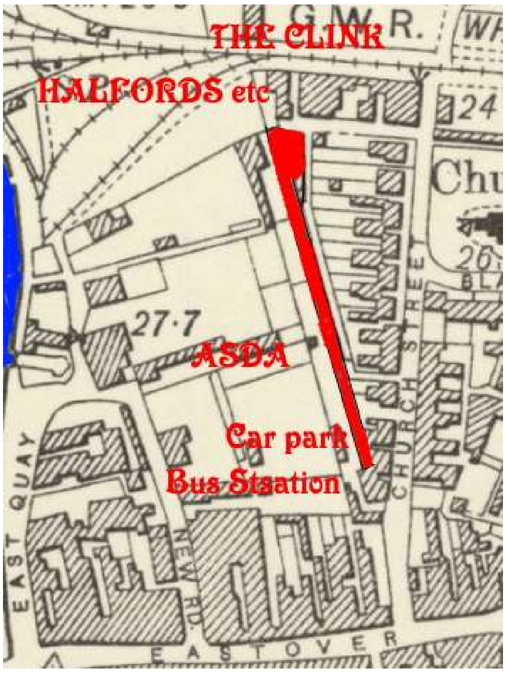
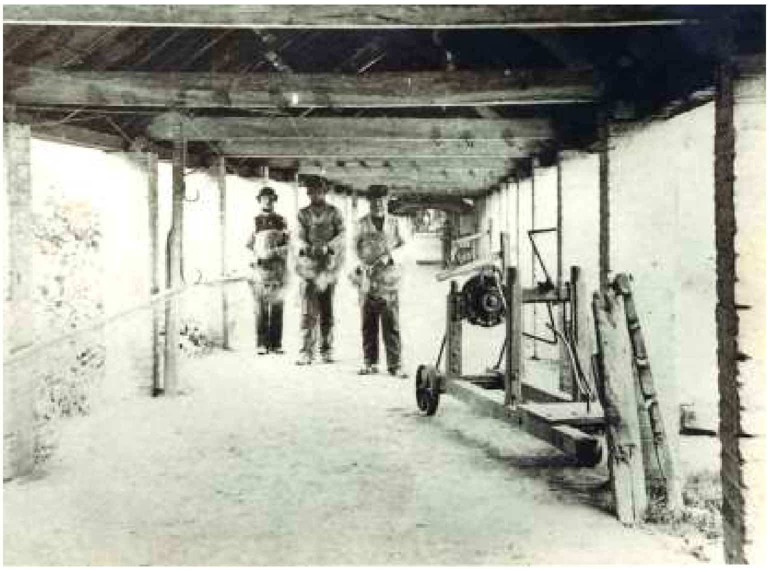
Rope making in Bridgwater
by Tony Woolrich

The following extract from Tomlinson's *Cyclopaedia of Useful Arts*, 1852, has been prepared as it describes the manufacturing techniques used the Bridgwater rope-walk to the end of the sailing shipping trade in 1939. Edwardian newspaper advertisements said *WADDON SONS, Eastover, Bridgwater, Ironmongers, Rope Manufacturers, and Cycle Agents*.

There is permanent display of rope making equipment at the Blake Museum, with relics of Waddon's rope walk. The rope-walk was located off Eastover, parallel to Church Street. Following a fire in 1951 the site was substantially re-developed, and no trace of it remains.



Above The location of the rope-walk.



Above: The Bridgewater rope-walk in 1865.

The Blake Museum collection

Above. Display of rope-making equipment at the museum.

Editorial note

Tomlinson's *Cyclopaedia of Useful Arts* is a multi-volume encyclopedia focusing on manufacturing, mining, and engineering. It was edited by Charles Tomlinson, (1808-1897) a Fellow of the Royal Society, and a lecturer at King's College School, London. The original was published between 1852 and 1854 in two volumes with 40 steel engravings and 2,477 woodcuts. A supplement was published in 1862 by James S. Virtue, London and New York City.

It was devised to celebrate the Great Exhibition and the work is a valuable source of information about the "how", of handicraft, industry and manufacturing, since it contains numerous articles, illustrated by woodcuts, describing the techniques.

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A ROPE consists of a number of threads of hemp or other cord twisted together to make a cord. Several of these cords are twisted together to make a strand. Three of these twisted together make a hawser-laid rope, and nine of them make a cable-laid rope. Rope under 1in. in circumference is called a cord.

