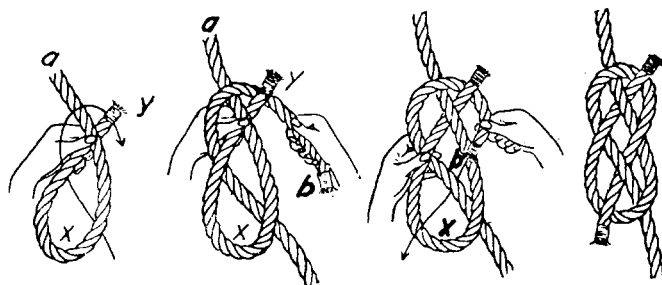


Figure 19. Carrick bend

Carrick Bend. For tying ropes together, no better knot can be used than the carrick bend, as it is quickly and easily tied. It is secure and does not draw tight. The carrick bend is often used as a fancy knot in braids or bands. In making the knot, lay the end of the rope y under the standing part a to form a loop as shown in Figure 19, at left; pass the other end of the rope b under the loop x, over the standing part at a and under the end y. Holding the ropes firmly in position, push the loop b through the loop x, making a slight loop. Then pass the end of the same rope b between the raised loop of b and the loop x, as indicated by the arrow and illustrated in Figure 19, at the right. If the standing parts of the rope are pulled, a modified form of the knot will be the result (Figure 20). This form of the carrick bend is sometimes called the double bowline.

Figure 20. Double bowline

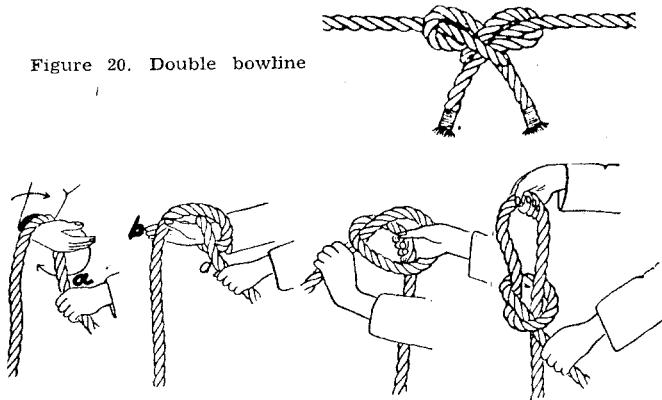


Figure 21. Slip knot

Slip Knot. The slip knot is one of the common knots. It can be easily and quickly made by catching the bight of the rope with the right hand, Figure 21, and then giving the hand a turn in the direction indicated by the arrow in such a manner as to catch the end a over the wrist. Grasp the bight of the rope at b, and pull it through the loop. Illustration at right in Figure 21 shows the completed knot.

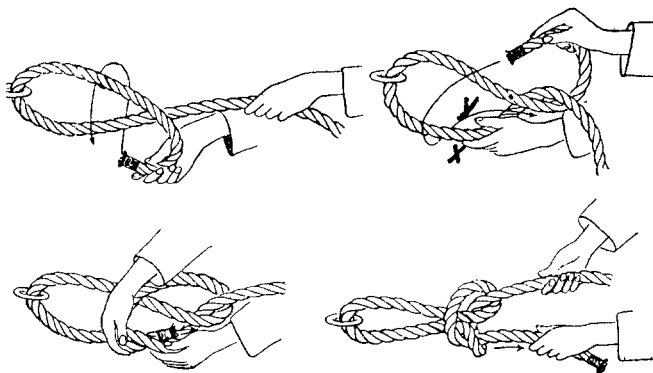


Figure 22. Halter tie

Halter Tie. The halter tie is often used in fastening animals. It is sometimes used instead of the bowline, but, unlike the bowline, draws tight, and if not carefully made it often slips. With the left hand on the standing part of the rope and the right hand holding the end, bring the short end down across the standing part of the rope as in Figure 22, upper left. Passing the end around the rope as indicated by the arrow, with the left

hand grasp the standing part of the rope at x (Figure 22, upper right). Now pass the end beneath both ropes, as indicated by the arrow and through the loop y formed by the left hand. In tightening the knot, draw on the short end first (lower right), or it may be pulled out of shape and two hitches formed.

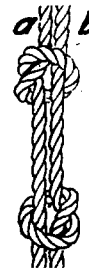


Figure 23. Fisherman's knot

Fisherman's Knot. The fisherman's knot derives its name from the fact that it is commonly used for joining silkworm gut on fishing tackles. In making it, the strands are laid together and an overhand knot (Figure 23) is made with one end a around the other strand b. The strands are then turned end for end and another overhand knot made with the other end b around the strand a.

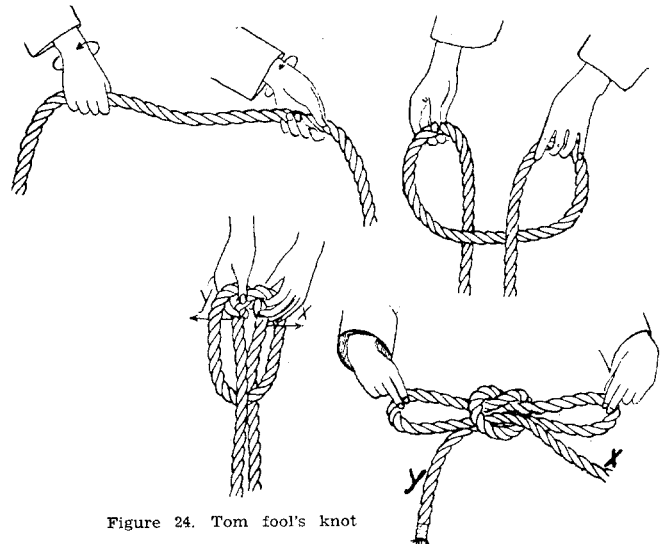


Figure 24. Tom fool's knot

Tom Fool's Knot. The tom fool's knot, or double bow, as it is sometimes called, is a trick knot and yet at the same time it is very useful. It is commonly used in ringing hogs, one of the loops being placed around the upper jaw. It is tightened on the jaw by pulling the standing part of the rope x, and untied by pulling the end of y (Figure 24).

To tie the knot, hold the rope with the palm of the left hand up and the palm of the right hand down. Turn both hands toward the right, as indicated by the arrows so that the palms will face each other. Holding the hands firmly in that position, bring the two loops together, as shown at lower left, so that they may be drawn through from opposite sides in the direction of the arrows. Releasing the hold upon the rope at x with the left hand, reach through the loop formed by x and grasp the rope y; and releasing the strand y with the right hand, reach through the second loop formed by y and grasp the rope x, then pull the ropes through in opposite directions, forming a double loop.

