

CIVIL DEFENCE ORGANISATION

SOUTH AUSTRALIA

ROPES, WIRE ROPES AND KNOTS.

OBJECT

The object of this paper is to outline the various fibre ropes used in rescue, their general care and maintenance, and to teach knots and lashings.

INTRODUCTION

The term rope is used for both fibre and wire ropes with which Rescue Parties are supplied. The term cordage is used to denote fibre ropes only.

Cordage stretches very considerably under load; the stretch in a new rope, when subject to its working stress, is about one-twentieth of its length.

Steel wire rope (S.W.R.) is stronger and less liable to stretch than cordage but it is not so flexible and, therefore, more difficult to handle.

Both cordage and S.W.R. require continual attention and care if their usefulness is to be maintained.

CORDAGE

Cordage may be made of a variety of materials such as manilla, hemp, sisal, cottons, coir or nylon. Whatever the material the rope is made, by twisting several fibres together to form a yarn, several of which are then twisted to form a strand and three or more stands are twisted together to form a rope.

The "lay" of a rope, which can be either right or left handed, depends on the way the strands are twisted together during manufacture and can be likened to the thread of a screw.

The size of cordage is denoted by its circumference in inches and the C^2 equals its safe working load (S.W.L.) in cwts. if the rope is comparatively new, dry and if there are no knots or sharp bends in it. The strength of cordage when taken around any sharp bend such as the hook of a block or when tied in a knot or when wet is decreased by about one-third owing to the uneven stress of the fibres.

Example (i) New, dry 2in. cordage.

(Circumference in inches)² = S.W.L. in cwts.

$$2 \times 2 = 4 \text{ cwts.}$$

Example (ii) Saturated 2 in. cordage with sharp bend.

(Circumference in inches)² x Safety Factor = S.W.L. in cwts.

$$2 \times 2 \times 2/3 = 2 \frac{2}{3} \text{ cwts.}$$

Untarred ropes are stronger than tarred ropes.
Three-stranded ropes are stronger than four-stranded ropes.

The strength of a rope is greatly reduced if it is:-

- (a) Stored wet.
- (b) Treated with oil.
- (c) Knotted - because the stress on the fibres is not uniform, the outer fibres are subject to the greater strain and may fail.
- (d) Passed over a sharp edge - this tends to cut and chafe the rope, causing permanent damage.
- (e) If the load comes on with a jerk.

Ropes are a vital part of rescue equipment. They must be kept in good condition so that they will be sound and thoroughly efficient when brought into use for rescue work, e.g. for lifting weights and releasing trapped persons.

New ropes are supplied in coils. A new coiled rope is uncoiled by laying the coil on one side so that the end of the rope in the centre is at the bottom and the bands loosened.

The method of bringing the bottom end out first is, strictly speaking, dependent upon how the coil was reeled, i.e., from the left or right-hand side of the reel. To avoid disturbing the balance of lay, either into or out of the rope, the ideal method is to rotate the coil when uncoiling.

CARE AND MAINTENANCE OF CORDAGE

To ensure the efficiency of fibre ropes, ALWAYS:

- (a) Stretch a new rope throughout its length before using it. To do this attach one end to a swivel hook (to allow for twisting) and haul on the rope.
- (b) Avoid cutting a rope unless it is essential to do so. If it is necessary, ensure that the cut end is whipped as soon as possible to prevent fraying. As a temporary measure to prevent fraying, tie a figure of eight knot near the end of the rope. Adhesive tape is also useful as a quick temporary whipping.
- (c) Avoid permanent knots in a rope, as these considerably reduce its strength.
- (d) Do not attempt to force a thick rope through a block made for a smaller rope. This causes chafing of the rope and lessens its strength.
- (e) Avoid passing a rope over a sharp edge. If it is necessary to do this protect the rope with a sacking or a piece of rounded timber. (Chafing piece.)
- (f) Avoid sudden jerks or violent stress on the rope as this weakens both the rope and any tackle used with it.
- (g) As far as possible, keep a rope dry. If it gets wet, do not attempt to dry it in front of a fire. Spread it on a ladder, laid horizontally off the ground to enable the air to circulate freely round the rope.
- (h) Store fibre ropes under cover off the floor, preferably on racks in a place free from extremes of temperature and out of contact with materials containing any acid or strong alkali, e.g., creosote. Also free from rats if possible.

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- (i) Examine ropes regularly for external damage and rotting of fibres.
- (j) If coiled rope has to be left in a place where it may be exposed to the weather, cover it with tarpaulin or some other form of protection.
- (k) Whenever a rope has been used, ensure that it is clean and dry before it is coiled and put away.

STEEL WIRE ROPE (S.W.R.)

Steel wire rope consists of a number of strands (normally six) with a fibre core. Each strand consists of a number of steel wires - the commonest form of construction being 6/7 indicating six strands of seven steel wires with a fibre core. During manufacture, wires and strands are either coated with lubricant to prevent corrosion and friction in the rope, or are galvanised.

The size of S.W.R. unlike cordage is normally measured by its diameter and $9 \times$ its circumference squared in inches equals its safe working load in cwts. if the rope is comparatively new and in good condition. As in the case of cordage an additional safety allowance must be made if the rope is taken around a sharp bend.

Example (i) $\frac{1}{2}$ in. new S.W.R. - convert diameter to circumference.

$$\begin{aligned} D \times 3 &= 1\frac{1}{2} \text{ in.} \\ 9 \times C^2 &= \text{S.W.L. in cwts.} \\ 9 \times (3/2)^2 &= 20\frac{1}{4} \text{ cwts.} \end{aligned}$$

Example (ii) New $\frac{1}{2}$ in. S.W.R. when sharply bent.

$$\begin{aligned} 9 \times C^2 \times 2/3 &= \text{S.W.L. in cwts.} \\ 9 \times (3/2 \times 3/2) \times 2/3 &= 13\frac{1}{2} \text{ cwts.} \end{aligned}$$

Care in Use

Wire ropes should never be bent sharply at any point. As a general rule, the smallest diameter round which a wire rope is to be bent should be approximately six times the circumference of the rope; anything smaller than this will set up undue strain on the steel wires. With a $\frac{5}{8}$ inc. diameter (i.e. 2 in. circumference) wire rope, the minimum diameter about which it can be bent without causing harm to the rope is 12 inches. Care must be taken, therefore, by packing or otherwise, to ensure that the rope is not damaged when it has to be bent round any object.

Inspection of Wire Ropes

Starting at one end of the rope:

- (a) Check the shackle used with the rope to see that it has not suffered distortion or strain, and that the shackle pin is in good condition and can be easily screwed home by hand.

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- (b) Examine the thimble and splice. The splicing cannot be seen as it is covered by the wire binding or "serving", but if the serving is loose or shows signs of bulging it is probable that this splice is starting to come undone.
- (c) Working along the rope a hand's breadth at a time, see that it is reasonably round, i.e., has not been flattened in use or suffered distortion which causes the wires to open and thus weaken the rope.
- (d) Look for broken wires. A broken wire in a rope should always receive prompt attention. Delay may lead to serious accidents, and will certainly cause damage to other wires. The method often used to deal with a broken wire by nipping it off with pliers is by no means the best way, for this leaves a little jagged end. To save time and trouble, simply bend the wire backwards and forwards with the fingers until it breaks, or, in the case of a short end, use a piece of wood. In this wire the wire breaks inside instead of outside the rope, and the end is left tucked away between the strands, where it can do no harm to the other wires or personnel.
- (e) Look for kinks. When a rope has been kinked, the kink may pull out when used and the rope appear to be reasonably straight although the structure of the rope has been distorted and damaged. The length affected by kinking may only be a few inches, and yet cause this part of the rope to be weak. The presence of a kink is best detected when the rope is lying slack on the ground.

Rope found defective should be labelled and placed apart from ropes in good condition until they can be examined by a competent person.

Storage of Wire Ropes

Wire ropes should be stored under cover in a clean dry place and in such a manner that no part of the rope rests on the ground. They must never be stored by laying on concrete, ash, clinker, or coke breeze floors as these materials have a bad effect on the steel. Periodical examination of all wire ropes in store is necessary to ensure that the ropes are not becoming corroded.

