Making a wheel

– how to make a traditional light English pattern wheel

Preface

As the use of horse drawn vehicles declined in the 1950s and early 1960s, demand for the traditional craft of wheelwrighting also fell. By the time interest in carriage driving and the use of horse drawn vehicles for trade and leisure revived, it had become hard to find a practising wheelwright to carry out repairs or make new wheels.

The Council for Small Industries in Rural Areas (CoSIRA), now the Rural Development Commission, with the help of the Worshipful Company of Wheelwrights, decided to set up a training scheme to ensure that the craft of the wheelwright was not lost for ever.

The training scheme still runs at the Commission's workshops in Salisbury, passing on the traditional skills of the wheelwright as well as introducing more modern techniques.

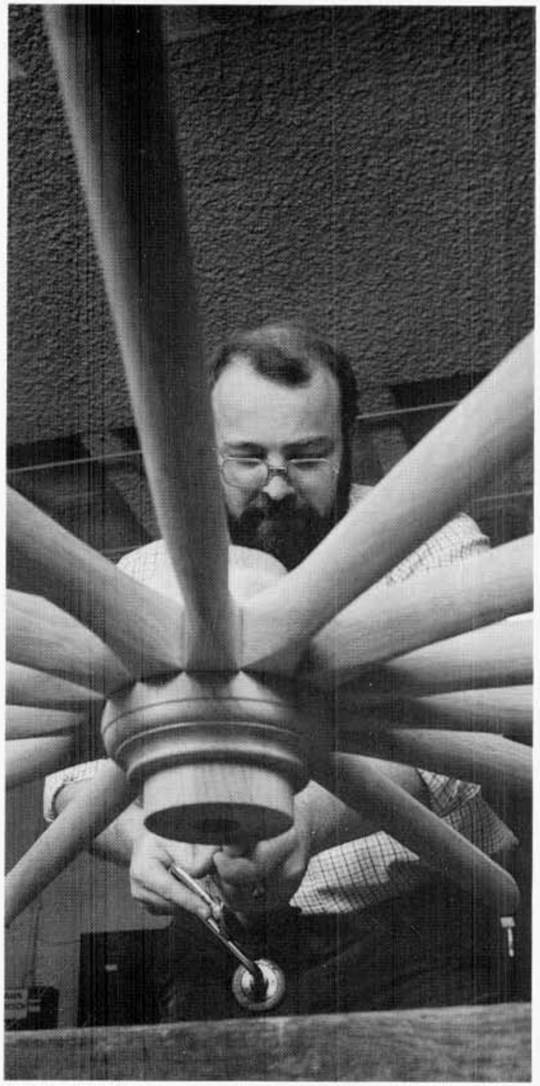
Today, as interest in horse drawn vehicles continues to grow, so the demand for well trained and experienced wheelwrights increases. The Commission and the Worshipful Company intend to keep the craft alive and flourishing well into the next millennium.

The authors

Both authors teach the Rural Development Commission's wheelwright course. To their knowledge, this is the only book describing the making of the traditional light English pattern wheel. It has been designed for students and all those interested in the wheelwright's trade.

The Rural Development Commission

The Commission works for the wellbeing of the people who live and work in the English countryside. We advise government on economic and social development and take action to help rural businesses and communities flourish. One way we do this is by providing affordable and accessible training programmes in a range of rural trades. For further information on the wheelwright course or on our other courses, please contact: Craft Training, Rural Development Commission, 141 Castle Street, Salisbury, Wiltshire SP1 3TP.



Introduction

This manual aims, in a practical way, to show the processes necessary for building a light wooden carriage wheel of the traditional English form. It describes the operations in a way which should enable a workman familiar with the use of woodworking tools and techniques to make such a wheel.

Naturally, the size of a wheel is determined by its intended job and the parts of that wheel are made proportionately heavy or light. It is difficult to set out rules suitable for assessing the proportions of wheels and we will not attempt to do so here. Some factors take care of themselves, for example the combined width of the total number of spokes in the wheel must be less than the maximum circumference of the stock. It may be worth pointing out that the diameter of the wheel is very roughly proportioned to the length of the axlebox, since the leverage exerted by side-thrusts on the felloes increases as the diameter of the wheel increases. But it is simplest and most satisfactory to recommend a study of the proportions and sizes of wheels and their parts that were used in traditional old vehicles. In doing so the style of the forms of spokes and stock will be noted and this will prove useful in repairing or making reproductions of old vehicles.

Several kinds of wheels which did not rely entirely on wooden mortices in a wooden stock to hold the spokes were introduced in the 19th Century. It is not our purpose to deal with these here. They were mostly inventions designed to facilitate mass production of lightweight vehicles in America and some of the lightest kinds can prove difficult to repair without the extensive use of machinery and jigs. Even in making wooden wheels of the traditional pattern, a variety of special tools and pieces of standing equipment are necessary and some woodworking machinery is helpful. These will be referred to in the text.

Suitable hardwoods will also be needed and the selection of timber is a matter of crucial importance. The traditional species have been found to have the right physical properties of strength and resilience. The choice of the correct run of the grain and degree of seasoning are vital for the strength and life span of the wheel. If the wheel is to be stored under particularly dry conditions or used in a dry climate, the moisture content of the timber will need to be correspondingly lower. For normal purposes, in this country, a moisture content of about 16% is an acceptable maximum. Most carriages are stored in unheated sheds, many without damp courses. Wheels made with timber too wet will, of course, shrink inside their iron tyres. Less frequently, those which have been exposed to excessively wet conditions may swell and the dish may increase because the spokes bend. There is also a danger that rot may set in if timber of too high a moisture content is used, this moisture would be trapped by the usual impermeable paint finish and so rot may result. The most awkward storage and usage situations for wheels involve long spells in differing degrees of humidity, the impermeability of the paint or varnish finish provides a barrier to protect against short term fluctuations in humidity, over periods of days or a very few weeks. But if the paint film is damaged, or if the storage or use varies the humidity dramatically over long periods, shrinkage or swelling may result. To some extent this may be avoided by soaking spokes in hot linseed oil before assembling the wheel, but the oil dries slowly and may make painting difficult for a long time unless it is done well in advance of assembly.

The wheelstock

Elm is the timber used in English wheelstock for making the stock. A round log is best seasoned for stocks, cut to the length of the eventual stock plus an allowance for end shakes of about 1" to 2" per end (2 - 4" overall). An allowance in the diameter for sapwood of 2" or 2" is also needed, so for a 7" stock a piece 9" or 9" under the bark would be required.

Various techniques have been tried to speed up the drying process. One traditional one was to immerse the stock, with a pilot hole bored through it, in a running stream for a few months, the water replacing the sap is alleged to speed the drying time when it is brought out of the stream. Another involves the use of a microwave oven.

A good standard, however, is to stack stocks on a shelf in the workshop to dry with a pilot hole - say 1" diameter through them. If the bark is left on, the stock will have less tendency to develop drying shakes. Drying time will depend on the size of stock and the air flow and humidity and temperature but is unlikely to be less than 15 or 18 months and could be as much as 7 years.

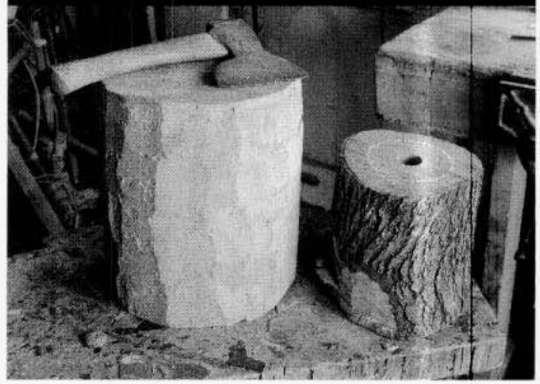
The Procedure

A dry elm blank is selected and the required circumference marked on it with dividers. To do this it will be necessary to plug the pilot hole if one has already been bored, and these plugs can be arranged to be used when turning the stock. A small wheelstock can be cut down to the marked line with a large bandsaw, otherwise the traditional technique of chopping the stock down to size using a side axe will be necessary.

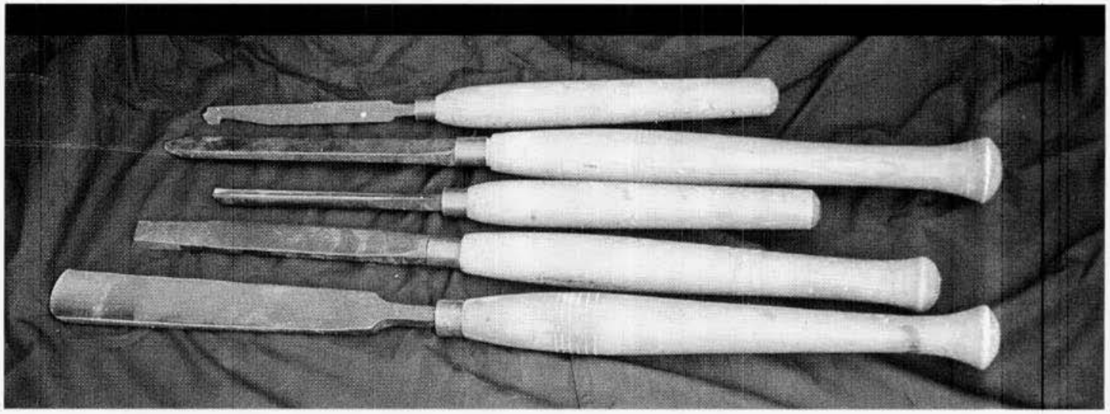
1.

An English wheelstock, turned and morticed.

2.



The stock has been prepared for turning by using the side axe shown resting upon it, the smaller one on the right is marked out to be cut down to size, the line is visible on the top.

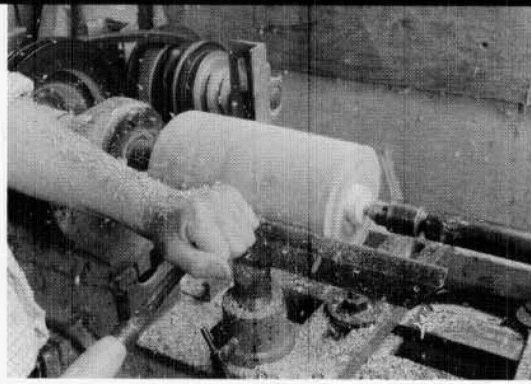


Several types of turning tools.

3.

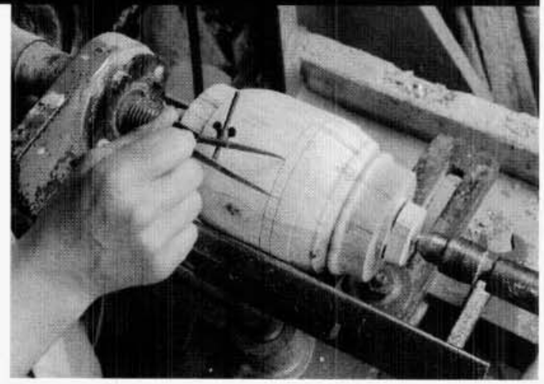
The chopped stock is mounted on the lathe, here a turned plug is inserted to the pilot hole.

4.



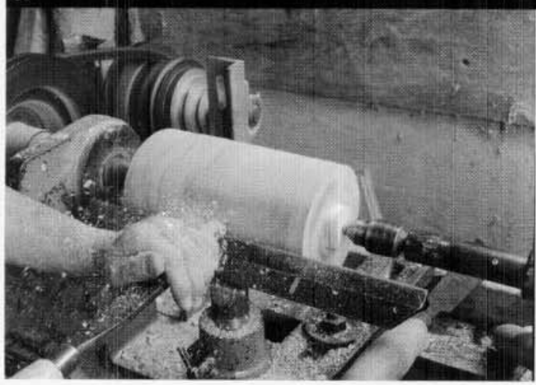
The stock is turned with gouges and scraping tools.

5.



The stock has been turned to a cylindrical form, the callipers are used to check its diameter and also check that its sides are parallel by trying the size at several points along it.