HITCHES

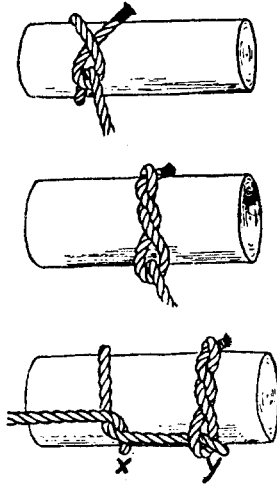


Figure 26. Half and timber hitches

Half Hitch. For temporarily fastening ropes when there is a steady pull, the half hitch is often used. Its chief use, however, is in connection with other knots or hitches. The half hitch is made by passing the end of the rope around the standing part and pinching it between the rope and the object to which it is attached (Figure 26, top).

Timber Hitch. The timber hitch is much more secure than the half hitch and is often used by carpenters, foresters and lumbermen in moving logs or timbers. It is, in part, a repetition of the half hitch, since the end, instead of being simply tucked under the rope, is wrapped about it once or more (Figure 26, middle).

Timber Hitch and Half Hitch. As the name implies, this hitch is a combination of the timber hitch and the half hitch. The two when thus used together make a more secure hitch than either alone and are especially useful in lifting timbers, long pipes, pumps, or other long objects where a nearly straight end pull is desired. When the loops cannot be passed over the end of the object, the half hitch x should be made first. The end is then pressed back to form the timber hitch y (Figure 26, bottom)

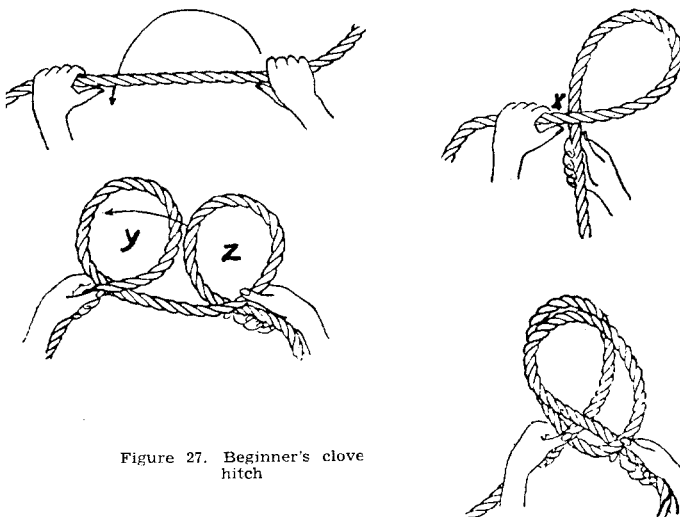


Figure 27. Beginner's clove hitch

Clove Hitch. The clove hitch is the most used of any of the hitches, being the simplest, most convenient and most secure method of fastening tent ropes, guy ropes or other temporary stay ropes. It may be formed either in the end or in the middle of the rope, without access to the ends, and it will be secure with either end of the rope used as the standing part.

1. **CLOVE HITCH - BEGINNER'S METHOD.** To make the hitch by this method, the rope is held in both hands as shown in Figure 27 (upper left). The right hand is then made to describe a curve, as illustrated by the arrow, passing under the rope at x (upper right). Hold the half hitch in the left hand and throw the second loop in the same manner as the first (Figure 27, lower left). Slide the loop last formed z over the first y, as indicated by the arrow.

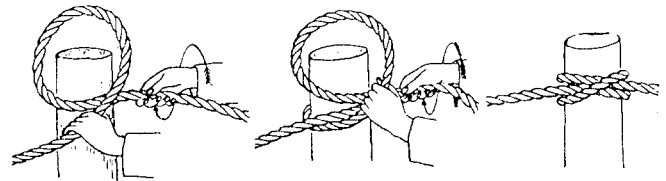


Figure 28. Sailor's clove hitch

2. **CLOVE HITCH - SAILOR'S METHOD.** Oftentimes it is desirable to form a clove hitch where there is a pull on the rope. This can be done by sustaining the weight with the left hand as in Figure 28, left, forming a loop with the right hand as illustrated in the beginner's method (Figure 27) and passing the loop over the top of the post. The end of the rope is then held in the left hand, and another loop made with the right hand (Figure 28, middle), is thrown over the post.

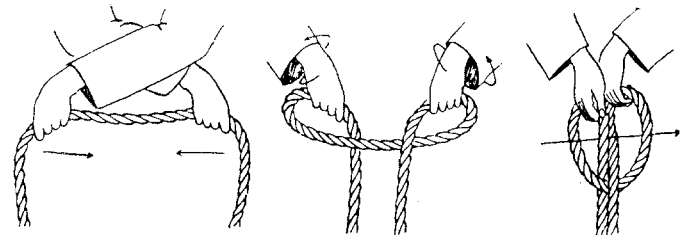


Figure 29. Farmer's clove hitch

3. **CLOVE HITCH - FARMER'S METHOD.** This method of making the clove hitch is the most practicable and the one most commonly used. Crossing the arms, the left in front of the right, grasp the rope as indicated on the left in Figure 29. Without twisting the rope, bring the hands to the position indicated in Figure 29, middle. The hitch is completed by turning both hands to the right, as indicated by the arrows. Both loops may then be held in the right hand.

Scaffold Hitch. A very simple but satisfactory form for fastening scaffolds may be made by slightly modifying the clove hitch. Make a clove hitch of ample size so that when it is placed over the end of the scaffold the ends swing freely below it, as in Figure 30. The ropes are then tightened by being pulled in opposite directions to the end of the plank, as shown in Figure 30. Turn the

plank over, draw the ropes up and fasten the short end to the standing part of a bowline knot (Figure 31). A scaffold hitch is made on the other end of the plank and the scaffold is ready for use.