Lubrication of steel wire ropes

<u>Ropes</u>	<u>Lubricant</u>
Galvanised small cords ...	Dry
" flexibles ...	Petroleum Jelly
" punt ropes ...	Graphite
Haulage Ropes ...	Graphite or Crater Compound for wet conditions
Winding Ropes ...	Graphite or Hodson's Compound for wet conditions.
Earth Moving Equipment and Shovel Ropes 8 ...	Graphite
Logging Ropes ...	Graphite
Scraper Ropes ...	Graphite

SAFE WORKING LOAD ROPES

C.D./R.S.5

DIA.	CIRCUMFERENCE		FIBRE ROPES	STEEL ROPES
	EXACT	APPROX.	SAFETY LOAD	SAFETY LOAD
1/8"	0.3927"	* 3/8"	0.141 cwt.	1.269 cwt
5/32"	0.4909"	1/2"	0.250 "	2.250 "
3/16"	0.5890"	5/8"	0.391 "	3.519 "
1/4"	0.7854"	3/4"	0.562 "	5.058 "
9/32"	0.8836	7/8"	0.765 "	6.885 "
5/16"	0.9817"	1"	1.000 "	9.000 "
3/8"	1.1781"	1-1/8"	1.205 "	10.845 "
7/16"	1.3745"	1-3/8"	1.890 "	17.010 "
1/2"	1.5708"	1-5/8"	2.640 "	23.760 "
9/16"	1.7672"	1-3/4"	3.062 "	27.558 "
5/8"	1.9635"	2"	4.000 "	36.000 "
11/16"	2.1598"	2-1/8"	4.515 "	40.635 "
3/4"	2.3562"	2-3/8"	5.640 "	50.760 "
13/16"	2.5525"	2-1/2"	6.250 "	56.250 "
7/8"	2.7489"	2-3/4"	7.562 "	68.058 "
15/16"	2.9452"	3"	9.000 "	81.000 "
1"	2.1416"	3-1/8"	9.765 "	87.885 "
1-1/16"	3.3379"	3-3/8"	11.390 "	102.610 "
1-1/8"	3.5343"	3-1/2"	12.250 "	111.250 "
1-1/4"	3.9270"	3-7/8"	15.015 "	135.135 "
1-3/8"	4.3197"	4-3/8"	19.140 "	172.260 "
1-1/2"	4.7124"	4-3/4"	22.562 "	203.058 "

1 Gross or Lons Ton = 2240 lbs = 20 cwt.

1 cwt = 4 quarters = 112 lbs.

1 quarter = 28 lbs / 2 stone; 1 stone = 14 lbs.

NOTE: Calculations based on new ropes only.

Terms Used in Connection with Ropes

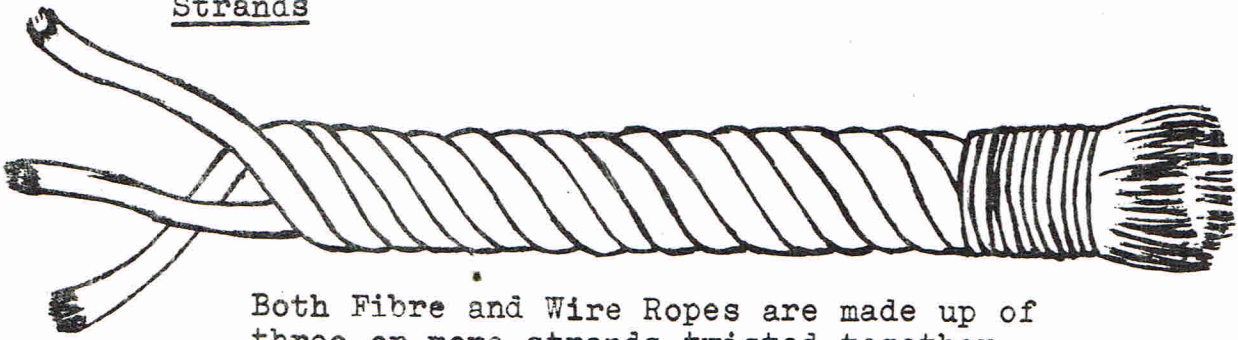
There are a number of standard terms for use in describing parts of a knot, etc., and the following should be learnt and understood by every member.

<u>ANCHORED</u>	Fastened to some immovable object, such as a large tree, post or well driven picket.
<u>BEND</u>	To fasten a line to another line or to an object.
<u>BIGHT</u>	The looped or loose part of a line between the two ends.
<u>FRAPPING</u>	The binding together of a lashing between two poles.
<u>HAUL</u>	The act of pulling on a rope.
<u>HITCH</u>	A simple fastening of a line to some object by passing the line round the object and crossing one part over the other.
<u>MOUSING</u>	Tying a piece of cord across the jaws of a hook to prevent a rope or sling from jumping out when the weight is temporarily supported.
<u>PARCELLED</u>	When part of a rope is wrapped to prevent chafing.
<u>PAYING OUT OR EASING</u>	to ease off or slacken a rope.
<u>REEVE</u>	The threading of a rope through pulley blocks or snatch blocks.
<u>ROUND TURN</u>	One complete turn of a rope round a spar or another rope.
<u>RUNNING END</u>	The free end of a line.
<u>STANDING PART</u>	The part of a line which is fixed.
<u>WHIPPING</u>	The binding of the end of a line with twine to prevent it unlaying.
<u>LASHINGS</u>	Lashings are used mainly to secure two or more poles firmly together. The form of each type of lashing can best be understood by a careful study of the circular "Lashings". The lashings may be made by using the 40 ft. x 1½" lashings carried in the equipment. <u>Square Lashing</u> - This is used to lash together two poles that touch and cross at right angles. <u>Diagonal Lashing</u> - This is used to lash together two touching poles at an angle, especially when their mode of use may cause them to spring apart. <u>Round Lashing</u> - This is used to lash two poles which lie parallel to each other. <u>Figure-of-Eight Lashing</u> - This used to lash three parallel poles together, as may be necessary to form a tripod or gin (Gyn).

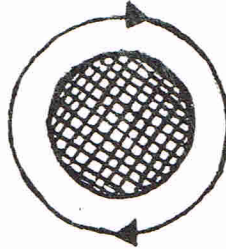
Knots and Lashings

Rescue personnel should be familiar with the following rope knots and lashings and, by constant practice, must learn how to make and adapt them with speed and proficiency. Knots must always be tied tightly.

Strands



Both Fibre and Wire Ropes are made up of three or more strands twisted together.



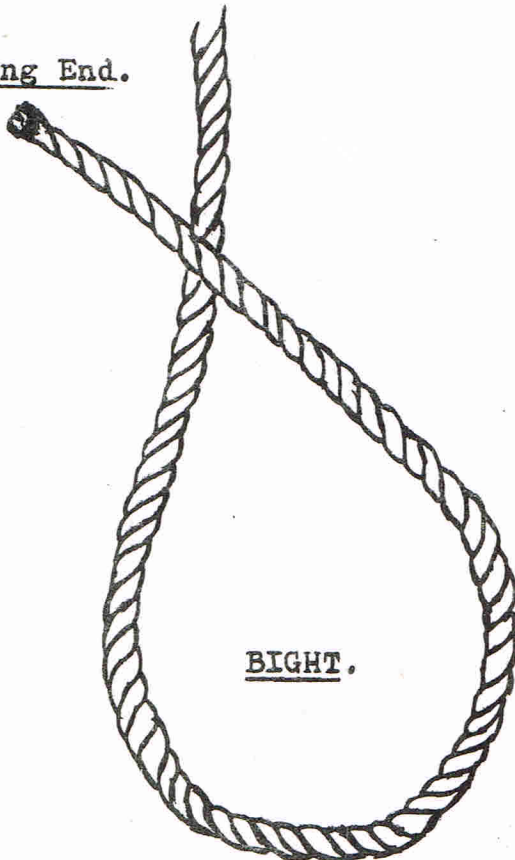
The size of fibre ropes is denoted by the circumference of the rope, in inches.
 3" e.g., a 3" rope means that it has a circumference of about 3" and is, in fact, about 1" thick.



The size of Steel Wire Rope (S.W.R.) is indicated by its diameter in inches: i.e., a 1/4" S.W.R. means that it has a diameter of 1/4" and is, in fact, about 3/4" circumference.

Standing Part.

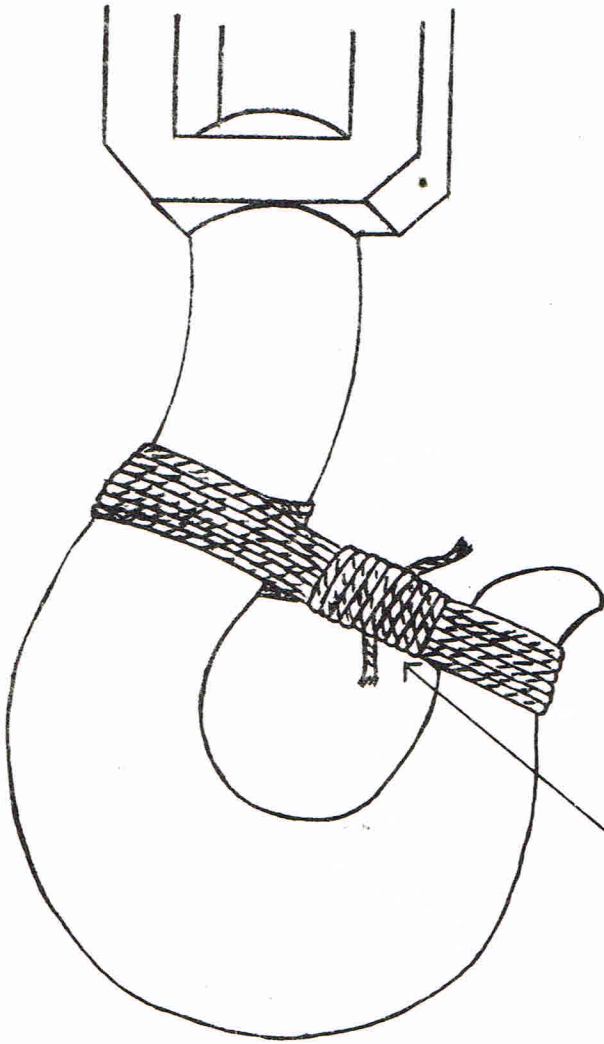
Running End.