Rope was then made from hemp, imported as bales of fibre, which needed to be combed or hatchled into straight lengths.

Spinning the Yarn

This was done in the rope-walk, 600 or 1200 feet long. At one end was a hand-operated spinning machine. The spinner had a bundle of fibre round his waist, and paid it out as it was spun into cords. The spinner walked backwards at about 2 miles an hour. In the roof of the rope walk was a series of equally spaced cross beams to which were fixed hooks to support the cords as they were made.

When he reached the other end of the walk, a colleague unhooked the fibre from the spinning machine and attached it to a reeler on which it was wound as the spinner retraced his steps. In the course of a working day a spinner could walk up to 18 miles.

Laying the Strands

Three cords were twisted into strands, the twist being the opposite way of the twist of the cords

Laying into Ropes

Three cords were then twisted into ropes, and a grooved conical block of wood called a *TOP* was used to control the action. In the course of making the rope, it shortens: a 100 fathom cable (600ft) requires 152 fathoms (192ft)

Ropes were made by machine from the time of the Napoleonic War at the start of the C19, but this was not done at Bridgwater.

Types of rope used at sea

Awning ropes	Bell ropes	Boat ropes
Bolt ropes	Breast ropes	Bucket ropes
Buoy ropes	Davit ropes	Entering ropes
Grapnel ropes	Guist ropes	Heel ropes
Man ropes	Parrel ropes	Passing ropes
Ring ropes	Slip ropes	Swab ropes
Tiller ropes	Top ropes	Yard ropes

ROPE, an assemblage of several twists or strings of hemp, twisted together by means of a wheel so as to form a flexible and tenacious cord or band. The term is usually applied to all cordage above 1 inch in circumference made of hemp spun into yarns or threads, of a certain length ; a number of these yarns or threads, according to the size of the rope, are twisted together into a strand. Three of these strands twisted or laid together is called a *hawser-laid rope*, and 9 of them a *cable-laid rope*. When the rope is made very thick it is called a *cable*, and when very small a *cord*.

Rope-making is an art which all nations seem to have practised from the earliest times. Various kinds of fibre have been used for the purpose, such as hemp and flax, tough grass, the husk of the coco-nut, the fibres of the wild banana, &c, and animal substances have also been used, such as strips of oxhide, horse hair and wool, and in our own day metallic wires have been twisted and plaited into cords and ropes of great strength and of various sizes.

Thongs of leather were used in the rigging of ships during many ages ; and at the present time in some parts of the world ropes of considerable length and strength are formed by twisting thongs of leather. The ancient Romans are said to have made ropes by the twisting of vegetable fibres long before the time of Caesar; and after the invasion of Britain by that people, they are said to have used our native rushes or *junci* for forming ropes. Some writers suppose this to be the origin of the term junk applied to old cables and worn-out ropes.

The superiority of the fibres of hemp to those of most other plants has caused them to be chiefly used in the manufacture of cables, ropes, cords, canvas, and oil-cloth. The cultivation, retting, &c., of hemp is described under HEMP. In forming a rope, as already noticed, the fibres are first spun into yarns, the yarns into strands, the strands into a rope, and the ropes into a cable. The shortness of the hempen fibres (about 3½ feet being the average length,) re quires this complex arrangement. If they were long enough to form a rope the most advantageous method of using them would be to lay the fibres side by side, and to secure them at the two ends. Each fibre would then bear its own share of the strain, and the strength of the bundle would be that of the sum of the strengths of the separate fibres. As a long rope could not be formed in this way, the ends of the fibres are secured by twisting so as to produce sufficient compression to prevent the fibres from sliding upon each other when a strain is applied ; but in attaining this amount of compression by means of twist, the strength of the fibres is greatly deteriorated ; this very compression acts as a constant weight on the strength of the fibre, and must be deducted there from before the available strength can be applied. Réaumur found that a small well-made hempen cord broke in different places with 58, 63, 67, and 72 lbs., its mean breaking weight being 65 lbs. ; while the 3 strands of which it was composed bore 29½, 33½, and 35 lbs. respectively; so that the united absolute strength of the strands was 98 lbs., although the average real strength of the rope was only 65 lbs., thus showing a loss of strength from twisting equal to 33 lbs. Réaumur's experiments were made in 1711. The more recent experiments by Sir Charles Knowles give a nearly equal loss of strength by twisting. He found that a white rope of 3½ inches in circumference broke on an average of several trials with 4,552 lbs. ; while the aggregate strength of its yarns, 72 in number, was 6,480 lbs. (each yarn bearing about 901bs.); thus the loss was 1,928 lbs. or about 30 per cent.