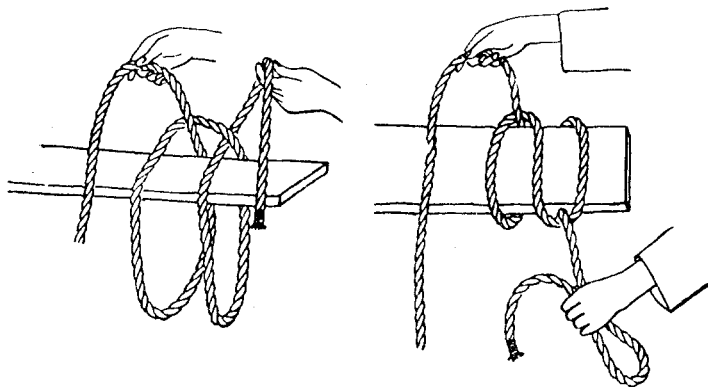


Figure 30. Making the scaffold hitch

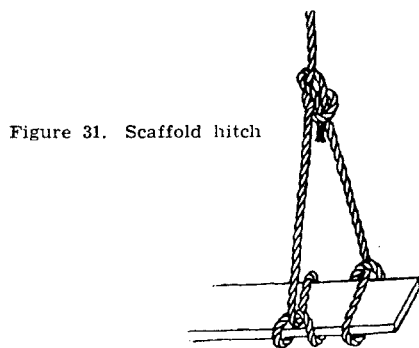


Figure 31. Scaffold hitch

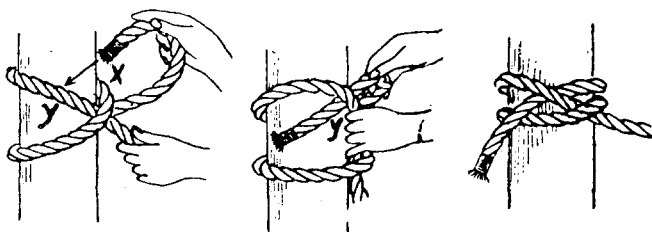


Figure 32. Miller's knot

Miller's Knot. This knot is the same as the clove hitch, but it is made in a different manner. The knot (really a hitch) is used by farmers and millers in tying grain and flour sacks and is also used in fastening ropes to long beams when the end of the beam cannot be reached.

Hold the standing part of the rope in the left hand while with the right pass the free end around the beam so that the loop crosses the rope *y* held in the left hand (Figure 32, left). The free end in the right hand is brought over the loop at *x* and under the standing part at *y* as indicated by the arrow. When the strands are drawn, the knot appears as in Figure 32, right.

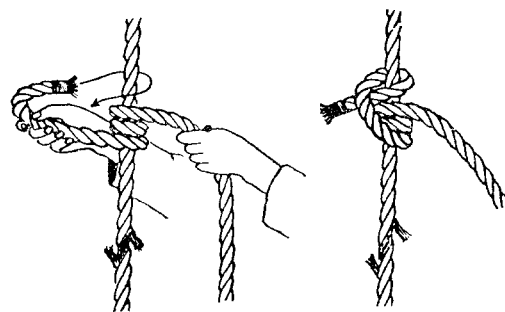


Figure 33. Taut line hitch

Taut Line Hitch. Very frequently in using ropes or cables, there are occasions when it becomes necessary to attach one rope to another. For instance, when a strand in a rope breaks under the weight of a heavy load, it is often desirable to relieve the tension at that point by fastening another rope above the break. Such a fastening can be made by using the taut line hitch.

Give the end of the rope two full turns about the taut rope, wrapping in the direction of the break (Figure 33) and drawing the wraps firmly and closely together upon the taut rope. Now pass the end over the two wraps as indicated by the arrow in Figure 33, and wind it once more about the taut rope, completing the hitch by passing it through the loop thus formed. The hitch will not hold unless it is tied very firmly and tightened while the weight is being applied to the new rope. The taut line hitch is very useful in case of emergency, but it should not be used as a permanent fastening.

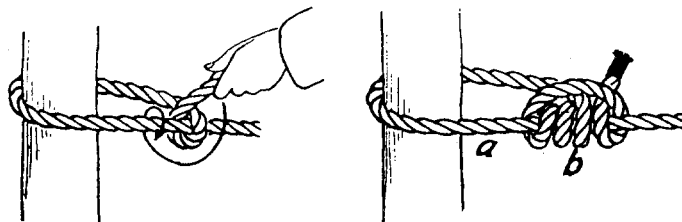


Figure 34. Snubbing hitch

Running Hitch or Snubbing Hitch. The taut line hitch described in the preceding paragraphs forms the principal part of the running hitch which is used in snubbing animals. The animal can be easily held by simply throwing the rope around a post and holding to the free end, which forms a half-hitch around the rope to which the animal is fastened (Figure 34, left). By using the half hitch in this manner, any slack can easily be taken up and as easily the animal can be given more rope. If a more permanent fastening is desired, the free end may be wrapped about the standing part as indicated by the arrow in Figure 34 and the hitch then completed as described for the taut line in Figure 33. The running hitch will not slip in the direction of the pull, i. e., toward the post, but by taking hold with one hand at *a* and the other at *b*, (Figure 34, right) it can be slid rather easily in the opposite direction and the slack thus quickly taken up. The running hitch should never be used as a permanent tie.

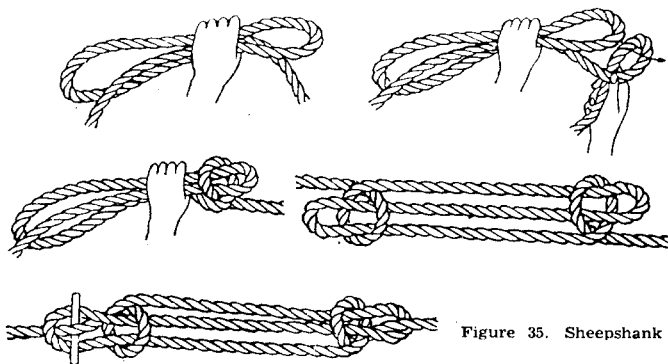


Figure 35. Sheepshank

Sheepshank. For shortening ropes of any size, either temporarily or permanently, there is no form of fastening that is more satisfactory than the sheepshank. This hitch is made by grasping the rope in the left hand, then bringing it up with the right hand so as to form a loop large enough to reduce the rope to the desired length (Figure 35, upper left). As the ropes are then held in the left hand, a half hitch is made with the right hand (Figure 35, upper right) and passed over the end. Reversing the rope, grasp the other end in the left hand and complete the hitch by repeating the process. The temporary sheepshank is illustrated at lower right in Figure 35. To make a permanent shortening, the ends are passed through the bights or toggled (lower left.) Sometimes the ends are whipped to the bights with binder twine, or else the overhand knot is used.