Running End - The free end of a line.

Standing Part - The part of a line which is fixed.

Bight - The looped or loose part of a line between the two ends.



MOUSING

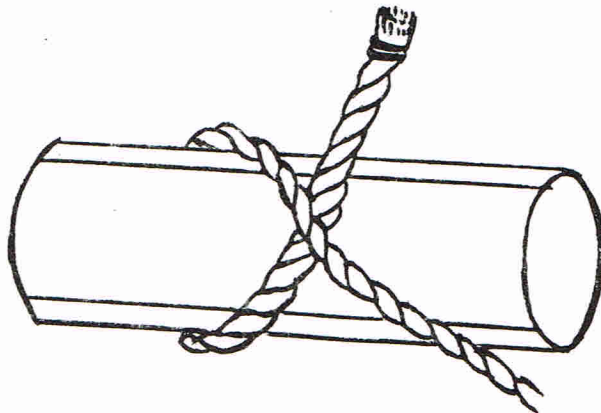
Tying a piece of cord across the jaws of a hook to prevent a rope or sling from jumping out when the weight is temporarily supported.

FRAPPING (or tightening) TURNS

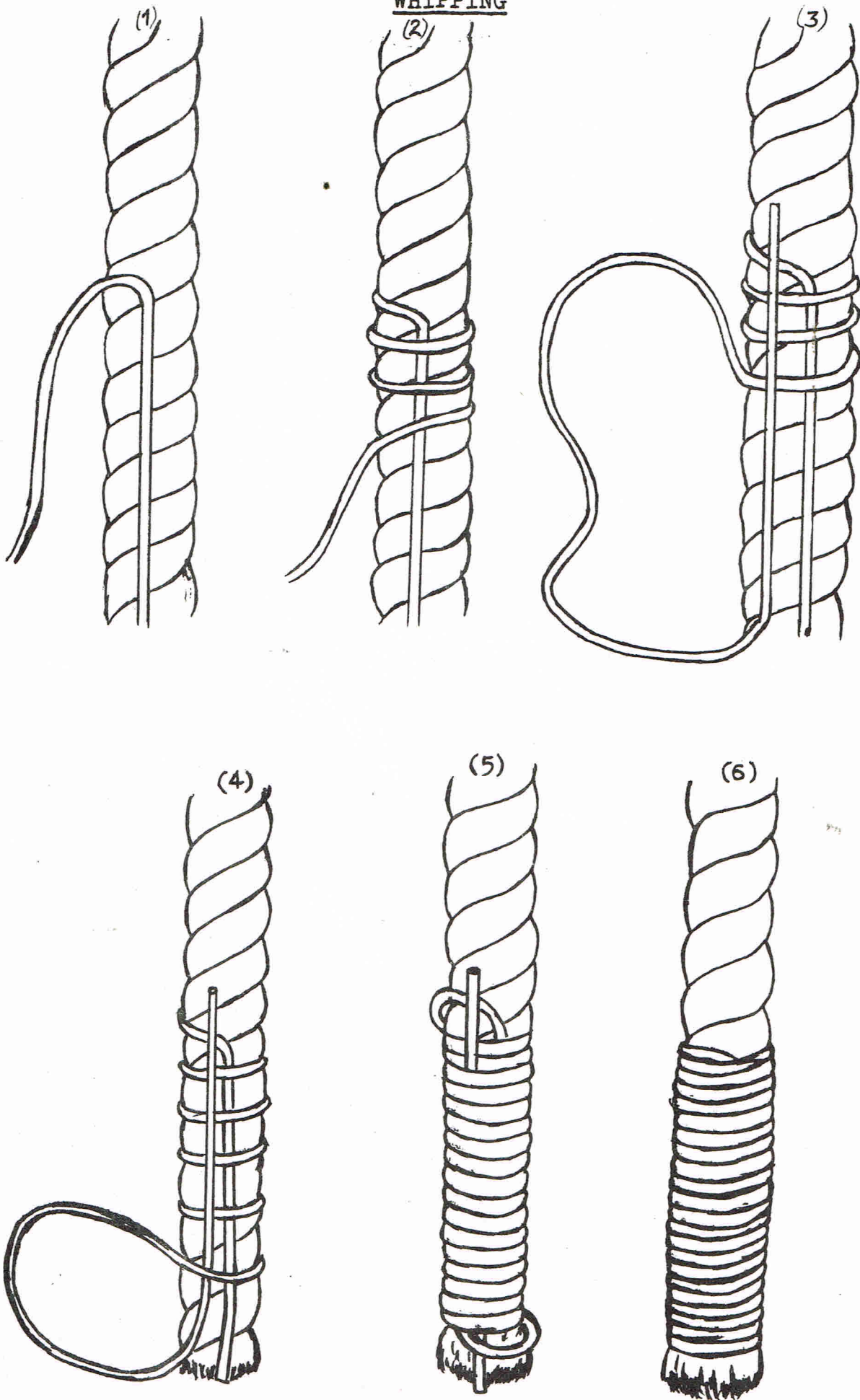
HALF HITCH

Basis of a number of knots used by Civil Defence - e.g., stretcher lashings, making lines fast, etc.

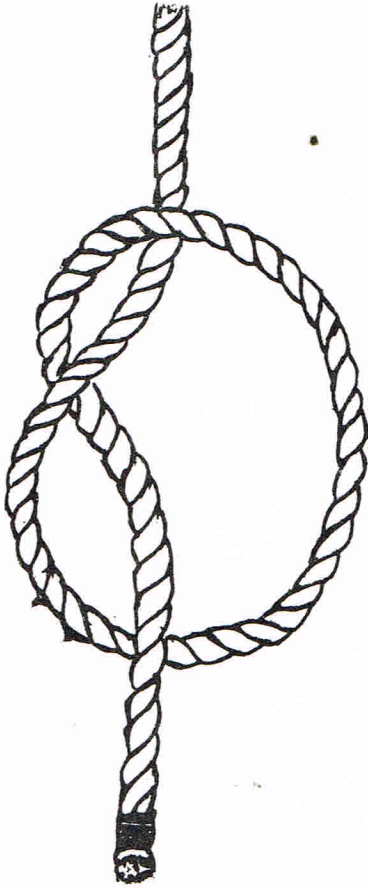
Often used as two half hitches for attaching ropes to objects such as poles or hooks (see also Clove Hitch).



WHIPPING



Used to bind the end of a rope with twine so as to prevent un-twisting or fraying. Whipping is also used to bind loose end of a rope to the standing part. The above method is the more common type of whipping.



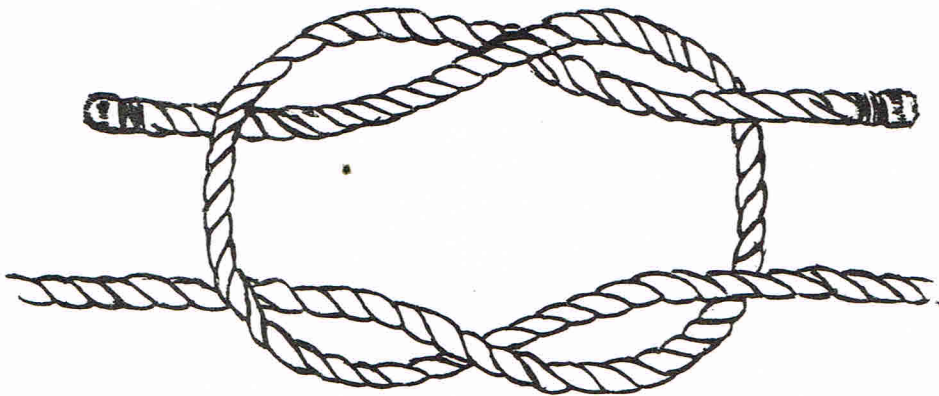
THUMB KNOT

Sometimes known as the Overhand Knot. Used as a simple stopper. This simple knot can be tied in the end of a rope to stop the rope passing through a pulley block or temporarily to prevent fraying of an end.