The strength of ropes is sometimes calculated by the following rule: — Multiply the circumference of the rope in inches by itself, and the fifth part of the product will express the number of tons the rope will carry. Thus, if a rope be 6 inches in circumference, 6 x 6 = 36, the fifth of which is 7⅕.

The weakening effect produced by twisting varies considerably among the fibres of the same rope according to their distance from the centre or heart of the bundle. If a certain amount of twist be given to a bundle of fibres, the outer fibres, occupying more space than the inner ones, will be strained more, and will act with less useful effect than the inner fibres, which will have to bear the greater part of the strain while the rope is being used. It will therefore be evident that if the fibres of hemp were twisted all once into a thick rope the outer fibres would be so much strained as to be of little or no use in contributing to the strength of the rope; but by first twisting the hemp into slender yarns, and a number of yarns into strands, and 3 of these into a rope, the strain is more equalized, and the important properties of length and strength are secured without too great a sacrifice of the strength of the individual fibres. There is also another reason why a rope could not be at once formed by twisting a bundle of fibres together. Such a rope when left to itself would immediately begin to untwist. This tendency to untwist is counteracted by twisting the fibres together in small portions and then combining them in such a way that the tendency to untwist in one part shall counteract that tendency in another.

Duhamel has endeavoured to ascertain the amount of twist that would produce the most useful effect. He made some ropes in which only ¼th the length of the yarns was absorbed in twisting instead of the usual proportion of ⅓rd. These ropes when used in shipping were found to be lighter, thinner and more pliant than those in ordinary use. Ropes made of the same hemp and the same weight per fathom, but twisted respectively to ⅔ds, ¾ths, and ⅘ths, of their component yarns, supported the following weights in two experiments : —

⅔ ds.	4,0981bs.	4,2501bs.
¾ ths.	4,850	6,753
⅘ ths.	6,205	7,397

The result of these experiments led Duhamel to make ropes without twist, by placing the yarns together and wrapping them round to keep them together. The rope had great strength, but not much durability on account of the outer covering soon wearing away or opening at bendings, and thus admitting water, occasioning the yarns to rot. These *salvages* or skeins of rope yarns are, however, used for the tackle of great guns, and for some other purposes where great strength and pliancy are required.

Fig. 1894.

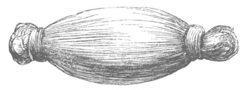

Fig. 1895.

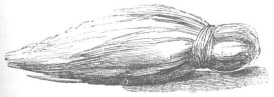

Fig. 1896.

Preparation of the yarn. Before spinning the hemp into yarn it is heckled or hackled for the purpose of separating and straightening the fibres. The heckle is formed of a number of straight steel prongs set in a board with the points upwards : they are of various sizes ; the smaller heckles strip the hemp of its short fibres or tow, when the hemp is said to be *cropped*, and is used for fine work, or for spinning below the usual *grist*, as it is called, the usual grist being a rope 3 inches in circumference, with 20 yarns in each strand.

In the process of heckling, a quantity of hemp sufficient for spinning into one yarn 160 fathoms long is first weighed out, and the heckler, holding the fibres at one end, throws the bundle loosely over the points, and pulls it gently towards him : a number of fibres is retained in the heckle, and by repeating the process they are all retained. He then lifts up the whole bundle, and passes it again through the heckle, the operation being assisted by the application of a small quantity of whale-oil to the points. The fibres, thus separated, and made tolerably parallel, are tied up into a bundle, Fig. 1896, called a *tow* of hemp, weighing about 3 ½ lbs.

Fig. 1893. HECKLING HEMP.

Heckling greatly improves the appearance of the hemp, converting the hard knotted mass, as shown in Figs. 1891, 1895, into a loose silky skein, Fig. 1896.

Spinning. — The fibres are spun into yarn in a long rope-walk of 600 or 1,200 feet, one end of which is called the *head*, or *fore-end*, and the other the *foot,* or *hack-end.* At one end is a spinning-machine, Fig. 1897, consisting of 2 upright posts with a wheel between them, the band of which passes over several rollers or *wheels*, Fig. 1897, turning on pivots in brass holes, the pivots projecting and terminating in small hooks, so that by turning the wheel the hooks are made to revolve rapidly. Posts are arranged at equal distances on each side the walk, Fig. 1899, and between every pair of posts a rafter is extended across ; hooks are driven into this rafter for the purpose of supporting the yarns as they are spun.