6.



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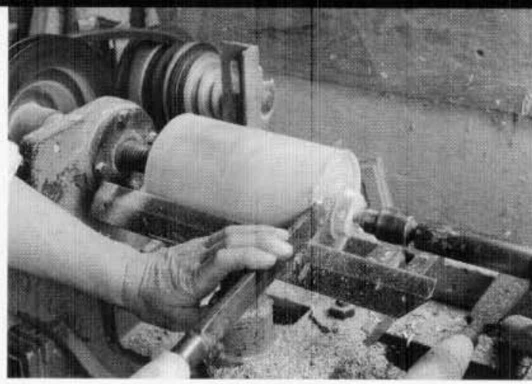

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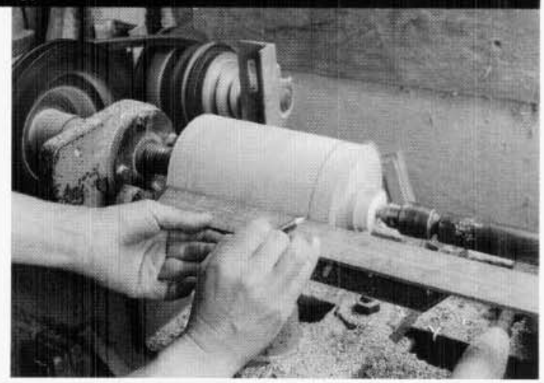
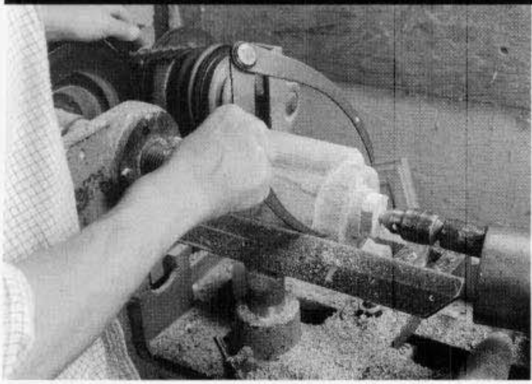


A sequence of pictures showing the stock hoop lands being formed.

9.



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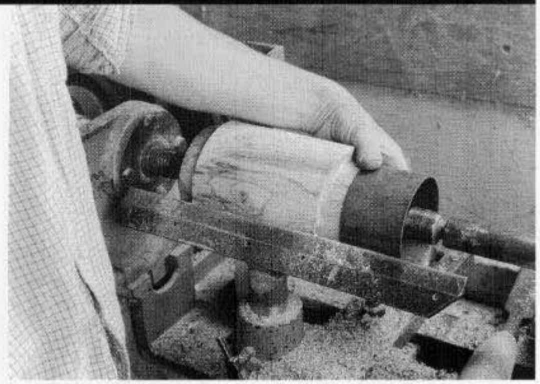


Here the diameter of the land for the front stock hoop is checked. The hoop itself is placed over the tailstock in readiness to try on to the stock. It should be a fit just capable of being driven on with a hammer when cold, the taper in the hoop will tighten it.

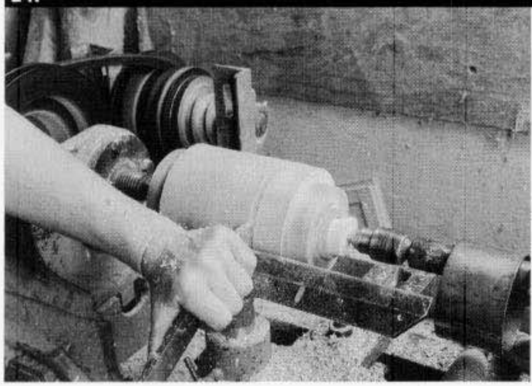
When the stock hoop lands are turned to size, the position of the spoke mortises are marked. Usually the spokes are arranged to straddle the halfway point between the inside edges of the two stock hoops – marked by measurement (Fig.11).

The spoke is positioned to straddle the mid-point described above, but the spokes are arranged in a staggered line and they must therefore have two lines (breast marks) marked, one either side of the front edge of the stock, in this case ⅜" apart (Fig.12).

The breast marks are cut into the stock with the corner of a chisel or parting tool (Fig.13). The mark for the back edge of the mortise can be made with a pencil, using the spoke itself placed against the work to arrive at the correct point.

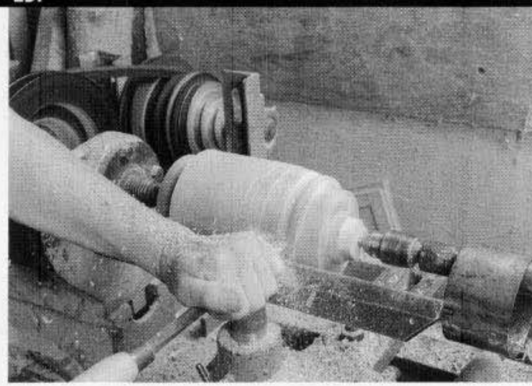
The following sequence shows the traditional English coach pattern beads being formed on a stock.

14.



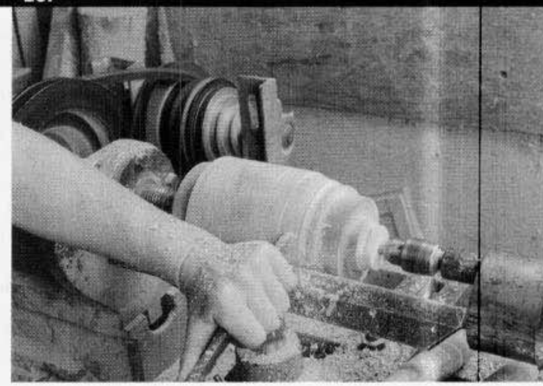
The step in front of the spokes is cut with a chisel.

15.



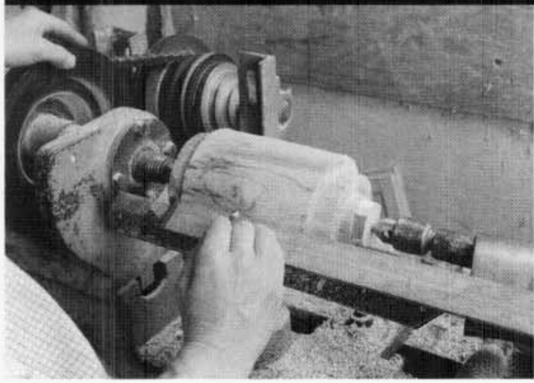
The beads are roughed out with a chisel.

16.



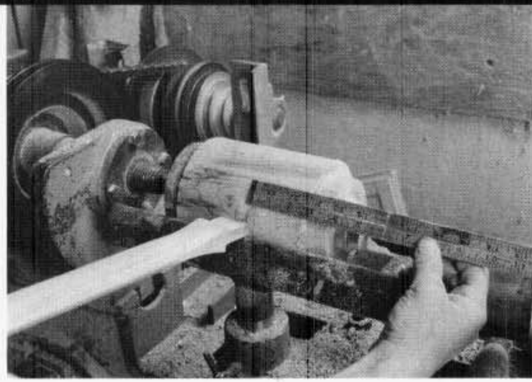
The main convex ovolo is formed with a narrow chisel.

11.



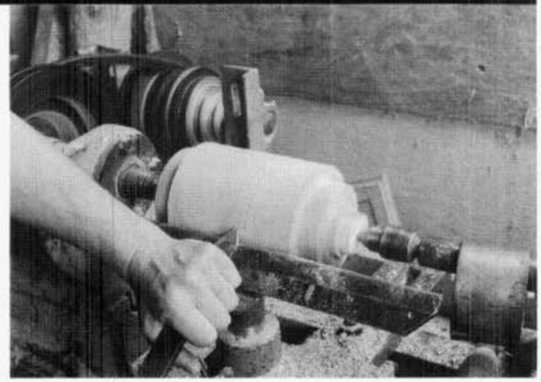
Marking position of spoke mortices.

12.



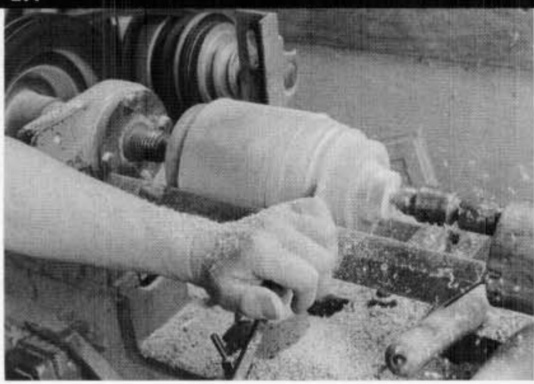
The spoke is positioned to straddle the mid-point.

13.



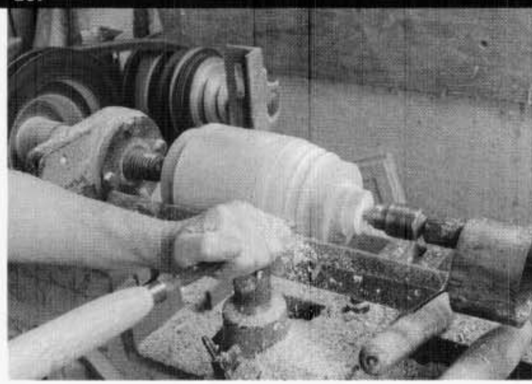
The breast marks are cut into the stock .

17.



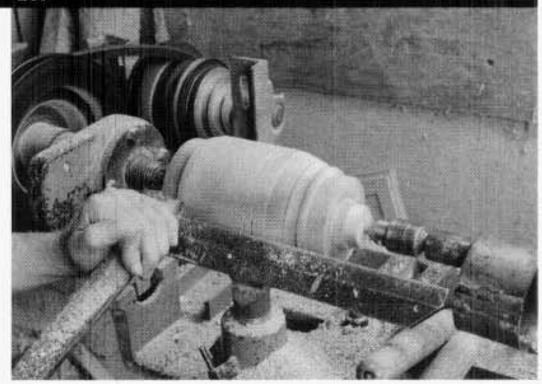
A narrow chisel forms the front bead.

18.



A specially ground scraper is the quickest way to form the cove up to the bead.

19.



The curve at the rear of the stock is formed. First make a straight cut to bevel the back of the stock and then round over the corner.

Axles

Axles for horse-drawn vehicles fall into two categories, those with tapered arms and those with parallel arms. In addition, a great many new designs have been tried and wooden ones may occasionally be seen on very early farm vehicles. The most frequent types of old axles are the following:

Cart arms

The journals are tapered, the axle box is a plain casting with two or three wings on the outside of its largest diameter. The arm is short tapering rectangular section iron and fitted one either side of a wooden axle bed. The box is fixed by a collet with a lynch pin. (Fig.20)

Drabbles

The axle is usually a continuous piece of iron, occasionally two arms set in an axle bed. The journals are tapered, a brass cap having a female thread covers the collet and lynch pin. Sometimes the box is secured by a flanged hexagon nut instead of lynch pin and collet. (Fig.21)

Collinge

The journals are parallel, the axle a continuous iron bar, the box is fixed with a collet which is held by counter threaded nuts, covered by a brass oil cap which can be recognised because it has a deep dome to accommodate these nuts. The outside, locking nut on Collinge axles is always left-hand threaded; the inner, longer nut has a larger, right-hand thread. Small vehicles such as hand-carts were occasionally fitted with a false or sham Collinge axle which has only one long nut per side; left-hand thread on the left-hand side, right-hand on the right. (Fig.22)

Mail

Similar to the Collinge, but the box is held on by a collar behind the wheelstock, fixed by three long "mail bolts" passing through the wheel-stock and through the collar. The cap is flat, since there is no need to cover the extended axle end and nuts which the Collinge type has. (Fig.23)

When lubricating these axle types, a general rule is that the tapered journals are greased and the parallel ones are oiled with gear oil, at least until there is too much wear in the axle to keep the oil in, after which grease is used as a last resort. The caps and boxes are arranged with oil reservoirs, the axles are provided with leather washers which are designed to retain the oil. All types have the large end fitted at the back of the wheel-stock. All are fixed flush with the back of the stock except the Collinge. This protrudes from the

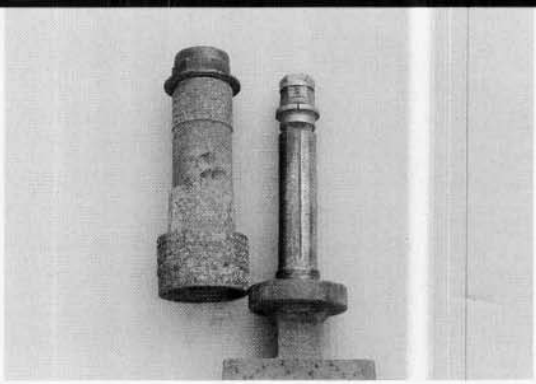
20.