FIGURE-OF-EIGHT KNOT

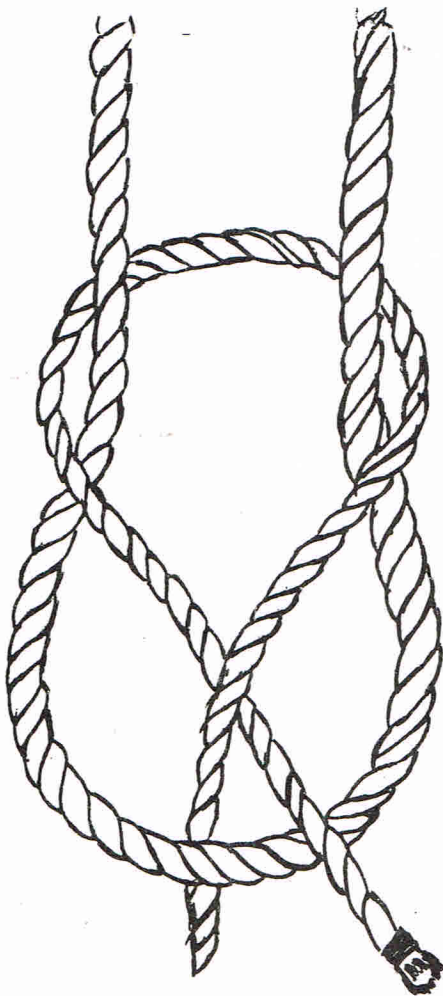
Used as a stop, and can be used in place of thumb knot: e.g. to prevent the end of a line running through a sheave. It can be put in the end of a rope to prevent it from unreeving.





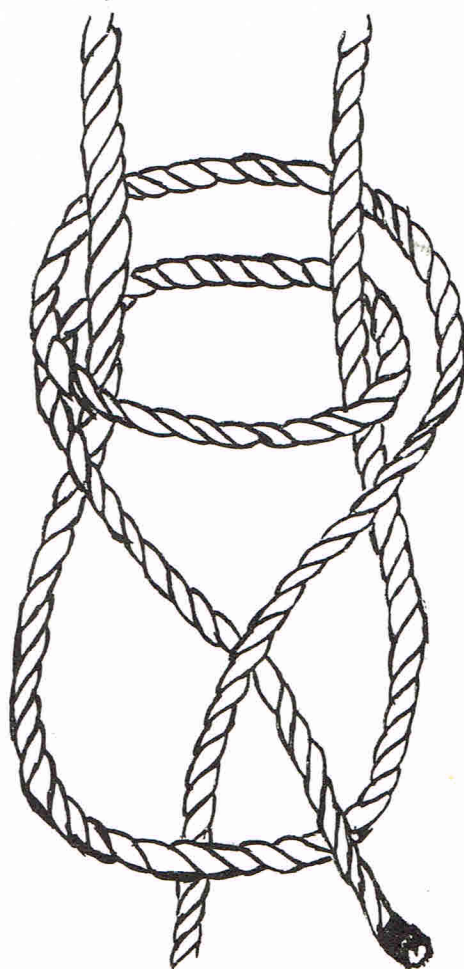
REEF KNOT

For joining two ropes of EQUAL THICKNESS.



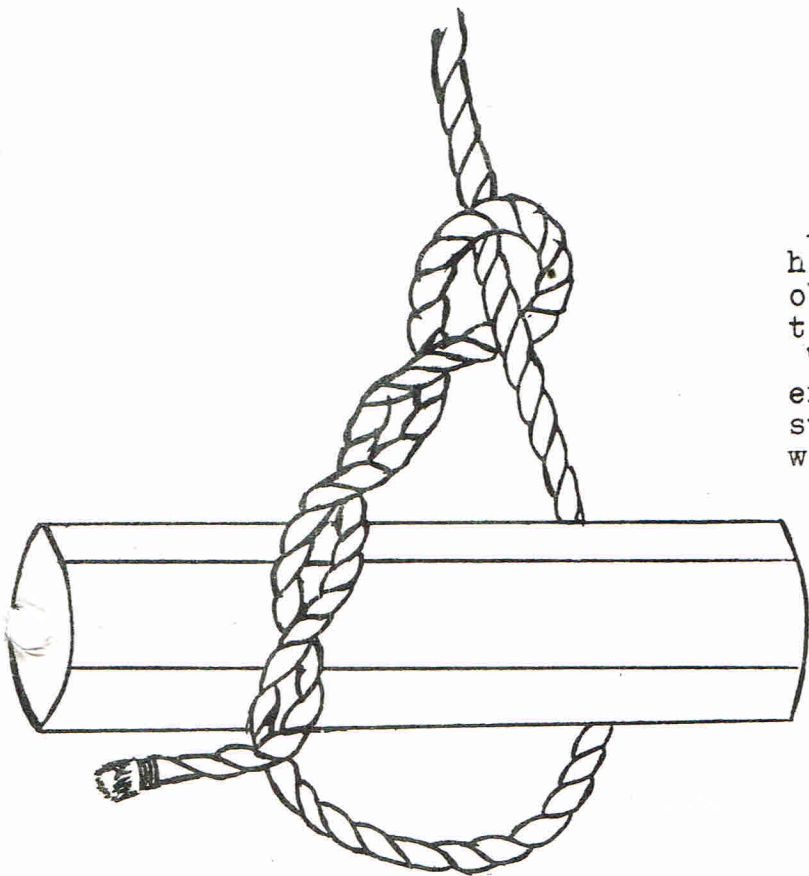
SINGLE SHEET BEND

Used to join two ropes of UNEQUAL THICKNESS.



DOUBLE SHEET BEND

A slightly more secure version of the single sheet bend. Used when there is a big difference in size of ropes: e.g. joining 3" and ½" ropes.



TIMBER HITCH

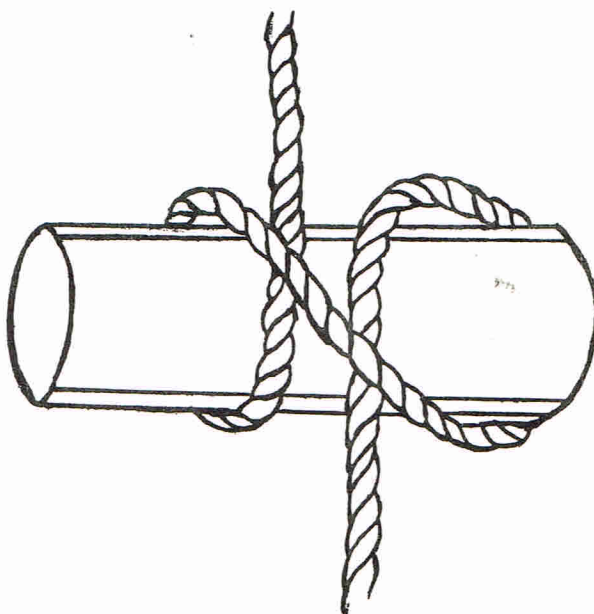
A simply made knot used to hoist any irregularly shaped object, such as a baulk of timber, plank or pole.

When a continuous strain is exerted it is advisable to supplement the Timber Hitch with a Half Hitch.

CLOVE HITCH

(tied in end of rope)

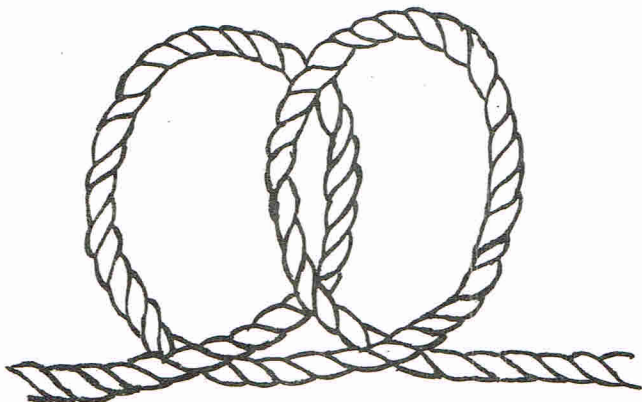
When tied thus, in the end of a rope, it is a good anchoring knot and is easily untied.

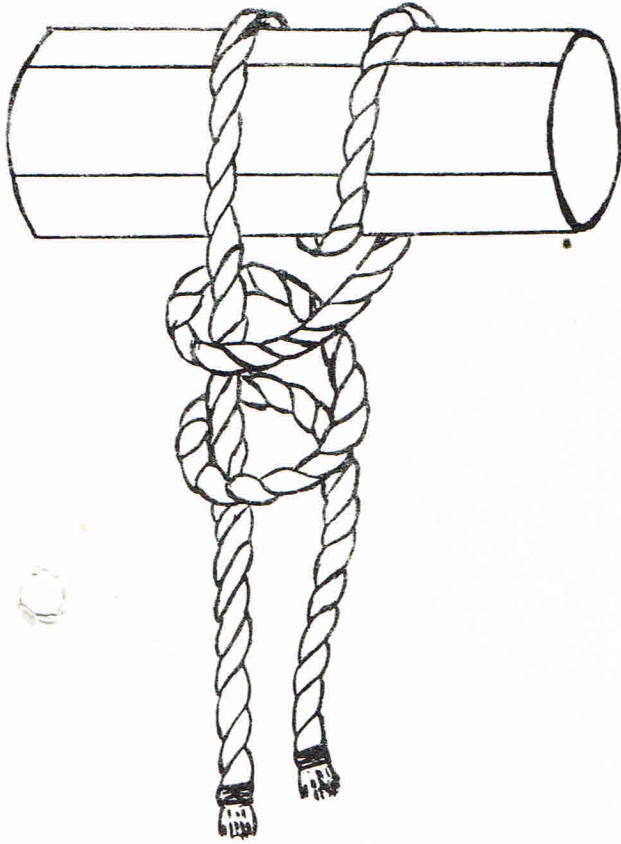


CLOVE HITCH

(tied in centre of rope)