ROPE END KNOTS

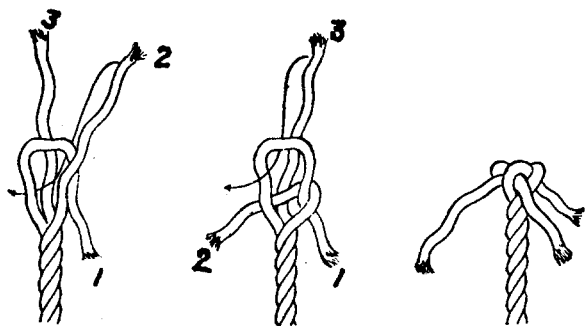


Figure 36. Crown knot

The Crown Knot. The crown knot, while in itself a complete and permanent fastening and of small value when used alone, is nevertheless very important as the basis of rope end splices.

To make the knot unlay the end of the rope far enough so that the knot or splice, if a splice is to be made, may be completed, bring strand 1 down between strands 2 and 3, forming a loop (Figure 36, left). Pass strand 2 across the loop thus formed as shown by the arrows, so that it will lie between the loop and strand 3. Strand 3 is now passed through the first loop, as indicated in Figure 36, middle and shown in illustration at right. Pull the crown down tightly by pulling on each of the strands.

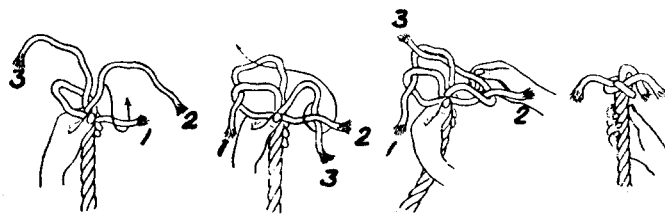


Figure 37. Wall knot

Wall Knot. Among the rope end fastenings that are easily and quickly made, the wall knot is the most used. For a small rope, unlay the strands about 3 inches. Hold the rope in the left hand loose strands upward. With the right hand, grasp the end of strand 1 and bring it across the rope, forming a loop and allowing the end to hang free (Figure 37). Hold the loose end in position with the left thumb. Grasp strand 2, pass it under strand 1 (see arrow in Figure 37, left) and hold it against the rope with the thumb of the left hand. Again with the right hand, grasp strand 3, pass it under strand 2 and up through the first loop formed, as indicated by the arrow and shown in the middle illustrations in Figure 37. Draw each strand gradually until the knot is tight.

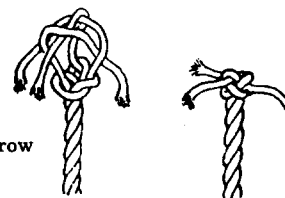


Figure 38. Wall and crown knot

Wall and Crown Knot. A more secure fastening than the wall knot is made by first making the wall knot (Figure 37), then finishing with the crown (Figure 38; see also description of crown knot, Figure 36.) The two knots are drawn together as in Figure 38, right.

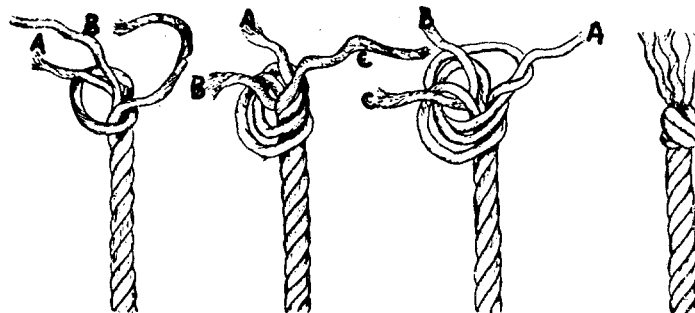


Figure 39. Rosebud knot

Rosebud Knot. This is a simple and practical end knot. Form the first loop by bringing the left strand a down to the left, around the other strands and up through the loop thus formed (Figure 39, left). Make the second loop by bending the strand b down to the left in front of the first loop, around back of the rope and through the two loops formed. Form the third loop by bending strand c down to the left in front of the other two loops, around the rope and up through all three loops (Figure 39, middle right). Tighten each strand gradually until the knot is formed.

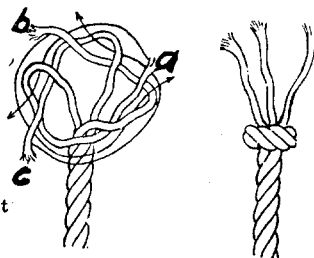


Figure 40. Matthew Walker knot

Matthew Walker Knot. This is one of the most permanent of the end knots and one of the most difficult. It can be most easily made by loosely constructing the wall knot (Figure 40; also Figure 37) then continuing as follows: Pass end a through the loop with b, end b through the loop with c, and c through loop a, as indicated by the arrows in Figure 40. Tighten the knot gradually by drawing each of the ends.

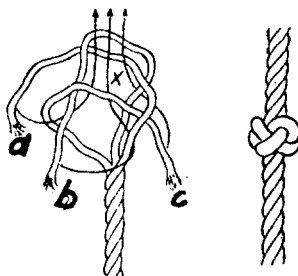


Figure 41. Diamond knot

Diamond Knot. This knot is very satisfactory when tied in the end of a rope, but is most used as an ornamental knot some distance from the end, when it is necessary to unlay the ends farther down the rope and relay the strands again when the knot is completed.

In beginning the diamond knot a crown knot is first made (Figure 36). Do not draw strands down tight but arrange loosely as in Figure 41. Pass end a around the loop of the next strand c and up through the center at x similarly; pass b around a, and c around b, each passing through the center x as indicated by the arrows. When tightening the knot, tighten the crown knot at the base first; if tightened by drawing on the ends first it will be drawn away from the twisted strands of the rope. Figure 41, right, shows the diamond knot completed.

SPLICES

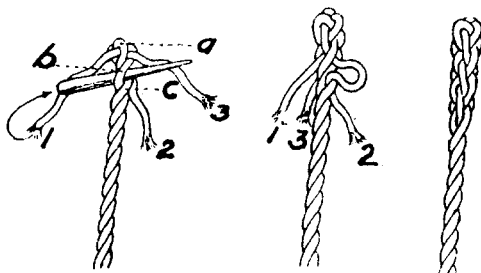


Figure 42. End or crown splice

End or Crown Splice. This is a permanent fastening on the end of a rope to prevent its unraveling. First make the crown knot described in Figure 36. Then splice back the loose ends. Strand 1 is passed over the nearest strand a on the main rope and under the second b, diagonally,

nally, almost at right angles to the twist of the strand (Figure 42, left). Strands 2 and 3 in turn, are in like manner spliced back, 2 over b and under c, and 3 over and under a. Each strand is tucked under but one strand of the main rope at a time (Figure 42, middle). To make a smooth tapering splice, cut out a portion of the fiber after each tuck and when finished pound the splice lightly with a short stick or hammer and roll it on the floor under the foot. In splicing ropes, a smooth, pointed hard wood stick or marlinspike is very convenient in raising the strands.