Cart Arms.

21.

Drabbles, axle.

22.



Collinge axle.

back because the collar of the axle is machined to over-hang the end of the box, in order to exclude dirt from the bearing. The form and fitting of these axle boxes has some bearing on the way in which the stock hoops are arranged. Collinge axles require that the front stock hoop should be wide enough to cover the brass cap. The stock hoop at the rear is normally much narrower, usually between ¾" and 1" wide on a light carriage wheel; it fits flush with the rear turned face of the wheelstock. The mail axle does not need quite such a wide front hoop since the cap does not have the deep dome required to cover the nuts and collet. The hoop will still be made wide enough to cover the oil cap. The rear hoop, however, is usually made wide enough to cover the loose collar through which the mail bolts pass and sometimes enough to cover the nuts on the end of those bolts as well.

23.

Mail axle.

Stock hoops

Stock hoops are bent in several ways, for example a strip of steel may be wrapped around a large diameter steel pipe after one end is welded to it. Alternatively, a strip may be knocked into a curve using a hammer and striking between two firm edges, perhaps a channel in a swage-block. Another way is to bend the steel in the open jaws of a vice or by using a wrench.

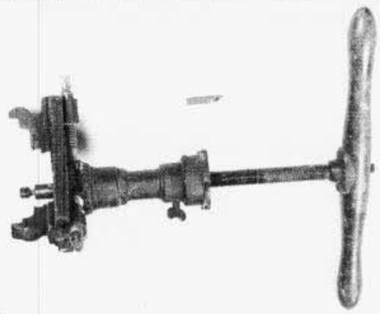
After welding, the hoops may be rounded up around a mandrel. The mandrel will also enable the inside to be hammered to a taper.

A slight bell-mouth will help them to be driven on to the stock. Stock hoops are made to fit tightly and are usually driven on cold, since if they are heated and they char the wood, they will be loose. The front hoops of carriage wheels were secured by two or three clout nails. If these are not available countersunk screws are a good alternative.

Boxing

The box needs to be fixed firmly into the stock. The hole is bored for the box with a boxing engine or, failing that, with chisels and gouges. A pilot hole will need to be bored first and the whole operation may be done to the stock before the spokes are driven. It is advisable to cut the mortices in the stock first so that the bottoms of the mortices do not tear splinters out as they burst into the hole. The stock is easier to handle with no spokes in it if it can be held in the jaws of a self-centring boxing engine although the boxing engine may also be used on the complete wheel. If other tools are used, such as the older type blacksmith-made boxing engines or perhaps boxing gouges, the job will proceed better and be found to be more controllable if the wheel is assembled first.

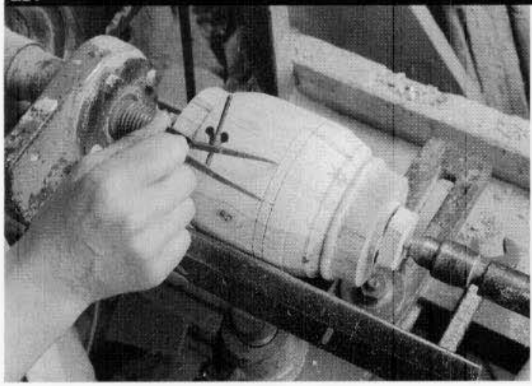
24.



Self-centring boxing engine.

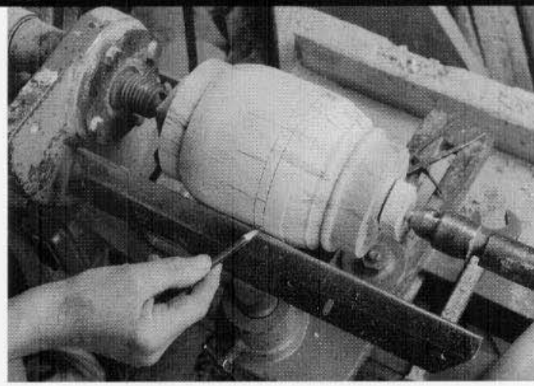
Marking out the spoke mortices

25.



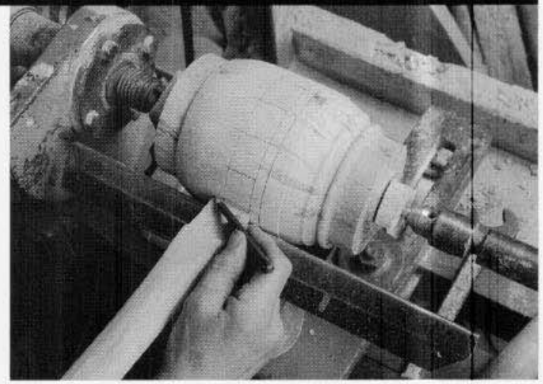
Spacings.

26.



Stepped spacings.

27.



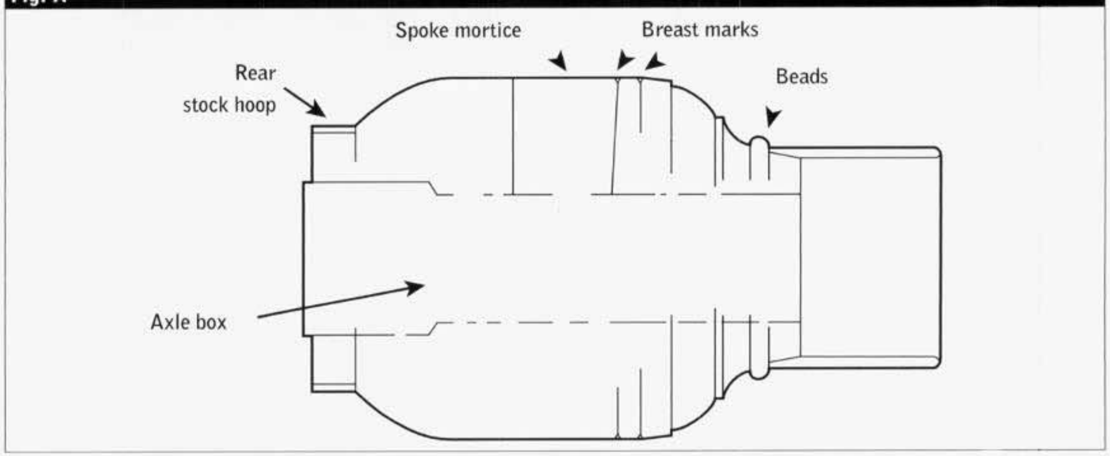
The back of the mortices being marked.

The spacings for the mortices are stepped out with dividers, adjusted to the precise spacing, i.e. when the dividers exactly meet the starting mark after they have stepped the right number of marks around the stock. It is easy to make a mistake with the numbers of mortices and a wise precaution to write numbers beside the marks.

Here the stepped spacings are each marked with a line along the axis of the stock. The tool rest on the lathe helps keep each line straight. If a morticing machine is to be used, one side only of the mortice will need to be marked.

Two pencil lines are drawn on the stock for the back of the mortices. If a spoke is available at this stage, offer it up as shown to give the position for the mark. The mortice should, for a wheel of this weight, be $\frac{1}{16}$" less in width than the tenon.

Fig. A

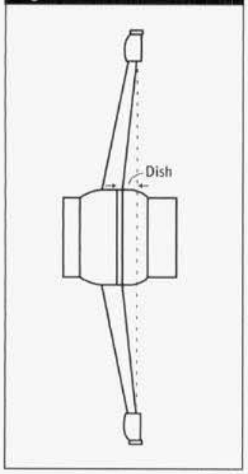


Sketch showing cross-section of a typical English carriage wheel stock. Note internal taper in the stock hoops and the angles of the morticers.

"Dish"

In traditional English wheelwork and some of the neighbouring Continental countries, the spokes are set at an angle to the stock giving a shallow conical form to the wheel which is referred to as "dish". In cutting the mortices and tenon shoulders allowance must be made for this angle. The amount of dish is usually expressed as a measurement derived from a line through the faces of the spokes at the point where they enter the felloes, taken back to the front breast mark. The sketch B explains this. Note the two breast marks used in English work. The reasons, practical and theoretical, for building "dish" into a wheel are discussed in several other works and need not concern us here.

Fig. B



The rear cut of the mortice can, in a wheel with an appreciable amount of dish, be made at right angles to the axis of the wheel, the face runs in line with the face of the spoke and the mortice therefore tapers in its depth.

Spoke mortices

The joints between spoke and stock are of paramount importance to the strength and true running of the wheel. The spokes are driven tight into the wheel, the force required for this varying with the weight of construction of the wheel. The mortices and tenons taper in the front to back way (see Figs A and C) and except in very ancient work and heavy wagon work they are parallel sided. The parallel sides are made to be a tight interference fit, increasing greatly as the wheel weight increases until a tenon 1" x 4", 4 inches long would be perhaps $\frac{1}{16}$" larger than its mortice. Whatever the size of the spoke it must be driven into its mortice tightly. A useful rule is to always drive it so that it begins to resist being driven when about one-third of its length remains to go into the mortice.

Fig. C

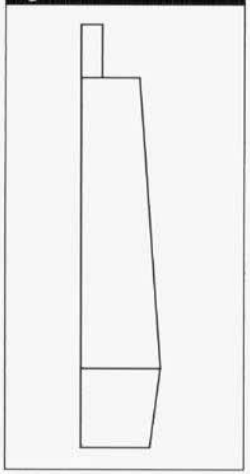
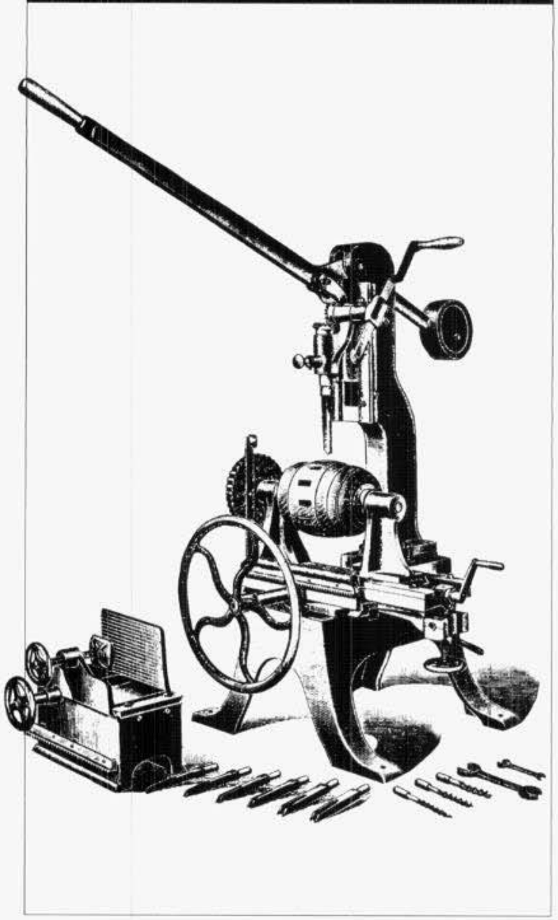


Fig. D.