The number of whirls in the spinning-machine (generally about 12) determines the number of spinners that can work together. Each spinner wraps round his body a bundle of hemp sufficient for the spinning of 1 thread of yarn, taking care that the *bight* or double of the fibres is in front, the two ends passing behind his back. He draws out from the face of the bundle as many fibres as the size of the yarn requires, and, twisting them between his fingers, attaches the bight to one of the whirl-hooks, while the wheel, being turned by an assistant, throws *twist* or *turn* into the fibres. The spinner holds in his right-hand a piece of thick woollen cloth, with one end hanging over the forefinger; with this cloth he grasps the fibres as they are drawn out, and presses them firmly between his two middle fingers, walking backwards all the time from the head to the foot of the walk, occasionally making a signal with his left-hand to the wheel man to turn fast or slow as may be required.

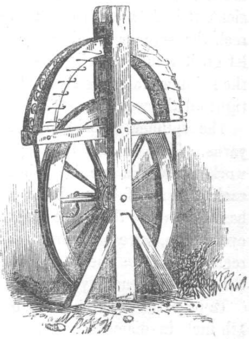

Fig. 1897.

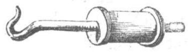

Fig. 1898.

He regulates the supply of fibres with his left-hand so as to make the yarn of equal size, drawing back some if they enter his right - hand in too great a number m and putting forward more if the supply is defective. If he does not allow the ends of the fibres to come near together in a flat skein, so the yarns may have a similar strength throughout. The thickness of the yarn depends on the quantity of hemp which passes through the spinner's hands in a given time, and on the rapidity with which the hook is made to turn.

The spinner walks backwards at the rate of about 2 miles an hour, and as the yarn increases in length, he throws it. over the hooks on the under side of the rafters, which are placed 5 fathoms apart. When the spinner has got to the lower end of the walk, and his length of jarn is sufficient, it is detached from the wheel and fastened to a reel, the spinner holding the end of his yarn, for if let go it would untwist : as the reeler turns the reel the spinner walks slowly in, keeping the yarn equally tight all the way.

The spinner is paid 7d. for spinning 6 threads or yarns. This is called *one quarter's work*. A good workman will in one day spin 8 quarters, or 48 yarns, each yarn 160 fathoms in length ; and as the spinner has to traverse the whole length of the walk twice for every yarn, once in spinning it out, and back again in reeling it in, he has thus to walk nearly 18 miles in the course of one day's work.

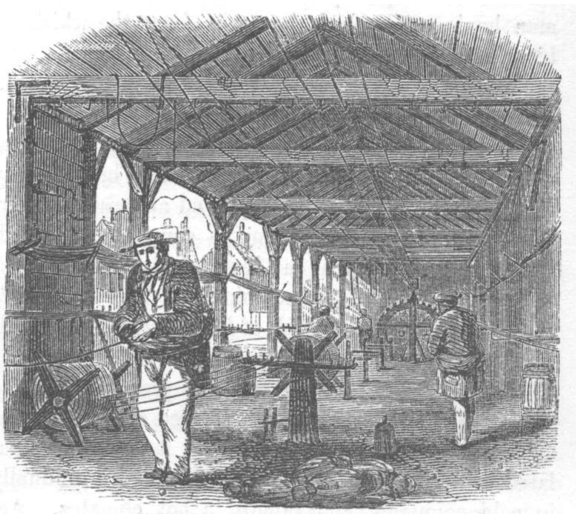

Fig. 1899. SPINNING ROPE YARNS.

Rope yarns are commonly from $^1/_{12}$th to rather over ⅛ inch in diameter ; 160 fathoms of white, or un- tarred yarn, weigh from 2½ to 4 lbs.

When a number of spinners are *set-on* at the same wheel, each fastens his thread to a whirl, and they all proceed together down the walk ; each man throwing his yarn on one of the hooks of each rail as he passes it. When they arrive at the foot, they join the ends of every pair of yarns and hang them over the post ; and in order to be able to separate them, a piece of twine is tied by the middle to the first pair a little in advance of the post ; the second pair is then put over the post, and a string is tied over them, and in this way every pair is tied in. This is called *nettling*. The spinners now *set-on* at the foot or *back- end wheel*, and spin up the walk. The forward wheel man having unhooked the yarns from the whirls of his wheel, and hung them over the posts, and tied them in pairs at the back-end, proceeds down the walk collecting the yarns from the hooks.