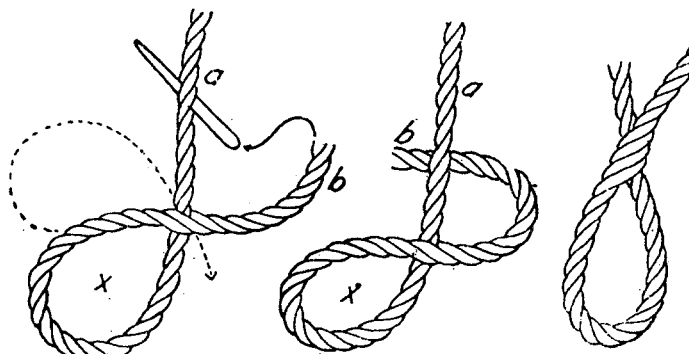


Figure 43. Loop splice

Loop Splice. The loop splice, (seldom used except in making rope halters) may be made at any point in the rope. It is simply a permanent loop through which another rope or some part of the same rope is to pass. In making the loop splice for a halter, raise two strands (Figure 43, left), pass the long end a, or lead rope, under the strands thus raised, so that when the loop x is drawn to the desired size, the rope a will pass through beneath the two strands at right angles to the direction in which they are laid. This is very important, for if the long end a is passed under the raised strands in the direction indicated by the dotted line, the loop splice when completed cannot be properly drawn up. To complete the splice, raise two strands in the long part of the rope, as indicated by the marlinspike, and pass the short end through. Draw the ropes closely together as in Figure 43, at right.

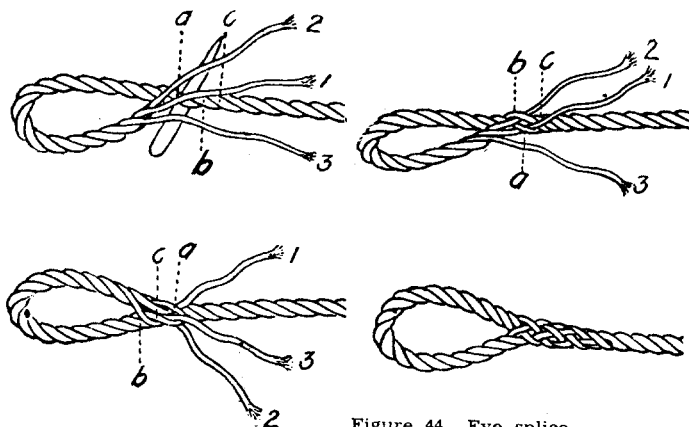


Figure 44. Eye splice

Eye Splice or Side Splice. The eye splice is used both in making halters and in splicing one rope to another. Untwist the end of the rope and place the strands in position, the two outside strands straddling the main rope and the middle or top strand running along the top of the rope. Now with the marlinspike raise any one of

the strands as a and pass the center strand 1, under it, diagonally to the right (Figure 44 upper left). Turn the main rope toward the left and pass strand 2 over strand a and under the strand b lying next to it (Figure 44, upper right). Now in order to press strand 3 under strand c so that it will be diagonal to the strands of the main rope, it will be necessary to bring the rope to the position in which it was first held. Then raise strand c of the main rope and be particular that strand 3 passes under it from the lower side so that the end comes out where strand 1 entered (Figure 44, lower left). Each loose strand should now pass under but one strand of the main rope. No two should be under the same strand and no two should come out from between the same two strands. Complete the splice by splicing in the strands as described for the end splice (Figure 42).

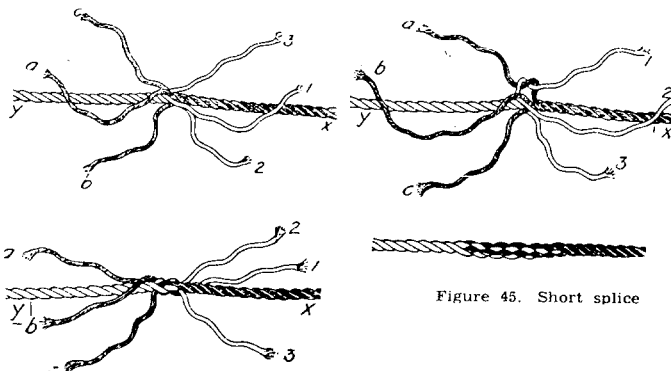


Figure 45. Short splice

Short Splice. To join two ropes together where there is a straight pull and where they are not required to pass through pulleys, the short splice is often used.

In making the splice the ends of the two ropes are unlaid for a sufficient distance and the two ends then locked together so that those from one end pass alternately between those from the other end (Figure 45, upper left). Notice that the strands from opposite sides are in pairs. Then, taking two strands from opposite sides, as the pair a and No. 1, tie the simple overhand knot in its right hand form as shown in upper right of Figure 45. Similarly, with the right hand knot or tie together the strands forming the pairs b No. 2 and c No. 3. Draw the knots tightly, then passing each strand of the rope x diagonally to the left, tuck the ends under the strands of y as described for the end splice in Figure 42. Turn the rope end for end and in the same manner splice down the strands of the rope y (Figure 45, lower left). Splice down the strands alternately, and each strand but one place each time. When the splice is completed each strand from both ropes should be spliced under at least two places. The length of the splice must depend upon the size of the rope and the load to be placed upon it. This splice may be made without tying the overhand knots, by simply splicing under the strands.

The Long Splice. Every farmer, in fact every person who has occasion to use rope, should learn to make the long splice. It is easily made, is as secure as any other part of the rope and leaves it so nearly its original size as not to impair its use through pulleys.