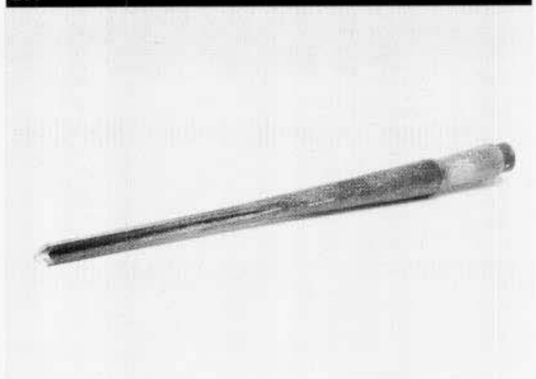


Stock morticing machine.

28.

Morticing by hand (see text).

29.



Bruzz.

30.

Whalebone gauge.

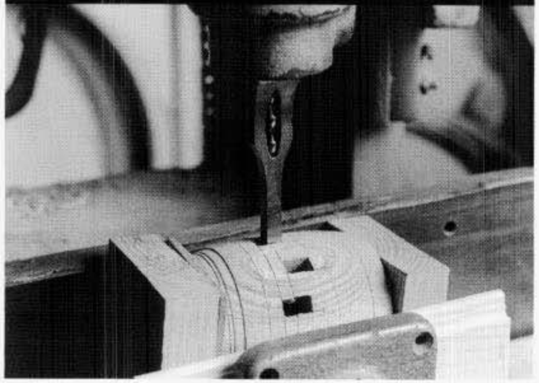
Morticing the stock

In morticing by hand, the bulk of the mortice is taken out in the usual way with an auger followed by chisel and mallet. To the right in this photograph (Fig.28) a stock is shown which has had its mortice holes started with an auger. The faces and backs of the mortices are cut with the aid of the bruzz, shown in use here.

The vee shaped bruzz cuts the corners of the mortice and the length of its blade helps in ensuring that the cut is made at the precise angle. The whale-bone gauge is used to determine and indicate this angle.

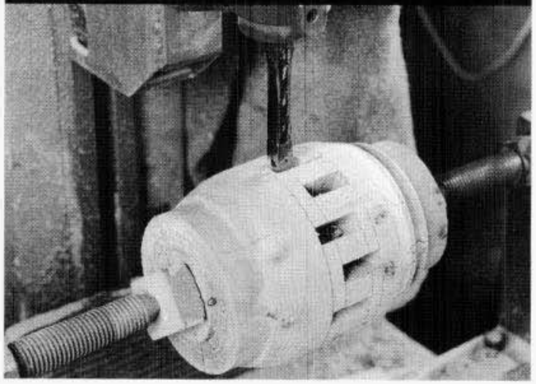
The gauge is a wooden bar bored with a series of holes through which a short piece of thin spring steel is wedged (in former times a piece of whalebone from the wheelwright's wife's corset was used). The bar is fixed at the face of the wheelstock, with a screw or a bolt through the stock, and stands on the turned end of the stock at an exact right angle to the axis of the stock. The spring is fixed at the same distance from the stock as the inside of the felloes. It projects from the bar to a point calculated to give the right amount of dish. Measure from the **front** breast mark to the bar and subtract the amount of dish from that measurement to obtain this distance.

31.



A jig used in a morticing machine.

32.



A morticing machine with a centring cradle for wheelstocks.

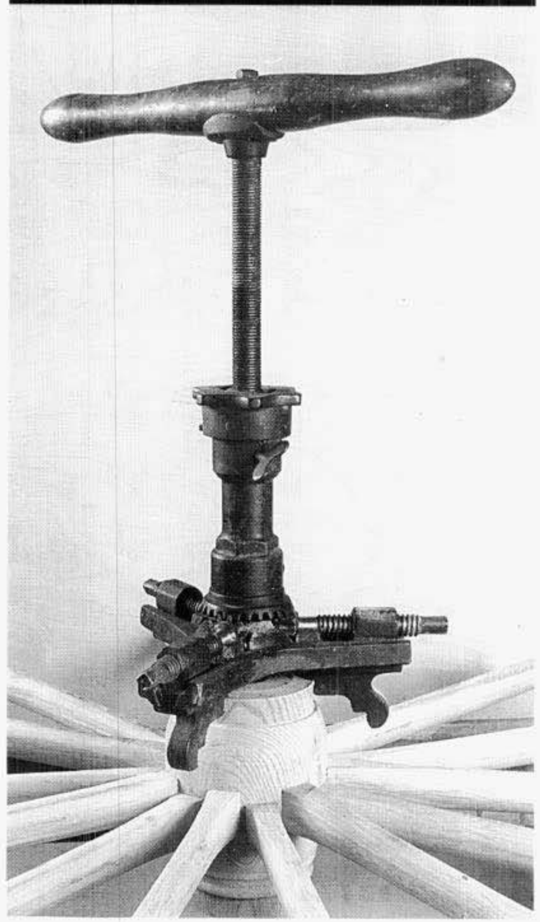
A morticing machine can be used to cut mortices efficiently and accurately. Most morticers will take stocks up to 5 or 6 inches diameter on their tables. The photograph (Fig.31) shows a small stock being morticed using a 3-sided wooden jig which both holds it parallel to the side movement of the table and enables it to be set at a pre-determined angle so that the faces can be cut to the correct angle. The stock will be re-set in the jig to cut the backs of the mortices at the correct angle (usually at right angles to the wheel's axis for the back cut).

Here a steel jig is used. Such a jig can be made to tilt to the angles required (Fig.32).

Morticing machines were once made which had such tilting mechanisms and in-built dividing heads to set out the numbers of mortices (Fig.D).

It is often convenient to cut the hole for the box next, the stock at this stage is easily handled and can be mounted in the jaws of a chuck of self-centring boxing engine (Fig.33).

33.



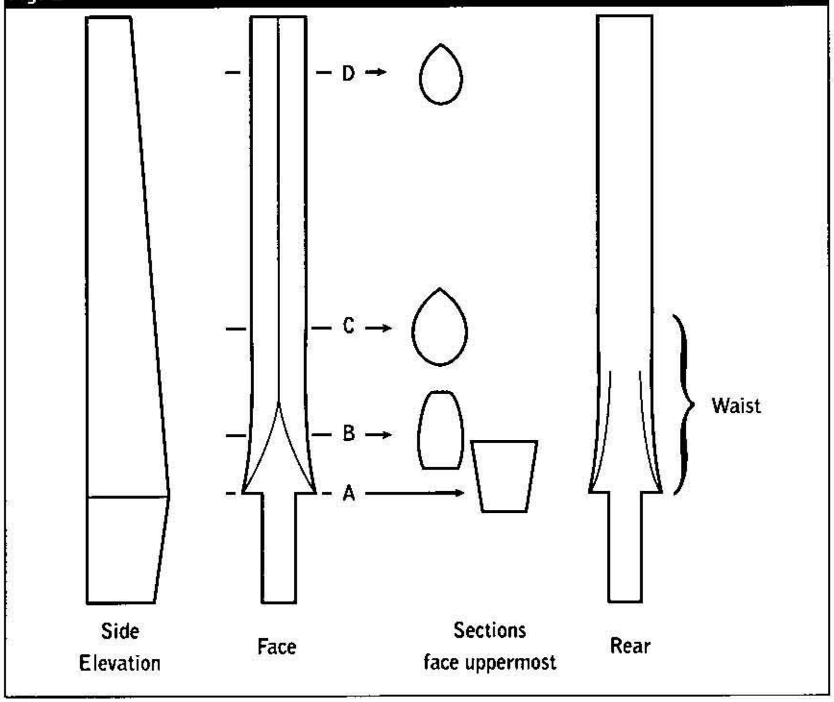
Self-centring boxing engine in use.

Spokes

Spokes are required to withstand compression and bending stresses. In former times the material for them was cleft from straight grained oak. The wedge shaped cross-section which this produced influenced the shape which spokes were made. The eventual standard pattern of English spoke is what concerns us here and is shown in Fig E.

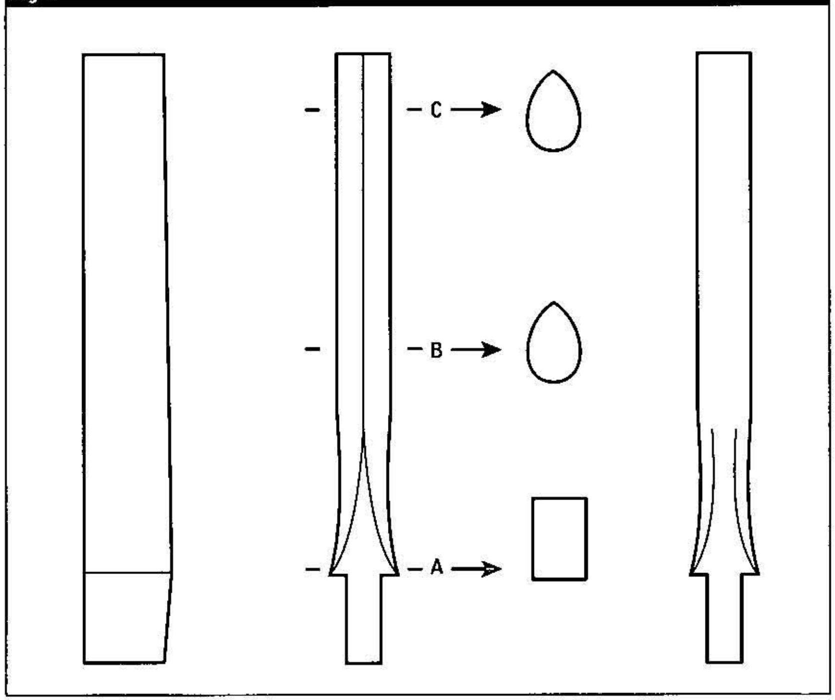
More recent work used and continues to use machine made spokes, most usually made by copying lathes, although the use of a spindle moulder to make spokes will be described here. In machine made spokes, the use of cleft timber is not practical, as sawn plank will be used and the spokes will be sawn from that. The taper in the length of the spoke seen in the side elevation is generally omitted from machine made spokes and the sides of the tenon shoulders, seen in section A, are usually left parallel.

Fig. E



Hand-made English coach pattern spoke.

Fig. F



Machine made English coach pattern spoke.

Preparing the unshaped spoke "blanks"

If cleft spoke blanks are to be used, the workman will need to start with green timber, as even oak which splits well will split (or "cleave") most easily when it is fresh sawn. Next, a drying process will be needed. The rule "one year for every inch of thickness and one for the tree" will give more time than is necessary for cleft oak spoke blanks, since timber in a small scantling will dry much more quickly than a wide through and through board. Nevertheless, it can be seen that this is a lengthy process and will require considerable organisation and time even if a kiln is to be used. The advantages in strength which cleft oak has over sawn oak have been frequently discussed in books. However, it can be appreciated that, for reasons of stock control, availability of dry timber from merchants and for the ease and even safety of machining to size, sawn plank is a great deal more practical in use. Whether the shaping of the spokes will be carried out with machinery or by hand methods, the preparation of the spokes begins in the same way if sawn spokes are being produced.

The sizes to which the spokes must be finished will have been determined, and the rectangular blanks are sawn and planed accurately to size. It is not strictly necessary to plane the sides, especially when using tungsten carbide tipped circular saws, but the front and back of the spoke should be planed. The tenons are cut next, and a number of machine methods are possible, some are:

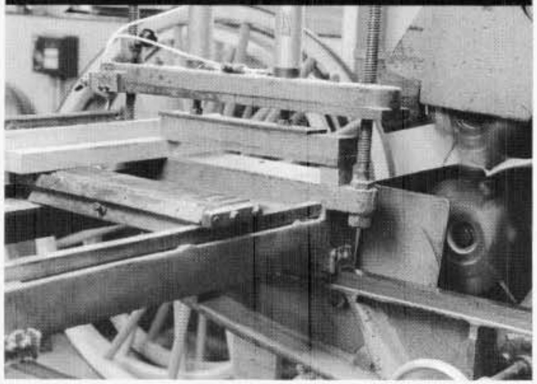
(a) Dado cutters used with a cross-cut saw. Here it is worth noting that since the tenon shoulders need to be cut at a small angle and it is difficult to set up a cross-cut saw to do this, some extra work will need to be done to the tenon shoulders if this method is used.