Rope-yarns are now in some places spun by machinery, as will be noticed further on ; but we may here mention that, by the improved apparatus of Mr. Lang of Greenock, the hemp is completely heckled, and each fibre is laid at full length in the yarn instead of being doubled as in hand-spinning. These machine- spun yarns have a strength of 55 per cent, over hand- spun yarns of equal grist.

If the cordage is to be tarred, the process of *tarring the yarns* is now introduced. Tarred cordage is considerably weaker than untarred, but it is better calculated to resist the wet. It loses its strength gradually in cold countries, and rapidly in hot climates. According to Duhamel,[1] untarred ropes sustained a greater weight by nearly 30 per cent, than tarred ropes ; and he states that white cordage, in constant use, is one-third more durable than tarred, that it retains its force much longer when kept in store, and resists the action of the weather one-fourth longer. Cordage, when only tarred on the surface, is said to be stronger than when tarred throughout. Messrs. Chapman, of Newcastle, have stated that the rapid decay of tarred cordage is due to the presence of the mucilage and of the acid of the tar, which they propose to remove by boiling the tar with water and concentrating the washed tar by heat until it becomes pitchy, restoring its plasticity before use by the admixture of tallow or oils.

Preparatory to tarring, the yarns are warped into a *haul* ; that is, they are unwound from the reel or roller, and stretched straight and parallel, when 300 or 400 yarns are assembled in a large group or haul, about 100 yards long. This haul is dipped into tar heated to about 212° in a copper or tar-kettle, and is then dragged through a hole, called a *grip*, or *gage*, or *sliding-nipper*, which presses the tar into the yarn, and removes the superfluous portion. The tar must not be too hot, or the yarns will be charred ; nor too cold, or they will be black ; they ought to be of a bright brown colour. The proper temperature is judged of by the closing in of a scum over the surface of the tar.

The yarns either tarred or untarred are next twisted or *laid* into strands, the twist of the strand being in an opposite direction to that of the yans, in order to counteract the tendency of the separate yarns to untwist, and that the yarns in their turn may counteract the tendency of the strand to untwist. The laying walk may be under the same roof as the spinning walk. It is provided with tackle-boards and wheels for twisting the strands, and stakes and stake-heads for supporting them. The tackle-board, Fig. 1900, for twisting large strands is fixed at the head of the walk ; it consists of strong upright posts supporting a plank pierced with holes which correspond to the number of strands, generally three, of which each rope consists.

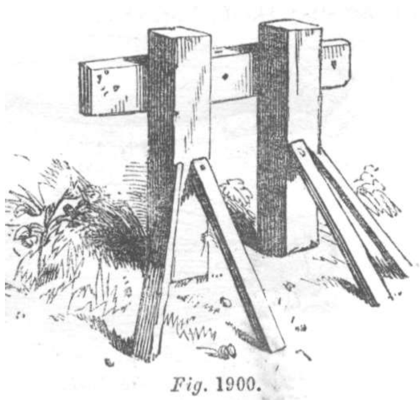
Fig. 1900.

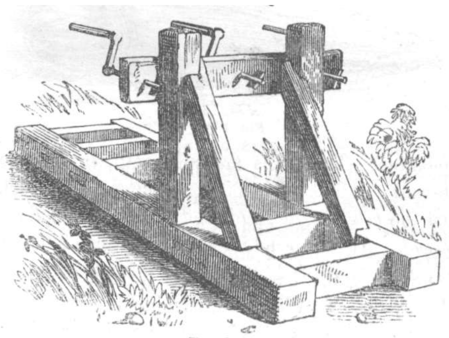
Fig. 1901.

Winches or *forelock* hooks work through these holes. One of the smaller wheels for laying the smaller strands is shown in Fig. 1902 ; it is supported on a strong post at the head of the walk : the axes of the pinions are prolonged into hooks, and the driving wheel is worked by a winch. The strands are supported by beams or stake-heads placed at intervals along the walk ; each stake-head, Fig. 1903, contains a number of upright pins, between which the strands are placed. The yarns as they are run out for laying are first secured to posts at the head and foot of the walk, and as they become shortened by being twisted into strands they are afterwards attached to movable sledges, Fig. 1905, situated at the foot of the walk. The sledge, called the *breast board*, corresponds to the *tackle-board*, Fig. 1900. The sledge is loaded with press-barrels, i.e. old tar-barrels filled with clay, for keeping it steady, and iron weights are also used for the purpose.