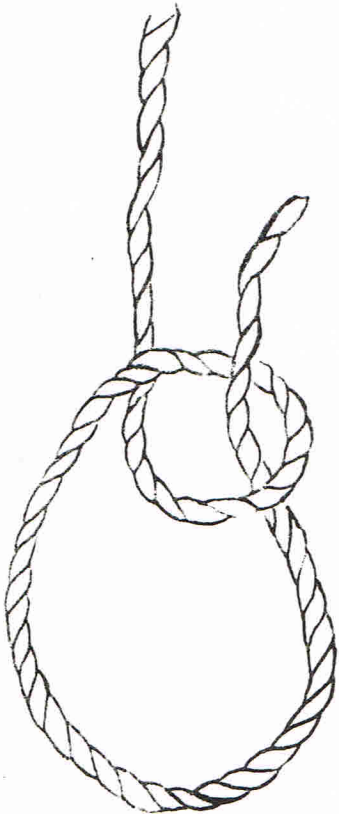
This forms the basis of many securing knots and can be used in the end of a rope or in the centre. Used to secure a line to any round object.



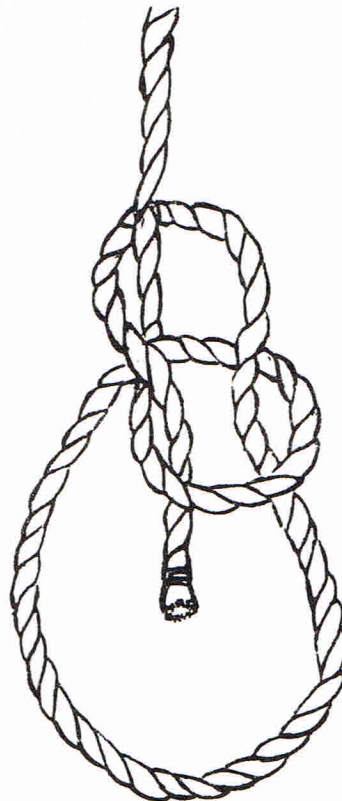


ROUND TURN AND TWO HALF HITCHES

Used to secure a line to any round object or ring. An example of this knot is the tying of a boat to a mooring ring.



STAGE I.



STAGE II.

BOWLINE

This forms a non-slip loop at the end of a rope and is a most useful anchoring knot. It may also be used for lowering or raising purposes and for attaching a rope to a person as a safety line.

CHAIR KNOT

The Chair knot is a good general purpose knot and one which is very important for emergency rescue work.

One of its main purposes is to form an efficient and quickly made sling in which a person may be readily raised or lowered.

The sling formed by this knot gives support to the chest and legs of the person being rescued.

One loop will be slightly larger than the other to keep the person being raised or lowered in a "chaired" position.

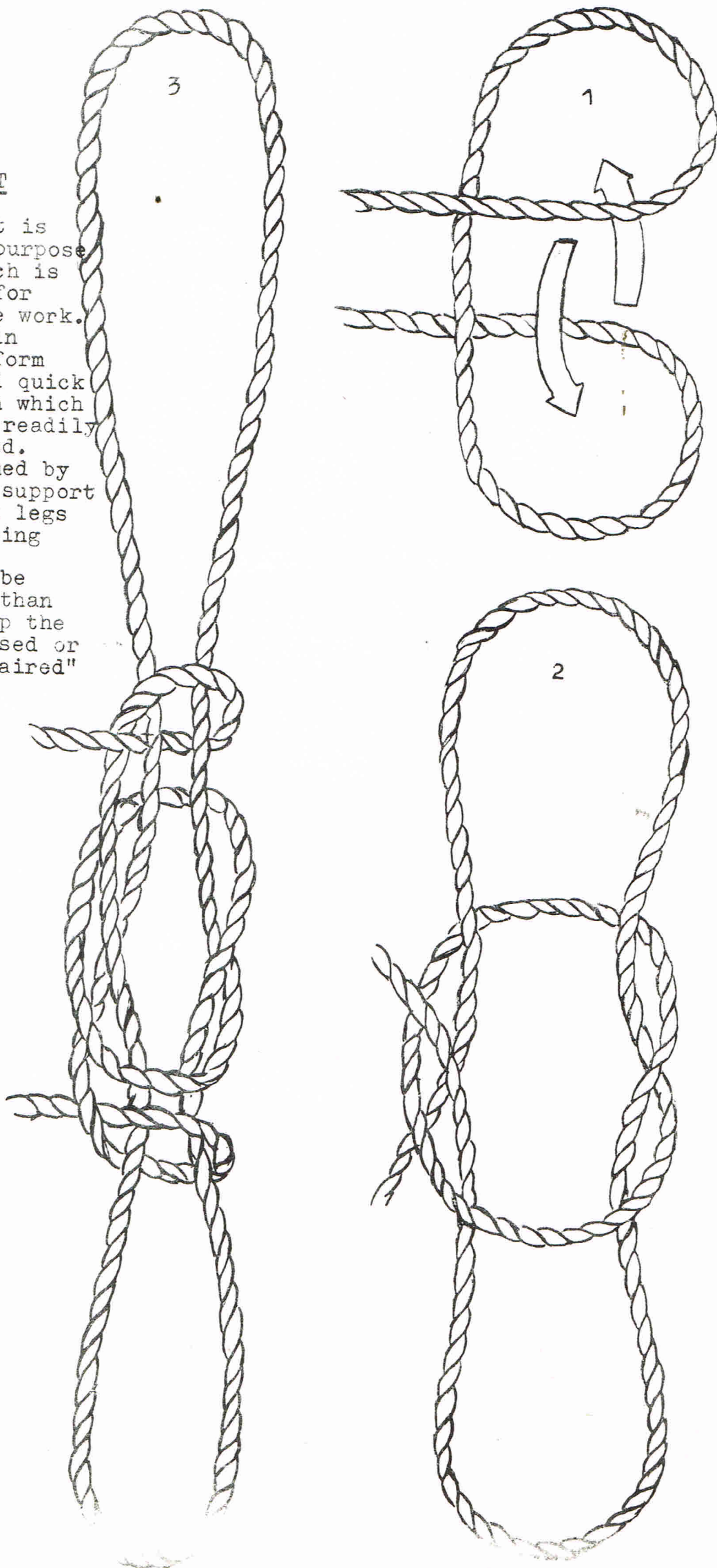
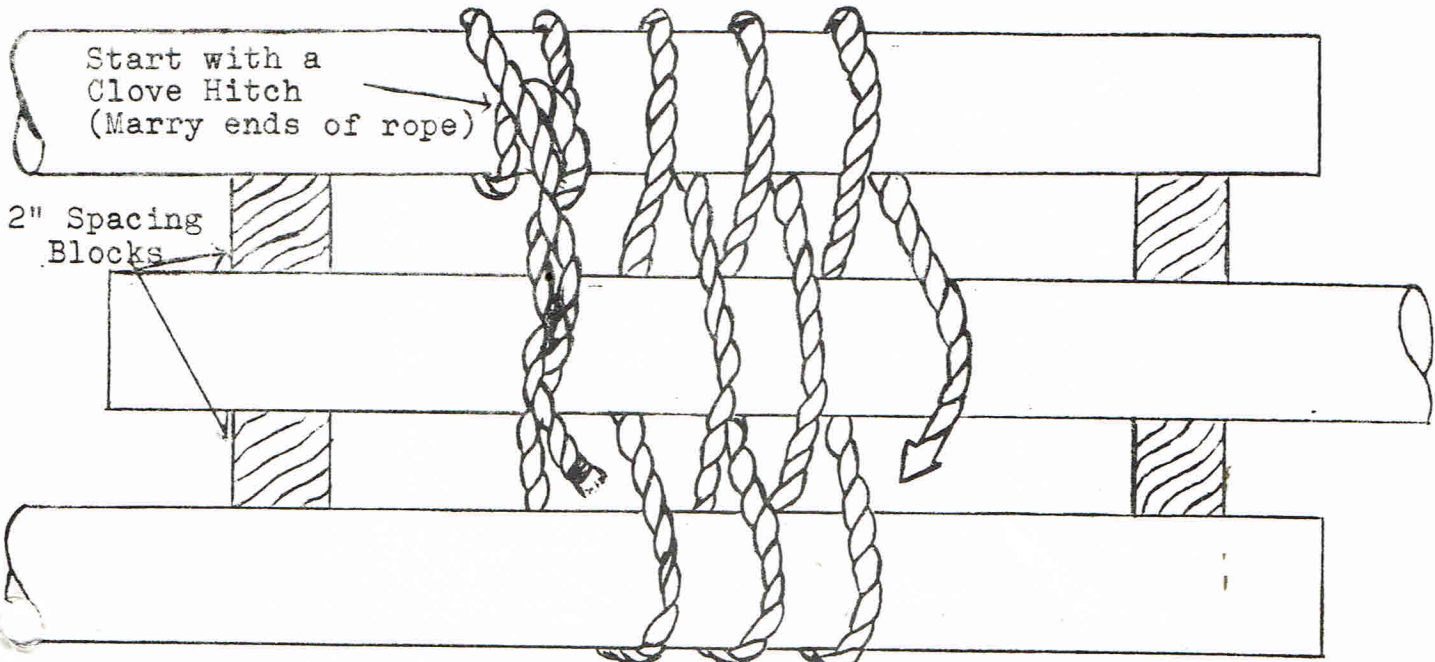
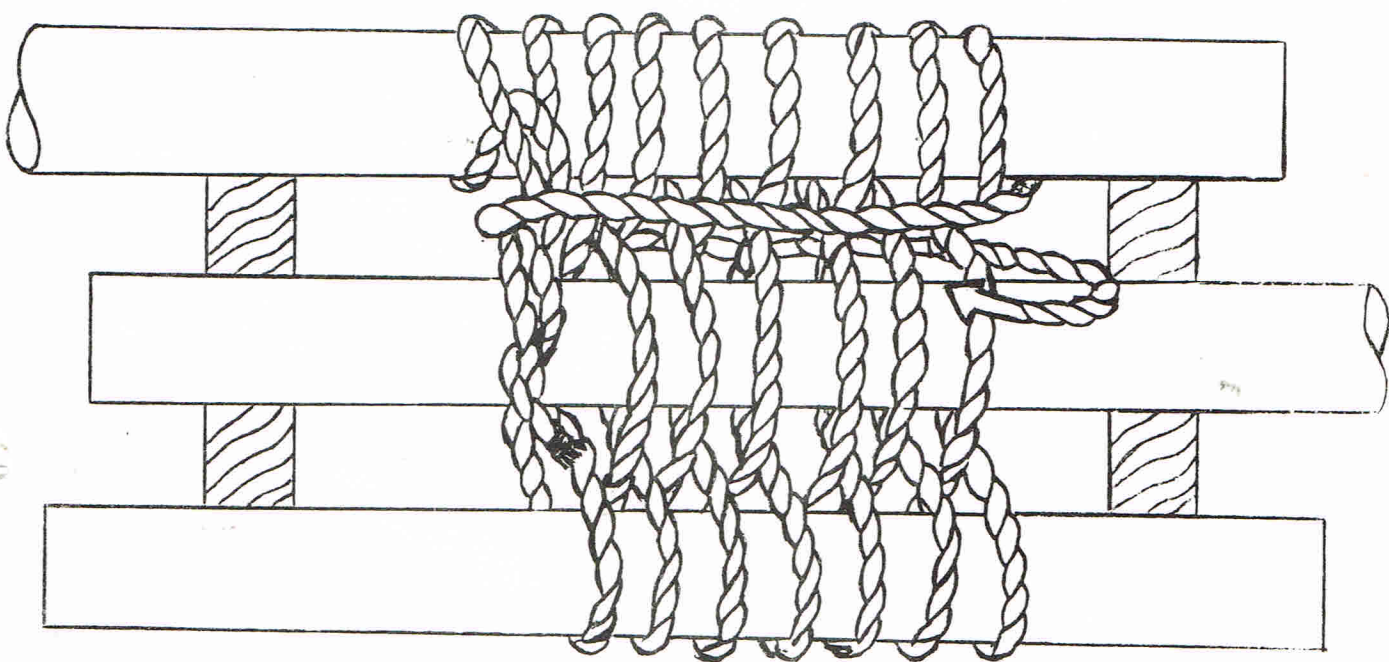