(b) The bandsaw can help to cut the sides of a very small number of spokes but it is necessary to mark each tenon carefully and use the saw with great accuracy. The tenon shoulders are best marked individually and cut by hand.

(c) With a tenoner it is possible to cut spoke tenons fast and accurately, and to set the machine to give an angled shoulder.

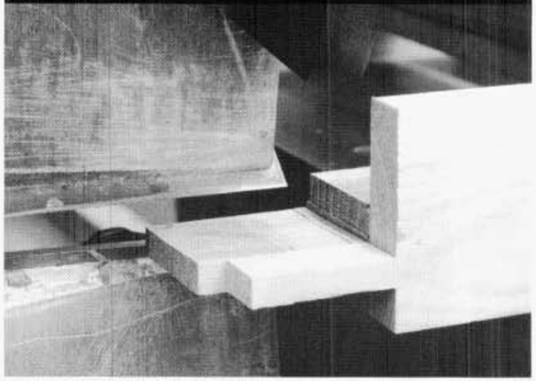
The tenons need to be a tight, but not splitting, fit in the mortises.

34.



A tenoner in use. The spoke blank is seen clamped in the carriage. The fence on the carriage is set to cut the tenon shoulders at an angle to suit the dish of the wheel.

35.



Here the tenon has been cut and the guards have been raised to show the cutter blocks.

Making spokes by hand methods

The first problem to address is that of holding the spoke blank while working on it. A spoke fiddle may be used, this will be clamped in a vice or horse. A second possible method is to grip the spoke in a large sash cramp. The back or bar of the cramp will need to be secured and then the spoke can be worked on. Perhaps the simplest way is to grip the spoke in a post vice. Some support may be needed for the end not in the vice, but with practice the workman should find that he can spare a hand for this or prop it up with his chest.

Machine made spokes (spindles)

When the spokes have been brought to their final shape they will need finishing. If there are any rough areas left from the use of the rasp a bastard-cut file can be used to prepare the spokes for sanding. Once sanded the spokes can be driven into the stock.

Driving the spokes

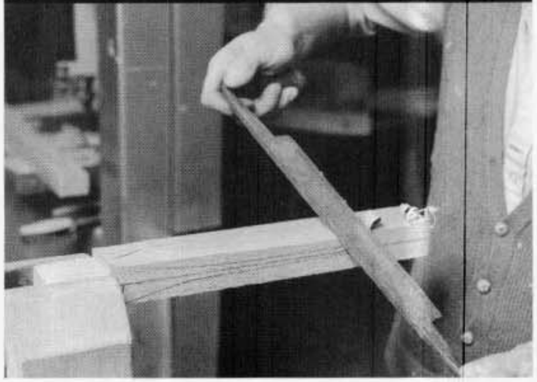
The stock has been carefully prepared for the spokes with mortises of a size calculated to give the right tightness (see pages 9 and 16) and cut at the precise angle to let the spokes lie in line to give the right amount of dish. It is frequently possible to save time by cutting the hole for the box through the stock before the spokes are driven.

The stock hoops may be fitted before the spokes are driven. For a small wheel - with a stock less than, say, 6½" diameter - the spokes are not driven so tightly that the hoops are

36.

The spoke fiddle. The spoke is secured between the points. The spoke is marked out with a centre line down the face side, and lines on the edges of the face.

37.

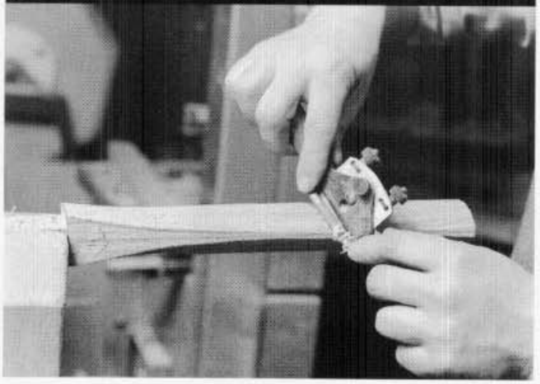


A drawknife in use. The first rough shaping of the spoke is most quickly achieved with a draw-knife. With practice, a draw-knife and plane can be used for all the shaping work on timber with a straight grain. Cut out the waist first, then shape the shank of the spoke.

necessary to discourage the stock from splitting. Small stocks can be gripped in an ordinary joiner's vice where the spokes are driven and if the hoops are not fitted this is easier to do. Another advantage in keeping the hoops off at this stage is that the whalebone gauge can be more easily attached directly to the turned face of the stock to ensure that the spokes lie true. There is also some possibility that if the whalebone gauge is run across the faces of the front stock hoop the gauge may not stand perfectly true. For stocks bigger than this the spokes will need to be tighter, in proportion to the dimensions of the tenons. The shocks given to the stock in driving larger spokes as well as the tightness of their fit make it advisable to fit the stock hoops before the spokes, as these shocks increase the splitting effect of the tight tenons.

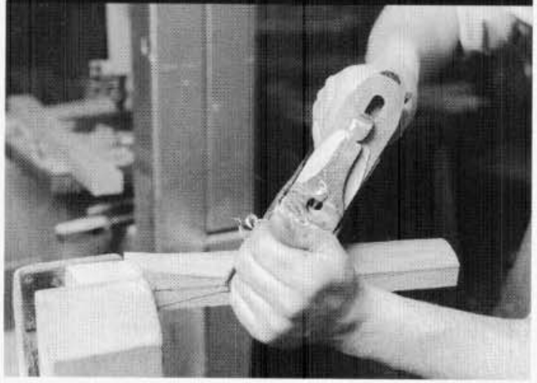
The whalebone gauge must next be fitted to the face of the stock. It is, as already mentioned, best fixed onto the turned face directly. If this is impossible packing spacers can be used, made of discs of planed timber or plywood bored for the screw or bolt which secures the gauge. Alternatively, the bar of the gauge may be fixed across the front stock hoop, having taken care to ensure that the bar stands at right angles to the axis of the stock. In this case this is usually ensured by the stock hoop being set accurately down to the front bead of the stock. The spring of the gauge is fixed at the point where the spoke meets the felloe. A measurement is taken from

38.



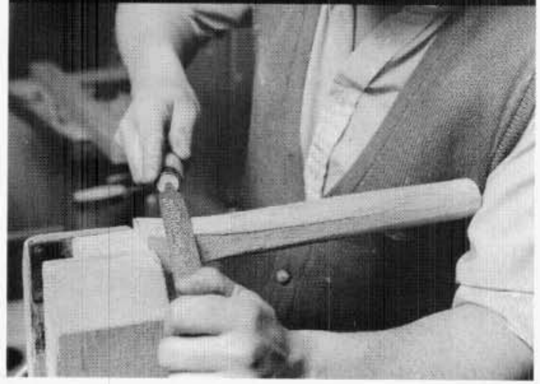
A spokeshave is less useful in shaping spokes than its name suggests, except for small spokes, but it can be used to give a fairly fine finish. A curved soled Spokeshave is needed when working in the waist of the spoke.

39.



A plane is used to remove ripples which may be left by the draw-knife. When working towards the shoulder it will need to be held at an angle as shown.

40.



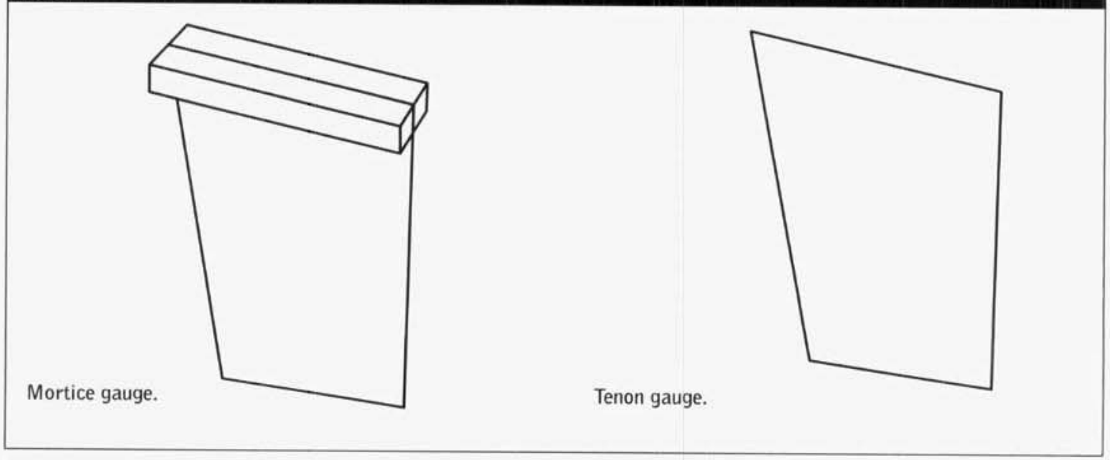
A rasp in use to shape the curves at the waist, this requires less practice than the draw-knife to give the required subtle shapes.

the **front** breast mark to the bar of the gauge, the amount of dish is then subtracted from it. The resulting measurement gives the length of spring pointer which is adjusted to protrude from the gauge.

The spokes are driven so that their faces run in line with the angle at which the front of the mortise is cut and this is checked with the whalebone gauge.

In order to achieve this, the back of the spoke tenon is trimmed off so that the spoke fits tightly into the already tapered mortise.
A mortise gauge or a small bevel may be used to check that the angle is correct. The bevel or the same gauge would also have been used in cutting the mortises by hand.

Fig. G



The tenon gauge matches the mortice gauge, any thin material will do to make it from, such as tin, cardboard, etc.

To trim the back of the spoke tenon, a plane or chisel may be chosen, but a draw-knife will enable the workman to easily judge how much material is being removed and when, as is always the case with spokes, many identical components are receiving the same treatment, it soon becomes a simple matter to accurately judge by eye that the spoke is being trimmed correctly. When trimming the first one or two spokes, the material is removed a little at a time always retaining the correct angle, the spoke is then tried in the mortise. The spoke is driven home with a hammer (or mallet or the poll of an axe) of a weight proportioned to its thickness. An approximate rule of thumb gives a 1" spoke a 1lb hammer and a 3" spoke a 5lb hammer, applied with a moderate though not feeble force. The correct degree of tightness is achieved when the spoke is felt to begin to tighten into its mortise with about ⅓ of the length of the tenon still to drive in.

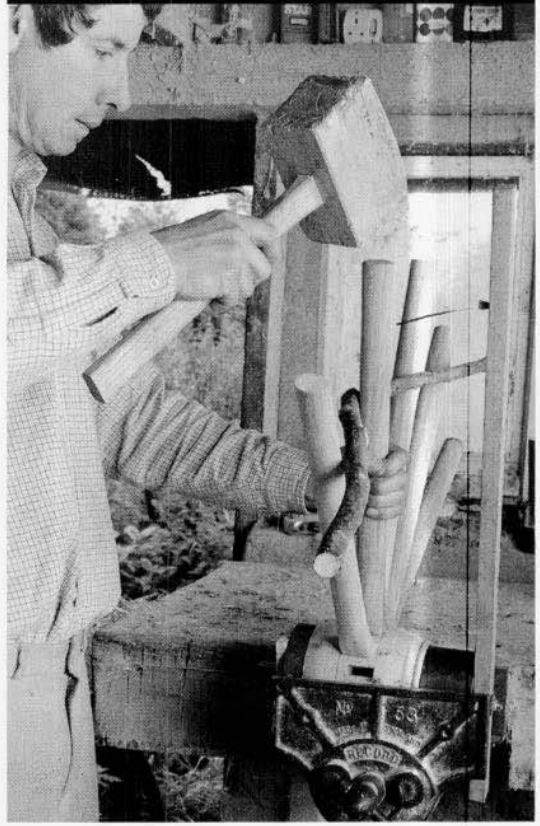
The whalebone gauge is used to check that each blow is driving the spoke at the correct angle.