Supposing now that the yarn is properly warped for laying into strands it is run out along the bearers of the laying walk, and the number of yarns required for the rope is counted out, and divided into three separate portions, each portion being placed in one of the divisions of the bearers, and hung upon the hooks of the tackle-board and sledge

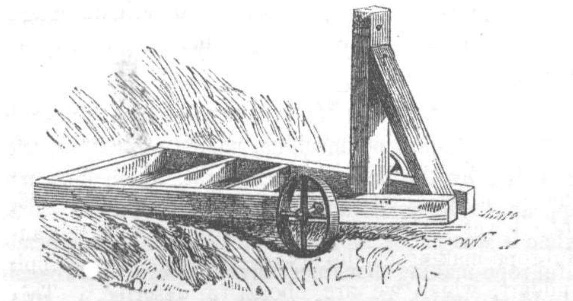

Fig. 1904.

The sledge is pulled backwards to stretch the yarns tight, and the press barrels are put on.

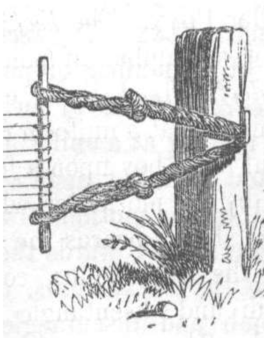

Fig. 1905.

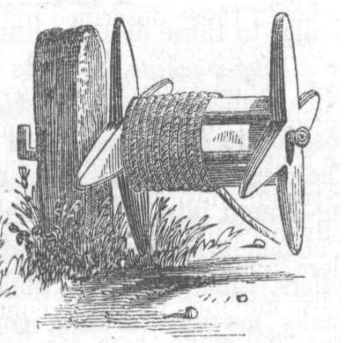

Fig. 1906.

The yarns are now examined to see that they are of equal length and properly stretched; the hooks at each end are now heaved round in a contrary direction to the twist of the yarn, and in this way the three bundles of yarn are formed into 3 strands. By the consequent shortening of the yarns the sledge is drawn forward some way up the walk. When the strand is full hard, or has enough *hard* in it, as it is termed, the twisting is discontinued ; the sledge is moved forward to slacken the strands, and to allow of their being taken off the hooks.

The three strands thus formed are laid or twisted together into a rope; for which purpose they are attached to the middle hook of the tackle-board, and then placed in the grooves of a conical block of wood, Fig. 1907, called a top, through which passes a pin for the handles or *woolders* as they are called.

A piece of soft rope called a *tail* is attached to each woolder by its bight in the middle, while the ends are used to secure the rope in laying the strands.

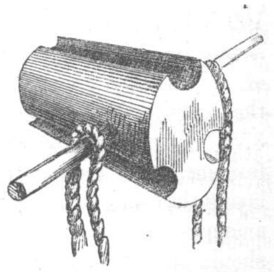

Fig. 1907.

Tops of various sizes are used, and when a top is of very large size it is supported on a sledge. Now the 3 strands being attached to a hook of the breast-board, and then continued along the grooves of the top as in Fig. 1909, the top is forced back as near the hook of the sledge as possible, and the men at the head again turn their hooks in the same direction as before.

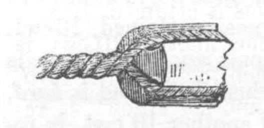

Fig. 1908.

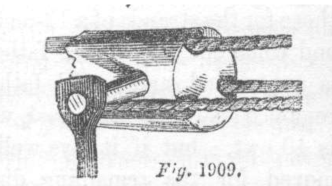

Fig. 1909.