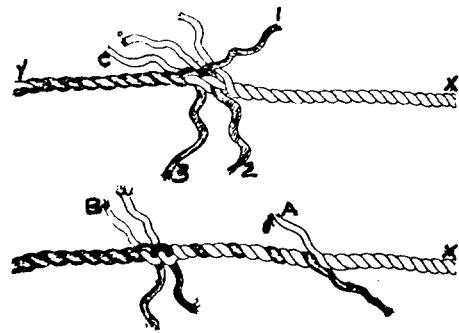


Figure 46. Long splice

To make the splice, first unlay the strands of the rope. A $\frac{3}{8}$ inch rope will require a free end of about 18 inches, a 1-inch rope about 36 inches, and larger ropes in proportion. Now lock the strands of the two ropes together as in beginning the short splice, in such a manner that the strands from one end pass alternately between the strands of the other end, forming the pairs a No. 1, b No. 2 and c No. 3 (Figure 45). At this point care should be taken that the strands are properly paired for a mistake here cannot be detected until the splice is completed and means that the work must be repeated.

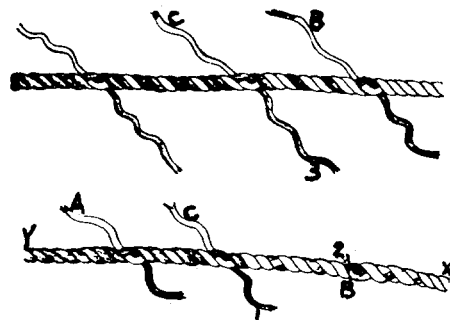


Figure 47.

The strands from any two of the pairs, as b No. 2 and c No. 3 are now tied together, leaving the other pair, as a No. 1 free (Figure 46, top). Unlay strand a one turn from its rope x and follow it by relaying strand No. 1 in its place, drawing it firmly and keeping it twisted tightly. Continue until 6 or 8 inches from the end of the relaid strand (No. 1) depending on the size of the rope, and tie as shown in Figure 48, upper left.

Turn the rope end for end and unfasten either pair of the tied strands, as b No. 2 (Figure 46, bottom). Proceeding as before, unlay strand b from its rope x and relay strand No. 2 in its place and tie as in Figure 48. The rope should now appear as in Figure 47, top, the ties should be separated the same distance and each strand coming from the left x should be placed in front of the strand from the right y, and tied. Crossing the strands otherwise, as a behind No. 1, a mistake often made, makes it impossible to complete the splice properly.

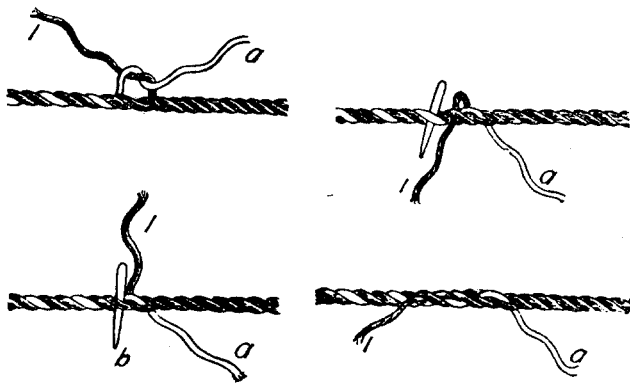


Figure 48. Finishing the long splice

The splice is completed as follows: With the ends properly tied (as described in Figure 48, upper left), with the right hand overhand knot (Figure 48, upper left) and draw down firmly into the rope (lower left). The end (No. 1) is now spliced down by being passed over the first strand a and under the second b as shown by the marlinspike in Figure 48 (lower left), then over the third c and under the fourth a (upper right). Draw down the end No. 1 and cut it off, leaving it 1/4 inch long (lower right). In identically the same manner, splice down and cut off each of the remaining strands a, b, c, No. 2 and No. 3. The splice is finished by pounding down the uneven parts and rolling it on the floor under the foot (Figure 49).



Figure 49. Long splice finished

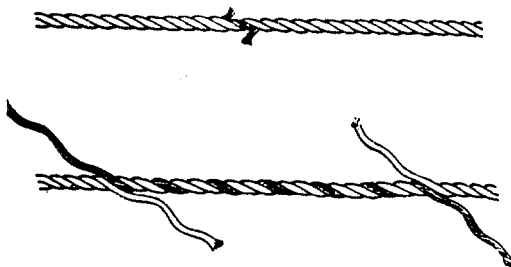


Figure 50. Mending broken strands

Mending Broken Strands. It is often desirable to mend a broken strand (Figure 50) or even to remove a portion of a rope that is badly worn or frayed. In either case unlay the strands as far as necessary, procure a new strand of sufficient length and relay it, as shown in Figure 50, bottom, and described for the long splice in Figure 46. The ends are tied with an overhand knot and finished as described for the long splice in Figure 48.

HALTERS

Rope Halters. Rope halters are inexpensive, yet very convenient and serviceable, especially in handling cattle. For cattle, halters are usually made of 5/8 inch rope, but for horses, large cows and bulls a 3/4 inch rope should be used. An ordinary halter will require

about 13 feet of rope. This will allow for a tie rope 6 feet long, a 36-inch headpiece and 14-inch nosepiece.

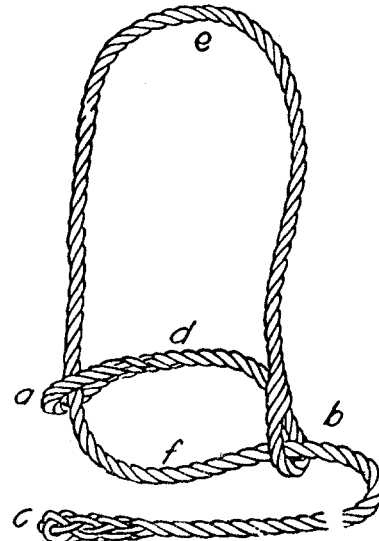


Figure 51. Double loop halter

Double Loop Halter. The double loop halter has the advantage of being adjustable to animals of different sizes, but it is not satisfactory for continuous use because there is some danger of its becoming loose and slipping off the head.

In beginning the double loop halter, first make an eye splice (Figure 44) in one end of the rope. The loop of the splice should be just large enough to allow the rope to pass through, otherwise the halter will loosen readily. From the loop of the eye splice, measure the distance that will be required to reach nearly around the animal's nose and make a loop splice (Figure 43) of the same size as the loop of the eye splice. Finish the end of the rope with the end splice (Figure 42, see also crown knot Figure 36) and pass the end through the loops as shown in Figure 51. In the illustration a is the eye splice, b the loop splice, c the end splice, d the nosepiece, e the headpiece and f the part passing under the jaw.