If the spoke proves to be setting in at the wrong angle, it may be moved a little with the spoke bridle, or in very light wheels with pressure from a hand. The bridle is a crooked stick, preferably of ash, or it can be a springy length of straight ash. The bridle requires two adjacent spokes to be driven or nearly to be driven home and from these it can get enough leverage to push the spoke being driven.

41.

The whalebone gauge in use, here a light wheel is held in a joiner's vice.

42.



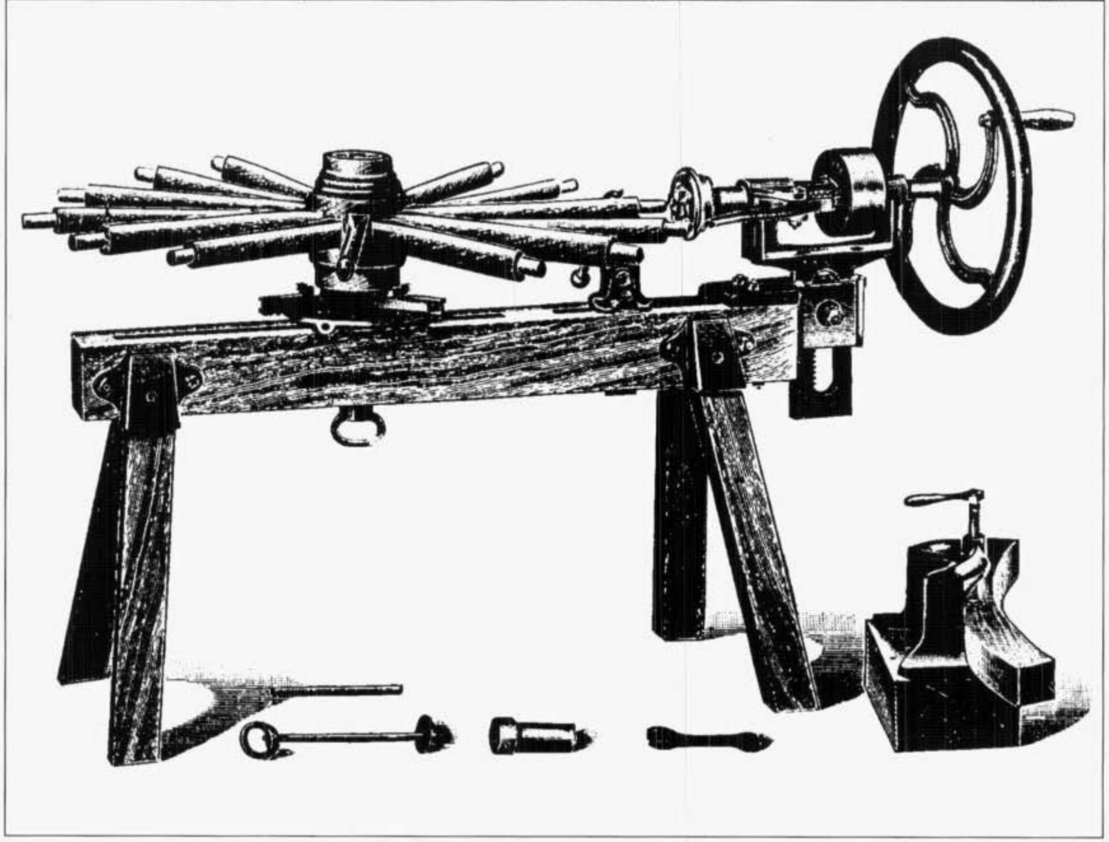
The spoke bridle in use, here it is pulling the spoke which is being driven forward.

The spoke angle can only be corrected as it is being driven, once housed in its mortise it cannot be altered.

At this stage the job is called a "wheel of stock and spokes" or in some old books a "speech". The next operation is to cut the tongues (or tangs) onto the spoke ends. The tongues which we shall describe are round tongues cut with a hollow auger. It is possible to cut round tongues with hand tools such as a tenon saw and chisels. The size and roundness must be ensured by the use of either a simple gauge with a hole in it or a rounder plane. A simple gauge is necessary to keep the shoulders of the tongue (these shoulders are called the "nock") parallel to the axis of the wheel. Square tongues are marked and cut in a similar way by hand methods. A hollow auger may be used in a hand brace, with a blunt point cut, to start it, on the end of the spoke by the use of a draw-knife or conical spoke trimmer.

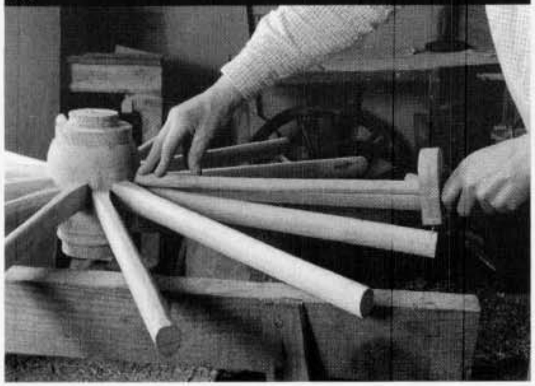
A borer is used with the wheel positioned so that the spoke is clamped rigidly to be cut with the tongue at right angles to the axis. The mandrel of the borer has a chuck to hold the hollow auger and rotates in bearings which are arranged to rise and fall for adjustment and lock in position when adjusted to the correct height. The mandrel can be advanced through the bearings with the hand lever.

Fig. H



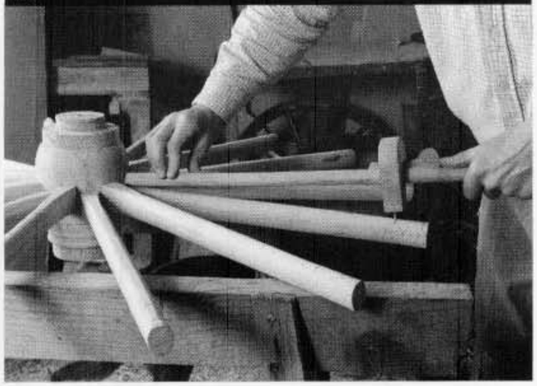
The horizontal borer.

43.



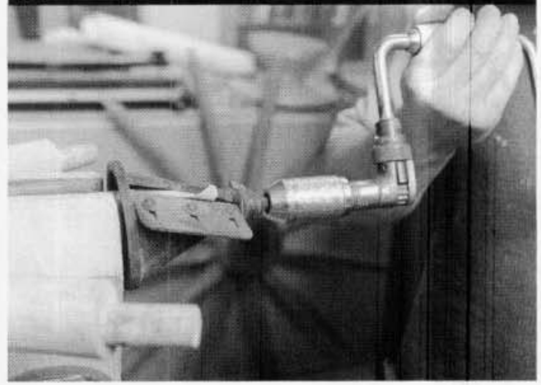
The spoke trammel in use.

44.



The nocks being marked.

45.



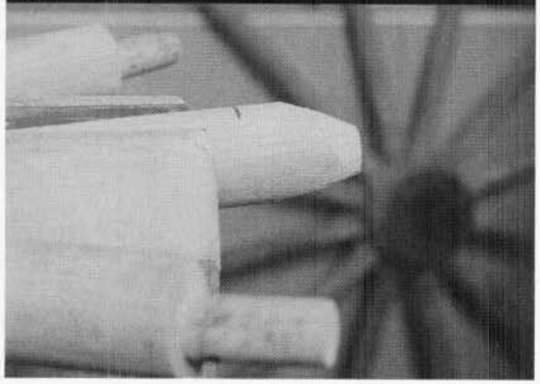
The spoke trimmer in use.

The spoke trammel (or "length gauge") marks the extreme length of the spoke. This point is arranged to fall ⅛" short of the outside diameter of the wheel "in the wood", ie the diameter before the tyre is put on. This clearance will allow the tyre to press the felloe down onto the nock of the spoke without fouling the end of the tongue.

The nocks of the spokes are marked. This is the inside diameter of the felloes and this mark is used to limit the length of the tongue.

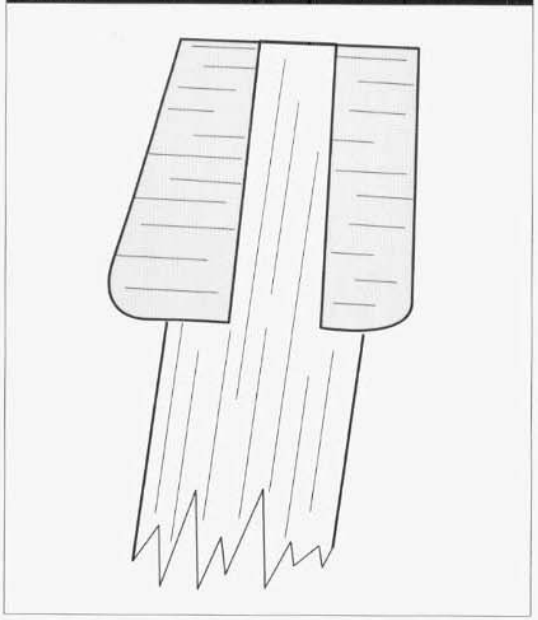
The spoke trimmer is used to prepare the end of the spoke for the hollow auger. If the hollow auger is rotating fast it may be possible to start the auger cutting cleanly without trimming the end of the spoke, but this trimmer eases the work. A draw-knife may be used for this job. Note that the tongue is positioned more to the face than the middle of the spoke.

46.



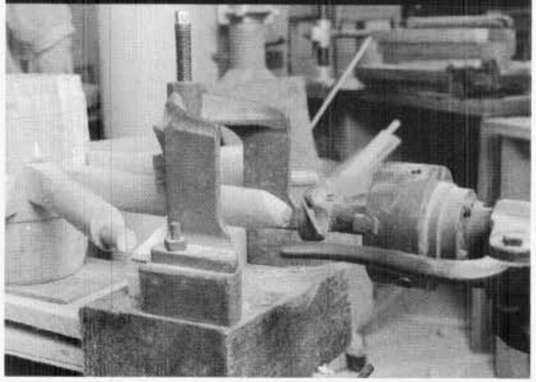
Showing a spoke prepared by the trimmer, the cut is arranged towards the face of the spoke.

Fig. I



Cross section of wheel at spoke junction with felloe, showing the bevel of the felloe. This bevel is the reason for arranging the tongue towards the face of the wheel.

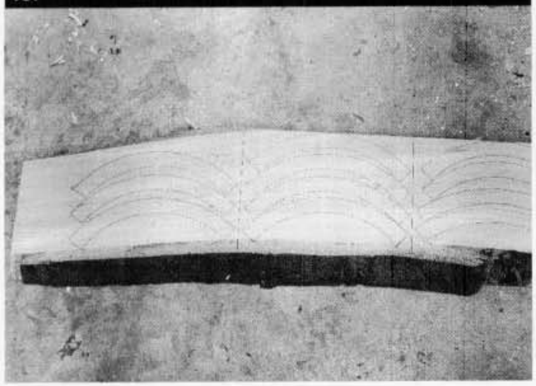
47.



A wheel arranged in the borer for the tongue to be cut.

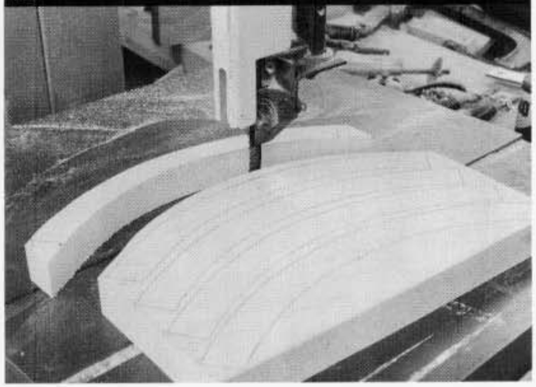
Felloes

48.