As soon as the sledge begins to move forward, the men diminish the load on the sledge, and turn the hook in a direction contrary to the former, by which means the top is forced forward; the 3 strands closing behind it as in Fig. 1908 form the rope. The reason for turning the single hook containing the ends of the three strands in a contrary direction to the three hooks to which the other extremities of the strands are attached, is to regulate the progress of the twists of the strands found their common axis, that the three strands may receive separately at their opposite ends just as much twist as is taken out of them in consequence of their being twisted the contrary way in being laid together. When the top is some way off from the sledge the tails are wrapped round the rope, and they by their friction prevent the top from moving by jerks and also enable the rope to close better. In this way a rope is formed by twisting 3 strands together. It will be seen that the strands unite into a rope on one side of the top, and are kept separate on the other side, and that as the rope is formed the top is gradually driven forwards. The motion of the top requires to be regulated so as to ensure equal hardness in the rope : the topman, therefore, before putting in the top, makes a mark across the strands of every beam : if, when the top reaches a beam the mark be above the bearer, the topman knows that the turning at the foretop has been too fast ; if the mark be below, he knows that the turning has been too slow.

In laying a very thick rope, the men may not be able to turn the hook of the sledge to which the strands are attached ; but they are assisted by other men, who apply woolders at intervals between the sledge and the top : the strap of each woolder is wrapped round the rope, and the pin is used as a lever to heave round the twist. The men at the woolders keep time in heaving with the men at the hook of the sledge ; and in the case of heavy ropes the top sledge is used to support the rope.

In laying the strands it is necessary to vary the pressure at different parts of the process, and also the angle at which yarns take their position in the strands; the angle which the strands assume in forming a cable also requires attention. In making a cable of 100 fathoms, for example, the length of the strands should be 152 fathoms and should be laid at an angle of 27°; hard is given until each strand is shortened the length of 10 fathoms, when the angle must be 37°. In making the strands the sledge travels 24 fathoms, and the angle then made should be 32°. In laying the cable, the length of the strands thus formed amounts to 118 fathoms, and the angle when hard should be 40°. The length of the cable when finished is generally 101 fathoms ; the strands entering with an angle of 35° while laying, and finishing at one of 38°.

With regard to the press-weights on the sledge : those for the strands of a 12-inch cable begin at 60cwt., and when the length of 5 fathoms is attained, l0cwt. is subtracted, and at 7½ fathoms another 10 cwt. is removed ; so that the press, when the strand is hard, is 40 cwt. : but if it lays well another 10 cwt. is removed for the remaining distance. In laying the cable, the press begins at 160 cwt. : this is reduced 10 cwt. at 1½ fathom ; another 10 cwt. is taken off at 2 fathoms, and when the cable is observed to lay well, another 10 cwt. is removed, leaving a press of 130 cwt. for the rest of the cable.

The *second lay* is performed with *four* strands, producing what is called a *shroud hawser-laid* rope.

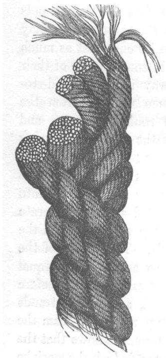

Fig. 1910.

The. 4 strands are laid in the same way as the 3, and under the same conditions; but in order to render the rope solid, a core-piece, consisting of a few yarns, is run through the centre. The *third lay*, or *cable-laid* rope, consists of 3 hawser-laid ropes, each formed of 3 large strands, twisted or laid together into one gigantic rope or cable. This, however, is now seldom made, the chain-cable having taken its place [see Chain-cable]; but as cable-laid ropes are very hard and compact, ropes of no very great size arc made in this way, if intended to resist the action of water.

Where great pliability is required, ropes are formed by *plaiting* instead of twisting; as for clock lines, sash lines, and generally where ropes have to pass over small pullies.

Flat ropes, used for mining purposes, are formed of two or more small ropes placed side by side and united by sewing, lapping, or intertwining with thread or smaller ropes. Flat ropes are also formed by similarly uniting a number of strands of shroud-laid rope. In either case the component ropes or strands must be alternately of a right-hand and a left-hand twist, or the rope would not remain at rest.

The weight of cordage may be calculated by the following rules : —

For shroud or hawser-laid rope, multiply the circumference in inches by itself; then multiply the product by the length of the rope in fathoms, and divide by 420, the product will be the weight in cwts.

For cable-laid cordage, multiply its circumference in inches by itself, and divide by 4. The product will be the weight in cwts. of a cable 120 fathoms long; from which the weight of any other length may be deducted.

Note

1) Duhamel du Monceau, *Traite de la fabrique des manoeuvres pour les vaiascaux ; ou l'art de la corderie perfectionne*. 4to. Paris, 1747.

The "Art of the Rope-maker," from the *Descriptions des Arts et Métiers"* series