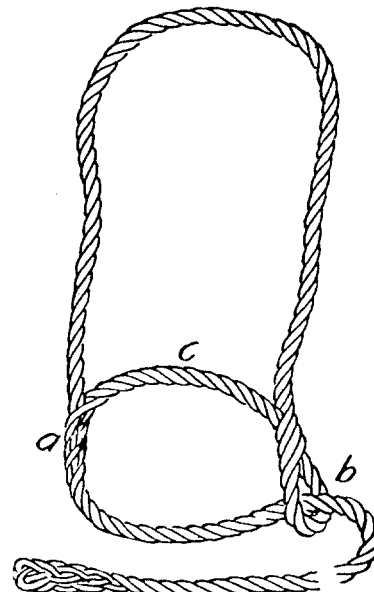


Figure 52. Single loop halter

Single Loop Halter. The single loop halter will not slip nor loosen, and for the same reason it is not adjustable to different sized heads. Since it is not adjustable, it will be necessary to ascertain the required length of the headpiece and nosepiece by measuring the halter on the animal's head before making the halter.

In making the single loop halter (Figure 52) the loop splice c described in Figure 43, is made first, then the nosepiece c, (Figure 52) is side-spliced into the cheek piece a. For description of the side splice see Figure 44. See also end splice Figure 42. Now pass the end through the loop splice and the halter is complete.

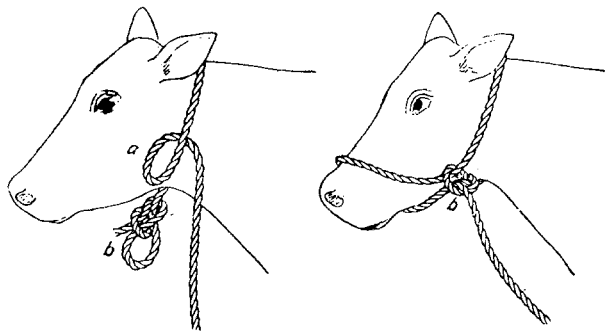


Figure 53. Temporary halters

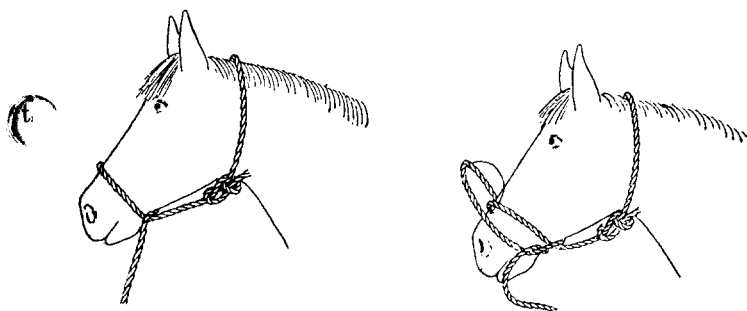
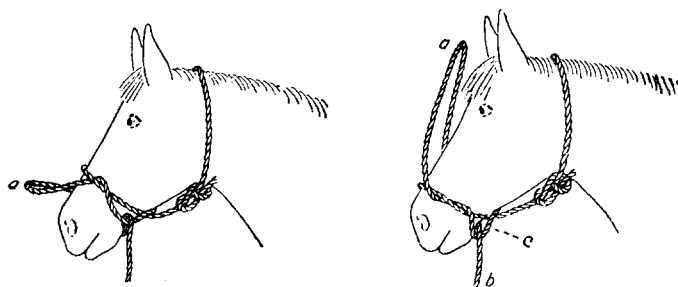


Figure 54. The hackamore



Temporary Halter. A very convenient halter for leading or temporarily holding cattle is made by fastening an iron ring or making a loop in the end of a rope. The end with the ring is first passed around the animal's neck. A loop a is then formed in the main rope (Figure 53), passed through the loop b and over the animal's nose, as shown in Figure 53, at right. To remove the halter, it is only necessary to slip the loop from the nose and draw on the standing part of the rope. Since the halter may be removed without passing the rope over the head it is very useful when dehorning cattle.

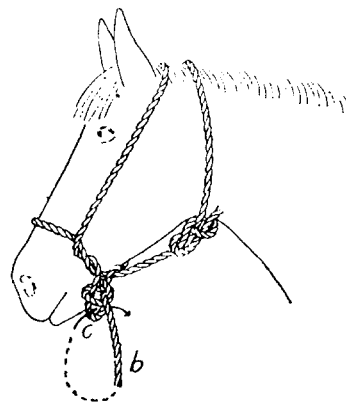


Figure 55. Finishing the hackamore

The Hackamore. The hackamore is a temporary halter used for leading or tying either horses or cattle. It is easily and quickly made and is secure when properly drawn up.

In making the hackamore, a long rope is usually used. One end is passed around the animal's neck and tied with a bowline knot. (For bowline knot see Figures 13 and 14.) A half hitch is then thrown in the rope and passed over the animal's nose (Figure 54, left). In like manner a second half hitch is made below the first and passed over the nose (Figure 54, right). The front part of the first half hitch is then raised above the second and is then passed downward under the first half rope b in Figure 55, upper right. To prevent the loops from drawing tight, the loop c is drawn down and a half hitch thrown over it with the rope b. If the animal is to be left tied for any length of time the rope b is passed through the loop c below the half hitch as indicated by the arrow in Figure 55, at bottom.

A DOUBLE-LOOP ROPE HALTER FOR SHOWING HORSES

A double-loop rope halter can be made from three-strand rope. The total length necessary, including about 7 feet of lead rope, is given in the table. A loosely laid soft rope is more desirable than the usual Manila rope. A rope that is exceptionally hard and stiff can be made more pliable and easy to handle if placed in boiling water for 15 to 30 minutes, then stretched out and dried thoroughly. This decreases the strength of the rope considerably, but for show halters, ample strength will remain. Soiled rope could be scrubbed while soaking.

There are three splices required for a complete halter: (1) the loop splice (page 8), (2) the eye splice (page 8), and (3) the end splice (page 7) which involves the crown knot. The loops that are made by the loop and eye splices should be just large enough for the rope to pass freely through them, yet not so small as to bind if the rope becomes wet.