A plank marked out to cut felloes.

49.



Sawing the felloes.

50.

Cleaning up the belly of a felloe with a compass plane.

Dry ash is selected for the felloes which are marked from a pattern cut from hardboard or thin plywood. The sawing may be more accurately square from the face of the timber if planed first and cut with the planed face on the saw table or, if the plank will finish thick enough, both faces can be planed through the thicknesser before bandsawing.

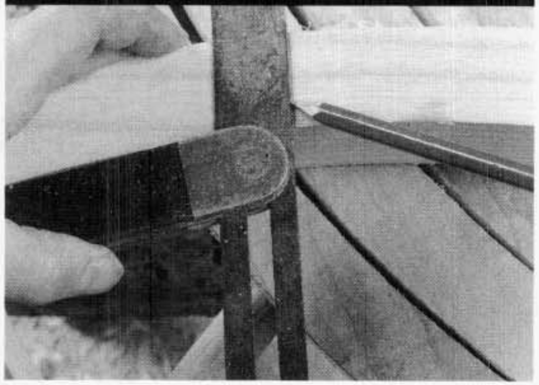
When sawn the insides, the "bellies" of the felloes need to be planed to remove the sawmarks (the cutting should be accurate enough for no more cleaning up than this to be necessary) using a compass plane. An alternative to the compass plane, but one which needs careful handling, is an angle-head disc sander. Yet another method is to use a pattern or jig with the spindle moulder to clean the felloe bellies.

The sliding bevel is used next, set as shown, to strike a radial line on the face of the felloe when it is held to the belly of the felloe.

The wheel is placed face down on the wheel stool and one felloe is marked with the bevel for a cut to be made midway between alternate pairs of spokes.

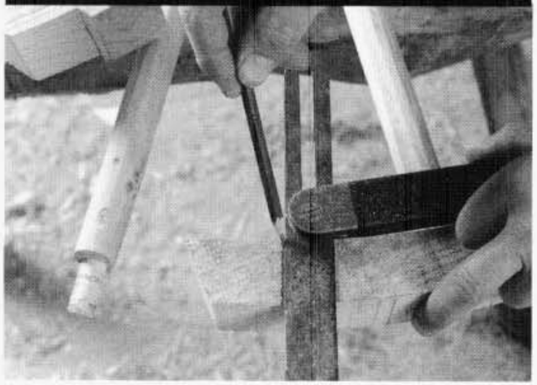
Next, one end of a second felloe is marked, cut and that felloe is placed against the first, butting the trimmed ends midway between two spokes. The end of the second felloe is marked and trimmed midway between two spokes. This is repeated around the wheel until only one felloe remains to be cut in.

51.



The sliding bevel being set to strike a radial line on the felloe.

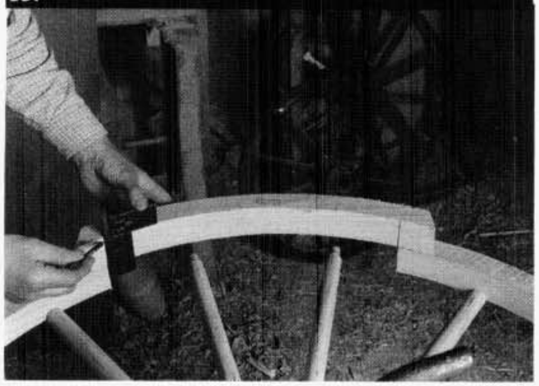
52.



Marking the end to cut off from the felloe.

The last felloe is laid exactly on top of the adjacent felloes and a line is struck with a square as shown in Fig.53 at the point where adjacent felloes end. The bevel is used as before to mark the point at which the felloe is to be trimmed. At this point the amount of gap between the felloes must be considered. It should be possible to save one operation later on if the felloes are cut precisely now.

53.

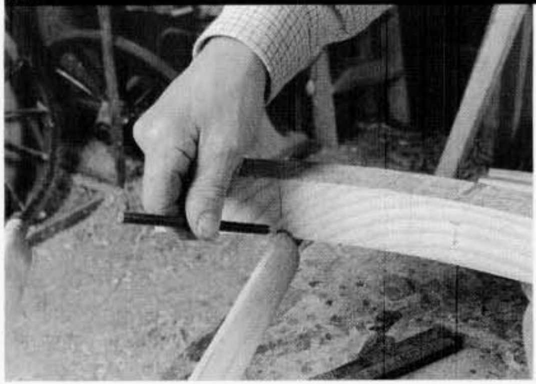


Marking the last felloe.

"Joint"

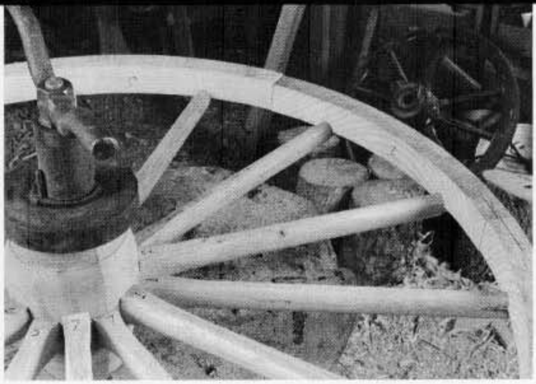
When a wheel is being built, its felloes are arranged with small gaps between them. This is known as "joint". Without this provision the tyre, when it fits, would draw all the felloes together tight without pressing them onto the nocks of the spokes, and consequently tightening them in the stock and maintaining a degree of pressure on all the spokes.
If the wheel has this condition whereby the felloes are tight - without tightening the spokes it is said to be "felloe-bound". When the felloes are fitted and wedged to the spoke tongues, the amount of gap may be judged by driving a wedge into the joint between two felloes, this with a few light hammer blows on the felloe-soles to jar them will push all the other joints together. On most new carriage wheels this gap will vary between ⅛" to ⅜", proportional to the size of the spokes. Too big a gap will enable the tyre to tighten to a point where it may bend the spokes unduly. When re-tyring an old wheel the joint gap will usually be less because the gap between felloe and spoke and between spoke and stock have been tightened once (or more) by the tyre.

54.



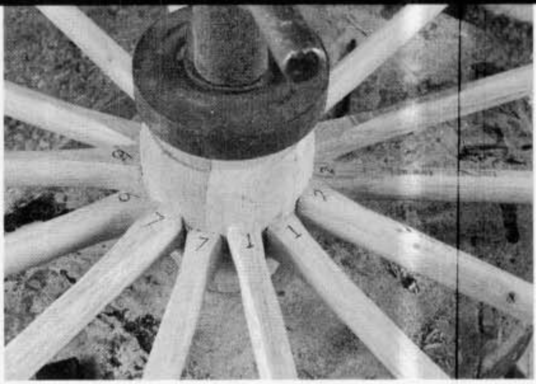
Marking position of tongue.

55.



Here the felloes are numbered, note the line across the felloe-joint.

56.



The felloe numbers transferred to the spokes.

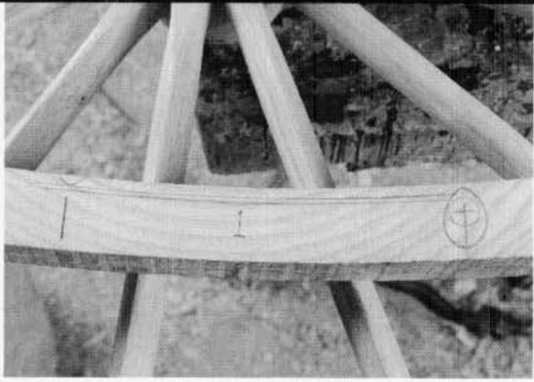
Marking the felloes for the borer

The felloes are arranged around the wheel, resting on the back of the spoke tongues. A line is drawn as shown (Fig.54) above each spoke centre to serve as the centre line of the hole bored to receive the tongue.

Each felloe is numbered and at least the first two numbers are repeated on the pairs of spokes to which each of these two felloes is fixed. This ensures that the felloes, when returned to the wheel after boring, can be fitted in the positions which they had while being marked. Next a line is struck across the joint between each pair of adjacent felloes, this will give the position and angle of the dowel (Fig.55).

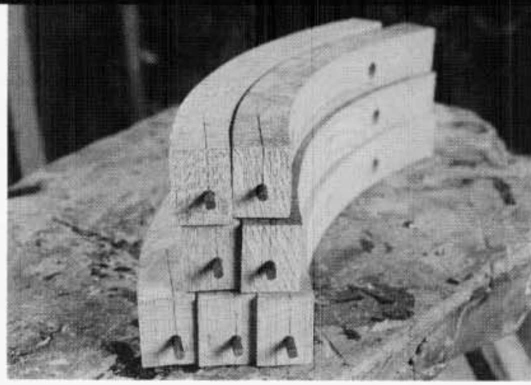
The inside (the belly) of the felloe is numbered and the positions of the holes for the spokes are marked with vertical lines. It is shown face side up, and the position of the spoke is arranged to place the face of the spoke about ⅛" back from the face of the felloe. In setting the height of the borer, between ⅛" and ¼" of felloe is therefore allowed to protrude in front of the face of the spoke and a small allowance in addition to that to permit some cleaning up of the face surface with a plane. This has been marked out on the right in the form of a section through the tongue and through the spoke end (Fig.57).

57.



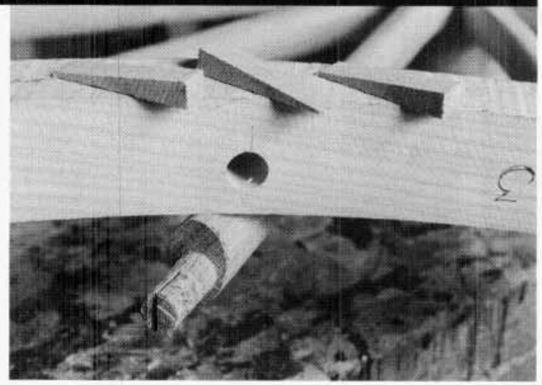
The inside (the belly) of the felloe.

58.



The felloes, bored ready for fitting to a wheel.

59.



Another view of a felloe bored ready to fit. The wedges are cut in readiness for fixing into the spoke tongue after the felloe is fitted, the tongue is cut with a saw to receive the wedge.

On the left is a mark made by inverting the felloe, laying it on the front side of the spoke tongue and drawing around the front of the spoke. Doing this gives a quick indication of how far back on the felloe the front edge of the hole for the spoke tongue must be, the ⅛" must be added to the mark and the hole centre will, of course, be half the diameter of the hole further back than this mark.

The reason for this has been treated in the sectional fig on page 19, the forward position of the spoke tongue will enable the felloes of the wheel to be bevelled from the back to reduce their width at the hole, without cutting into the spoke tongues.

Once they are cut to fit around the wheel, marked for their holes and numbered, the felloes are ready to be bored with holes for spoke tongues and dowels. The borer used earlier for cutting the spoke tongues (page 19) is the best machine for this job. It produces a quick, accurate result with no need for more marking out than has already been described. The holes are always bored parallel with the surface of the work piece on such a machine and the height is set at the start and remains the same for every hole made. The tongues and the dowels are most conveniently arranged at the same hole centre height and so the machine needs no re-setting. The dowels may be wooden, in which case they are made of oak by the use of a dowel plate.

Wooden dowels are made to about half the diameter of the tongues of the wheel. Steel dowels are frequently used and have the advantage that they are not cut through by a saw if it is used to cut the joints between felloes to fit them together perfectly. In a light trap wheel these would be ¼" or so in diameter arranged so that they have about 1" of length entered into each felloe (wooden ones are usually longer).