FIGURE-OF-EIGHT LASHING

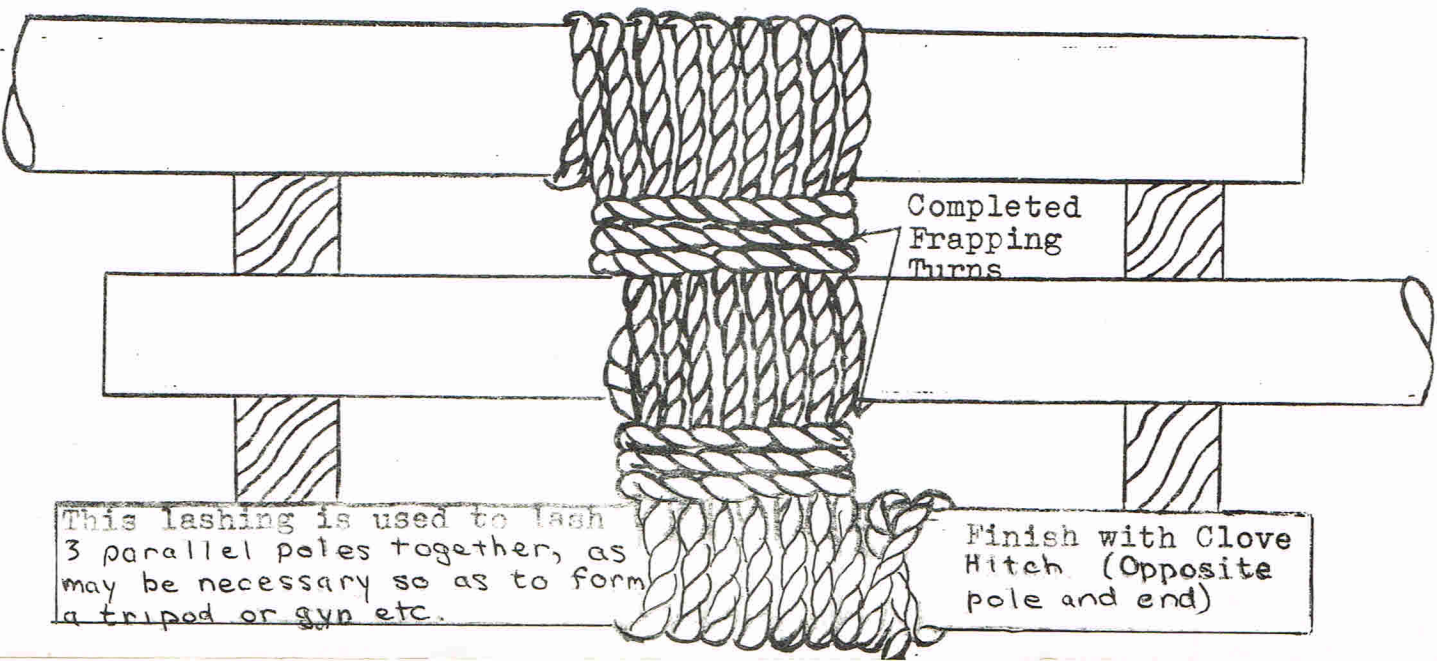
C.D./R.S. 5.



6 to 8 turns in Figure-of-Eight formation



2 to 3 Frapping (or tightening) turns around lashings



This lashing is used to lash 3 parallel poles together, as may be necessary so as to form a tripod or gyp etc.

FIGURE-OF-EIGHT LASHING (Cont.)

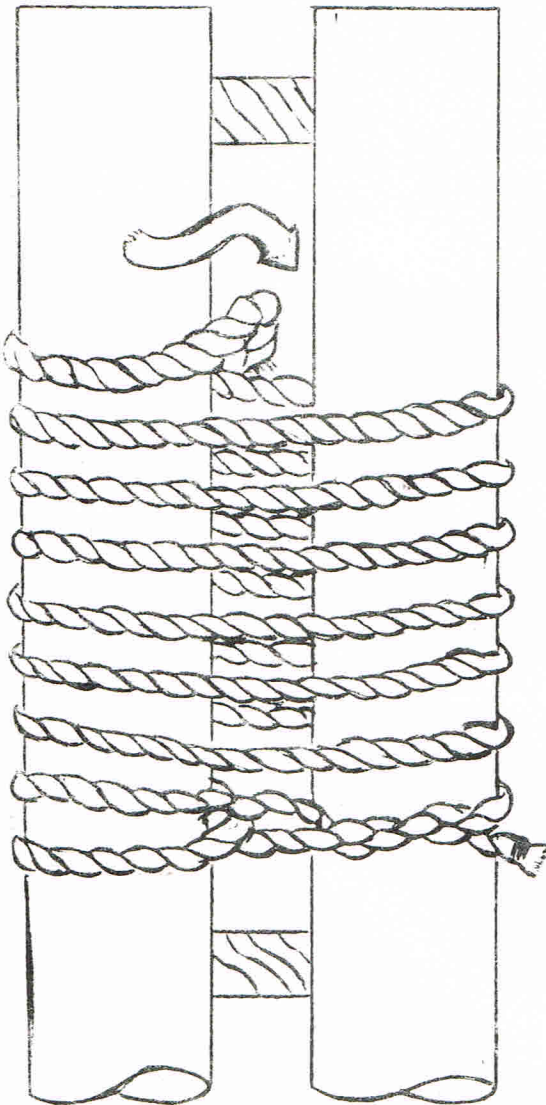
Spacing blocks, approx. 2" thick should be inserted (See diagram on previous page).