The only permanent dimension in a double-loop halter is the nose piece and this is measured from the outside of loop A to outside of loop B. Lay off 6 inches from one

end of the rope and mark it by tying a string around the position. This portion will be used for the eye splice. Then lay off, in the same manner, the length of nose piece selected.

| Approximate Age | Size Rope in Inches | Total Length Rope in Feet | Length of Nose Piece in Inches |
|-----------------|---------------------|---------------------------|--------------------------------|
| Foals | 3/8 or 1/2 | 12 | 12 |
| 1 to 3 years | 1/2 | 13 to 14 | 16 to 18 |
| 4 years or over | 5/8 or 3/4 | 15 | 19 |

TACKLES

Leading or Tying. A simple but effective method of using a rope for breaking a colt to lead is shown in Figure 56. A strong leather halter is placed on the colt's head. A long rope is procured and one end is passed around the body over the withers and just behind the front legs. It is well to have an iron ring in the end of the rope, or a loop tied with a bowline knot (Figures 13 and 14) so that the loop which passes around the body will loosen as soon as the tie rope is slacked. (A ring is best.) Pass the rope through this ring or loop, then between the front legs and over the chinpiece of the halter. When the rope is tightened the colt will usually lead up with but little resistance, and if he passes the person who is leading him the chinpiece of the halter acts as a pulley and his head is drawn around to the side.

This method is also often used for breaking halter-pullers. In this case the long rope is simply tied to the manger. If the manger is low, however, the rope should not be passed through the chinpiece of the halter, but through a rope or strap loop a, which is fastened to it. Otherwise there is too great a pull on the top of the head.

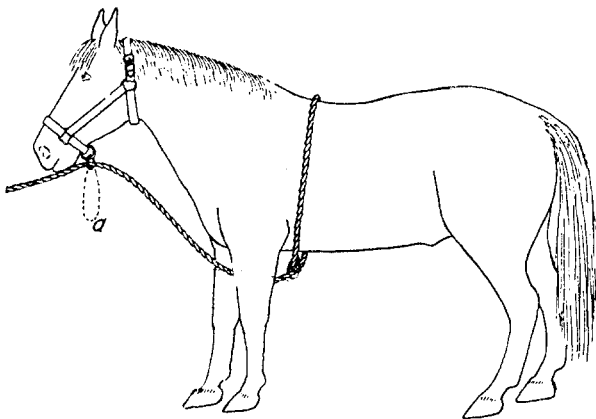


Figure 56. A simple leading tackle

Casting Horses. For casting horses a rope not less than 35 or 40 feet long should be used. The rope is doubled and a bowline-on-the-bight tied in the center (Figure 18). This is placed over the horse's head and adjusted to the size of the neck. The rope is then pass-

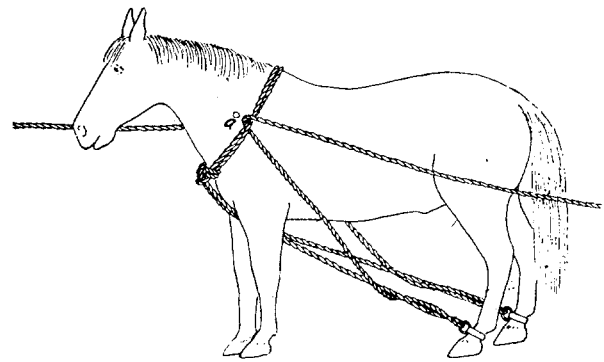


Figure 57. Casting a horse

ed between the forelegs, around the ankles of the hind legs, once around the main rope, as shown in Figure 57, and finally through the loop of the bowline-on-the-bight, at a. In order to prevent the rope from burning the hind ankles, ankle straps should be used. Hame straps with iron rings, placed on the ankles, answer the purpose admirably. The loop around the neck should be loose enough so that it will not choke the animal when thrown. If the horse is to be thrown on the right side, the person holding the rope on that side should stand in front and to the right, and the one holding the other rope to the rear on the left side. The horse is then caused to back and the ropes are pulled, thus drawing his hind feet up toward the body. As soon as the horse is down the person at the halter should twist the head, turning the animal's nose upward as far from the ground as possible. This prevents him from getting up.

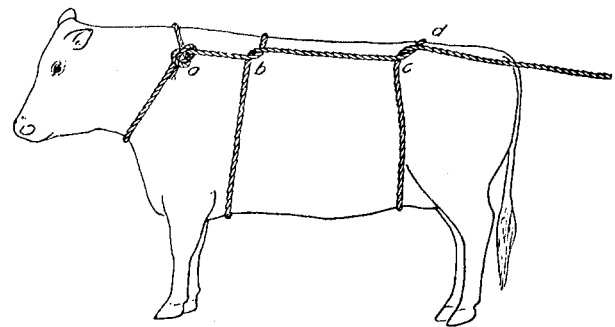


Figure 58. Casting cattle

Casting Cattle. For casting cattle, the method shown in the accompanying illustration (Figure 58) is simple and effective. A rope 35 or 40 feet long is needed. Place one end around the animal's neck and tie it with a bowline knot (Figures 13 and 14). Next, pass the rope around the animal's body just back of the forelegs, making a half hitch over the withers at b. Now pass the rope around the body at the hips, letting it draw up into the flanks. It is well to have the rope on one side, as at c, in front of the hip bone, and the one on the other side, as at d, behind it. This prevents the rope from drawing too far ahead over the loin, and also from slipping too far back. In throwing a cow, care should be taken that the rope is entirely in front of the udder. To throw the animal, pull to the rear and toward the side upon which she is to be thrown. When the animal is down, turn the head to prevent her from rising.

Explanation Of Terms Relating To Cordage

Yarn - Fibers twisted together.
Thread - Two or more small yarns twisted together.
String - The same as thread but a little larger yarns
Strand - Two or more large yarns twisted together.
Cord - Several threads twisted together.
Rope - Several strands twisted together.
Hawser - A rope of three strands.
Shroud-laid - A rope of four strands.
Cable - Three hawsers twisted together.
Yarns are laid up left-handed into strands.
Strands are laid up right-handed into rope.
Hawsers are laid up left-handed into a cable.

A rope is:

Laid - By twisting strands together.
Spliced - by joining to another rope by interweaving the strands.
Whipped - by winding a string around the end to prevent untwisting.
Served - When covered by winding a yarn continuously and tightly around it.
Parceled - by wrapping with canvas.
Seized - When two parts are bound together by a yarn, thread or string.
Payed - When painted, tarred or greased to resist wet.
Haul - To pull on a rope.
Taut - Drawn tight or strained.

ACKNOWLEDGEMENT

A major portion of this circular is reprinted from Extension Service Bulletin No. 24, Iowa State University, authored by A. A. Burger. Acknowledgement is made to Iowa State University for their publication and appreciation extended to them for the permission to reprint it.