Working upwards all the time, from the first Clove Hitch, continue lashing in a figure-of-eight fashion, with 6 - 8 turns. Make 2 or 3 Frapping Turns around the lashing; repeat on the opposite side.

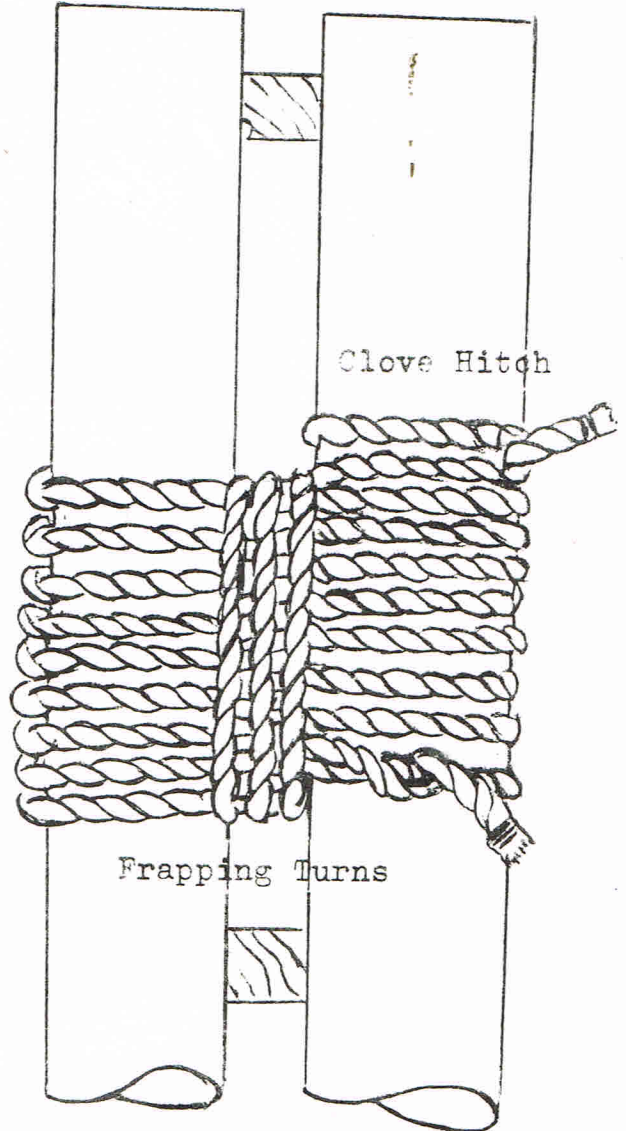
Finish with a Clove Hitch on the opposite pole to where the lashing began and on the opposite end of the poles.

ROUND LASHING

2" Spacing Blocks



2" Spacing Blocks



This lashing is used to lash together 2 poles which lie parallel to each other.

Insert spacing blocks between the poles to be lashed. Start the lashing with a Clove Hitch around one of the poles, (Marry the end of the rope) and continue with 6 - 8 close turns around both poles, travelling upwards.

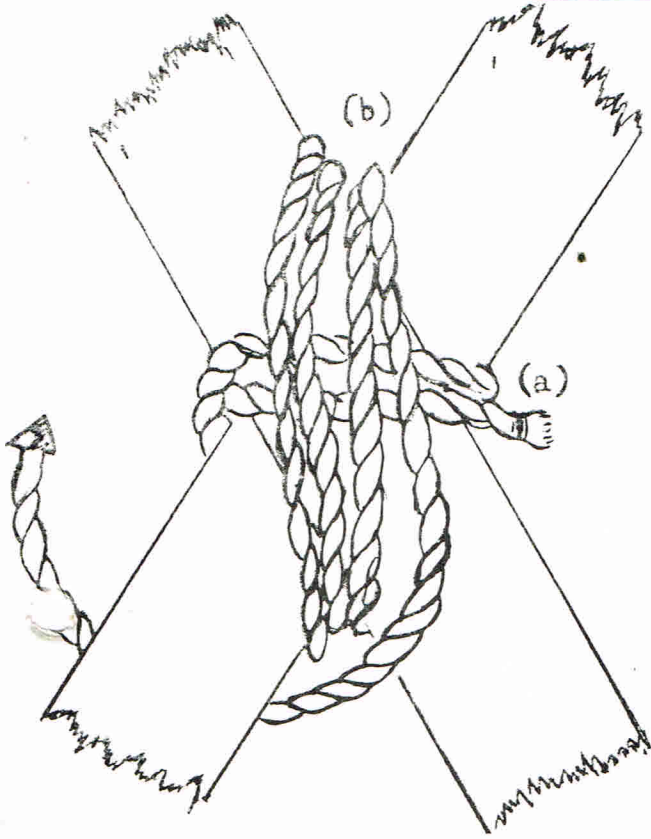
Make 2 or 3 Frapping Turns around the lashing, between the poles, finishing off with a Clove Hitch around the opposite pole above the lashing.

DIAGONAL LASHING

This lashing is used to lash together 2 touching poles, at an angle, especially when their mode of use may cause them to spring apart.

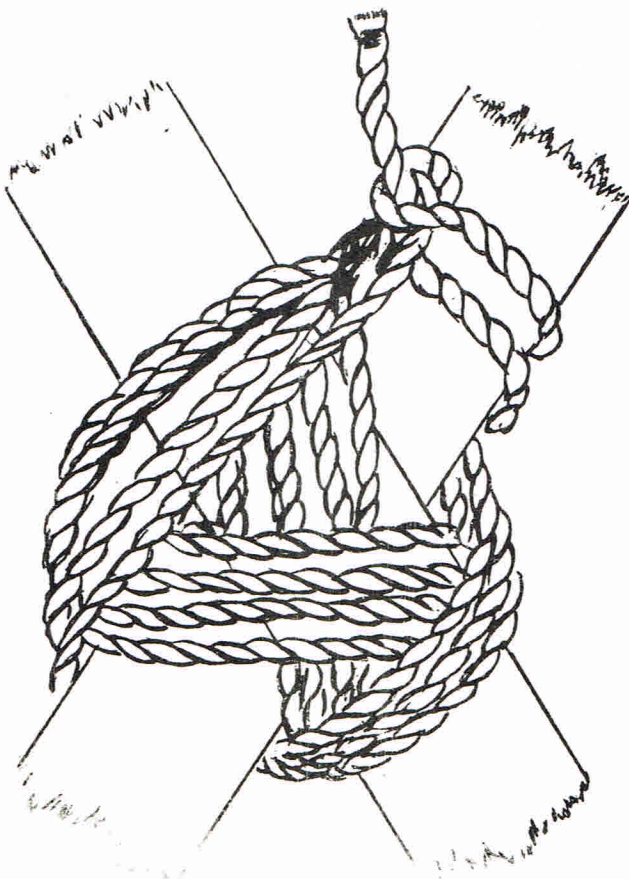
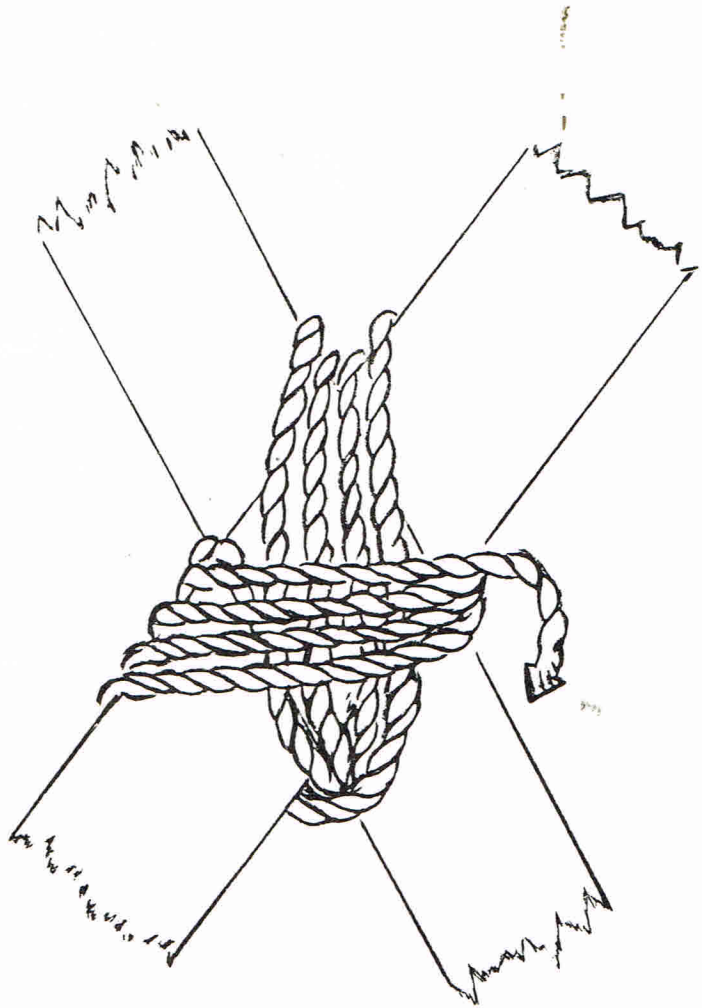
STAGE I

Start with a Timber Hitch (a) around both poles horizontally, then take 4 vertical turns (b) and draw all taut.



STAGE II

Take 4 horizontal turns (c) and draw taut.

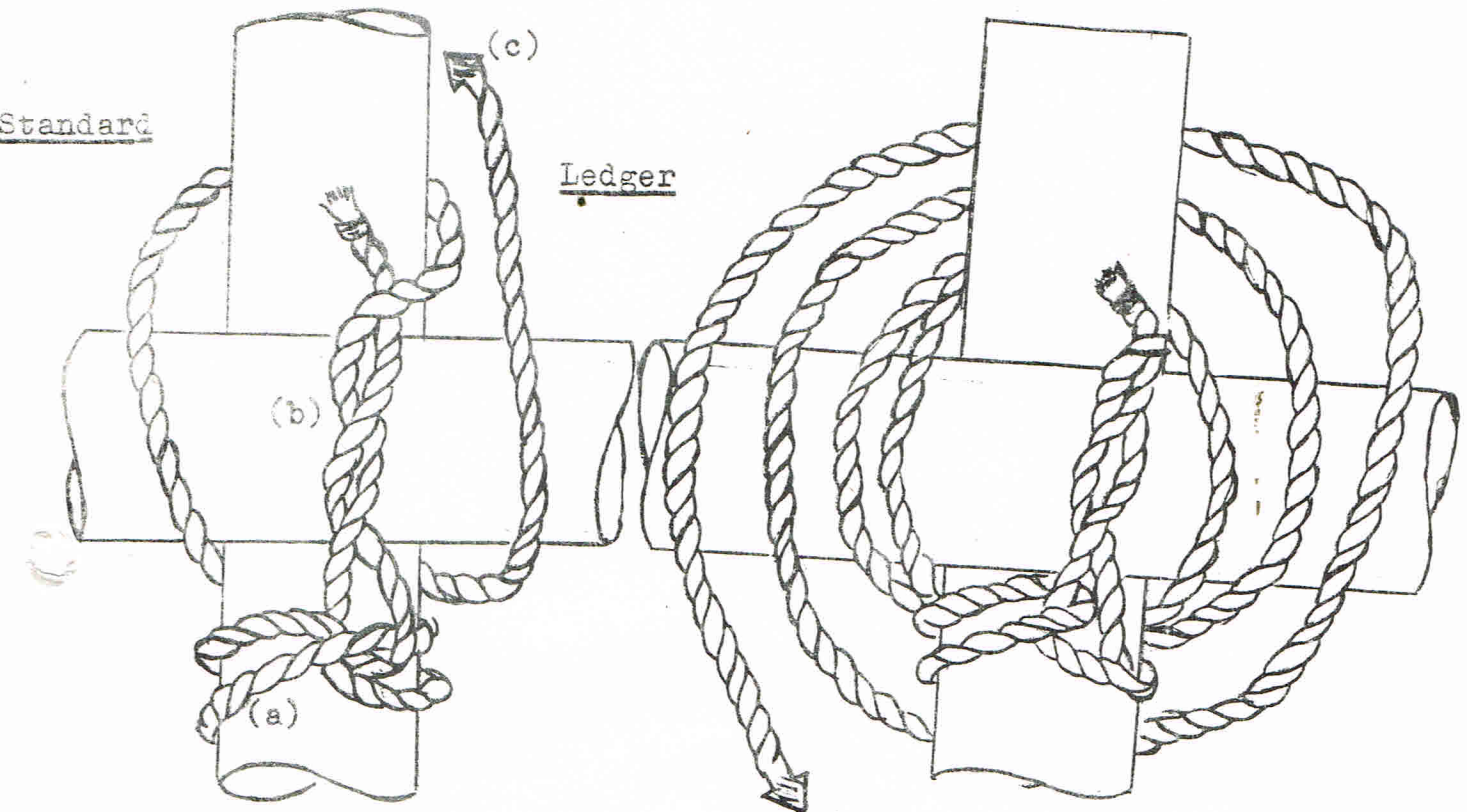


STAGE III

Finally, put 4 Frapping Turns (d) over the lashing, between the spars, draw well taut, and finish with a Clove Hitch (e)

SQUARE LASHING

This is used to lash together 2 poles that touch and cross at right angles.

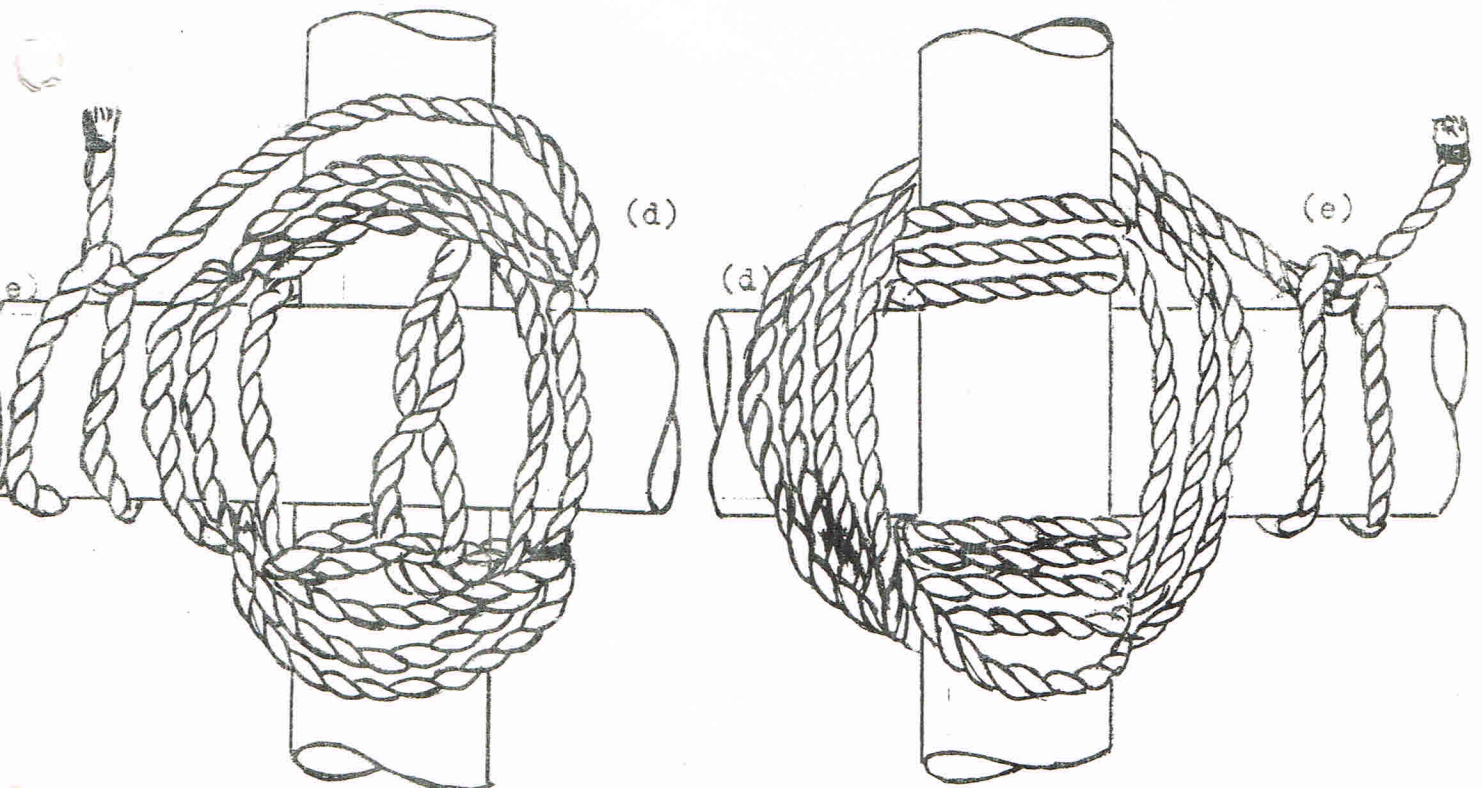


STAGE I

Start with a Clove Hitch (a) around the standard, below the ledger, 'marrying' ends up and around both standard and ledger as depicted (c)

STAGE II

Repeat this circuit 3 or 4 times, drawing the rope as taut as possible.



STAGE III (a)

Take 3 or 4 Frapping Turns (d) around the whole lashing between the spars, draw taut and finish with a Clove Hitch (e) on the ledger.

STAGE III (b) REVERSE SIDE

The square lashing complete as viewed from the back.