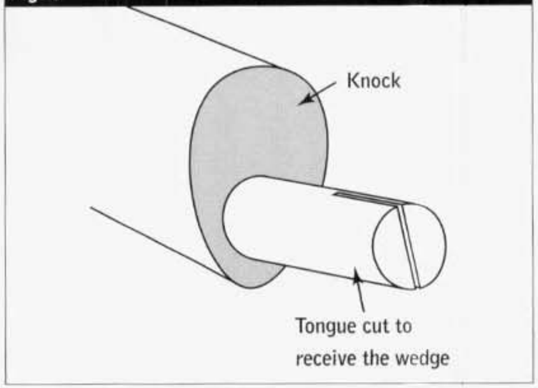
60.

Here the spoke dog is seen in use.

61.

The wheelwright fits each felloe to the spokes.

Fig. J



The tongue or tang cut on the end of a spoke.

The function of the spoke dog is to pull together a pair of spokes so that the ends of the spoke tongues may enter the holes from the inside of the felloe.

The wheelwright fits each felloe to the spokes, in the sequence of their numbering, and enters the dowels into their pre-bored holes as he does so. He walks around the wheel, driving the felloes home onto the knocks of the spokes. Then the wedges are fitted. He continues to circle the wheel, giving a light tap to drive the wedge in, and a sharper one to drive the felloe on once the wedge is gripping, until all the felloes are tightly fitted.

Dressing the felloes

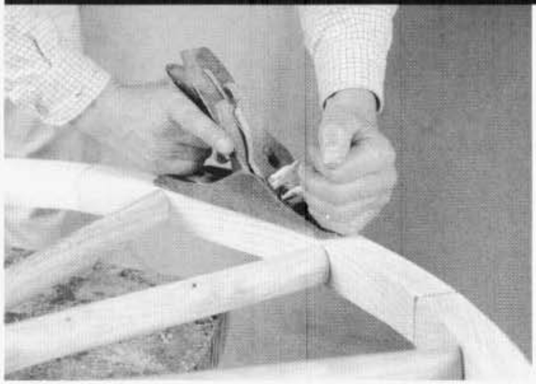
The next sequence of operations is to plane those three faces of the felloes which can be touched with a plane.

The wheel, face up, is fixed on the wheel stool and the face side of the felloes is planed, so that all their faces lie flat and true with one another. Some wheels may require a bevel to be planed around the face side, this is marked off on the sole of the felloe and planed next.

The sole is marked with a marking gauge or pencil gauge, for the bevel which is to be taken from the back of the felloes.

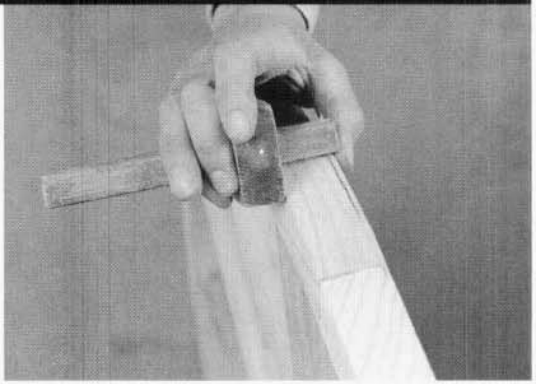
The wheel is clamped, face down, on the wheel stool and planed on the back, down to the line just marked. A power plane may help to take the bulk of the material off.

62.



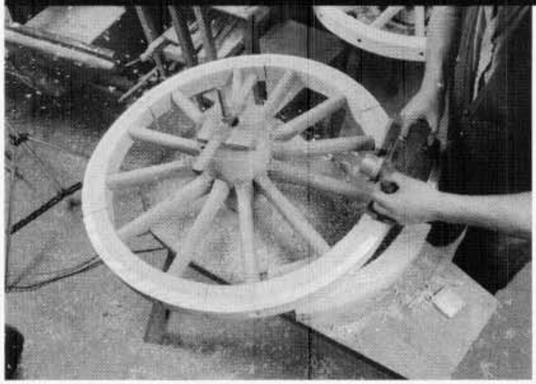
The face side of the felloes is planed, so that all their faces lie flat and true with one another.

63.



The sole is marked with a marking gauge.

64.



The wheel is planed on the back.

65.

A smoothing plane is used to clean up the cut made by the power plane.

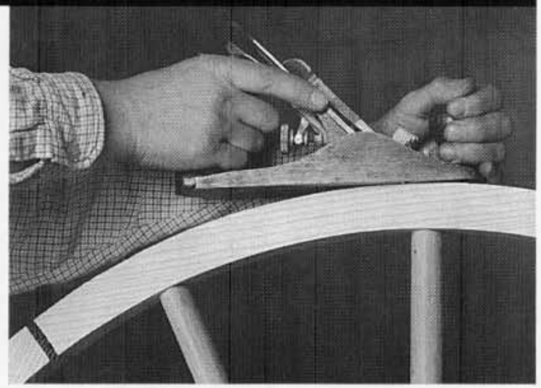
66.

The wheel is rotated slowly upon a spindle.

Next a spindle is fitted into the post vice to accept the wheel, which is rotated slowly upon the spindle. The wheelwright sights across the sole of the felloe to a mark (here a chalk mark has been made on the wall) and turns the wheel slowly. In this way he can see any sudden irregularities in the roundness of the felloes. He then marks the bumps to be planed off.

This procedure is followed until the wheel is acceptably round, a check can be made on the smoothness or truth of the curve of the felloes by drawing a hand along on them, placing the whole length of palm and fingers in contact with the felloe and moving wheel or hand slowly. The irregularities will become apparent.

67.

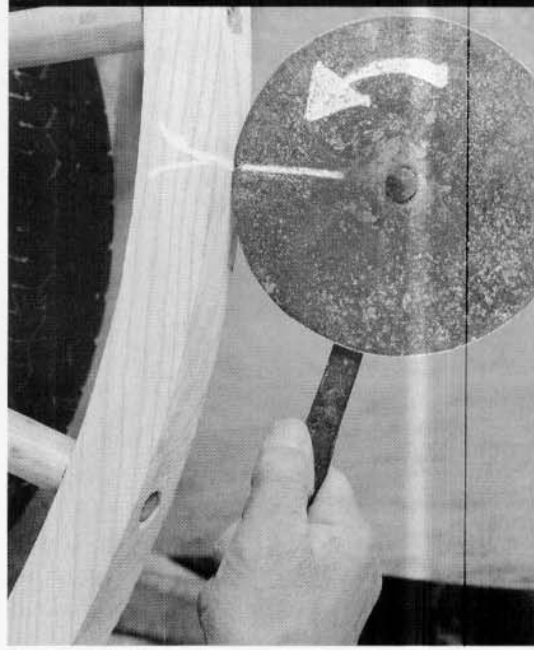


The high spots are planed off, it is convenient to remove the wheel from the spindle and prop it against the bench.

It may be necessary, if much material has been removed in this last operation, to adjust the width of the sole again, the marking gauge is used as before and the plane used to remove excess material. The spoke tongues may need to be trimmed so that they lie $\frac{1}{16}$" or so beneath the surface of the felloe, the tyre will only be able to press the felloe onto the nock of the spoke if the tongue does not interfere.

At this stage the wheel is ready to have its tyre fitted. The procedure is the same for channel bonds as for flat steel ones, the channels are bent in rolls in the same way as flat bars. Only when the tyre is bent to the correct radius can it be measured for cutting to length and welding.

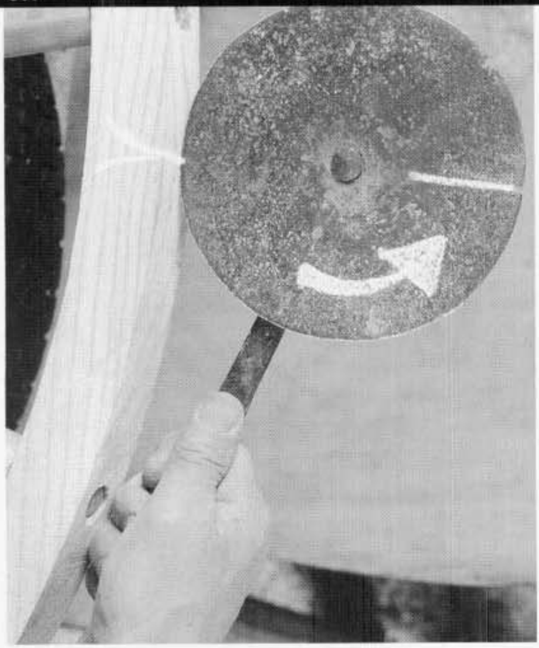
68.



The traveller at the start of the measurement.

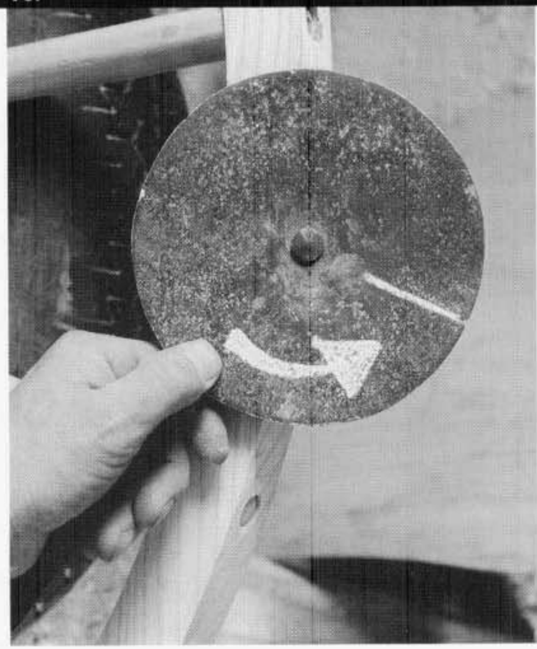
The wheel is laid horizontally and the traveller is prepared with an arrow to show the direction in which it rotates. A chalk mark is used to emphasise the notch which the traveller has on its circumference. A chalk mark is made at the point where the measurement is to start on the felloes.

69.



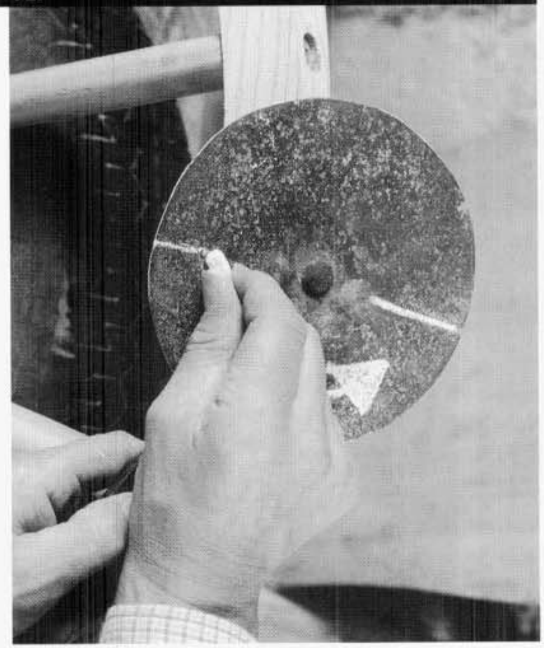
The traveller at the end of the measurement. The traveller is drawn upward across the chalk mark, leaving a trace of chalk on the surface of the traveller.

70.



The trace of chalk.

71.



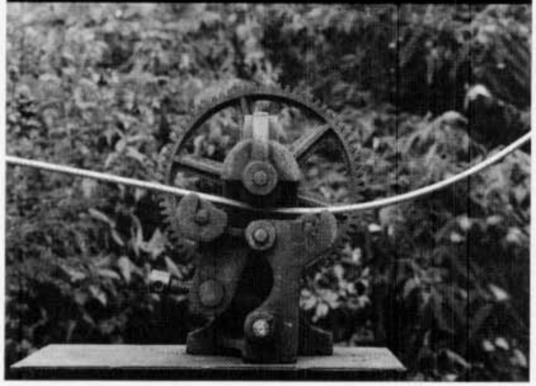
The mark is emphasised.

The notch of the traveller is brought up to straddle that chalk mark and the traveller is run around the wheel, the number of revolutions being counted.

When it reaches the chalk mark where it started, it is drawn upward across the chalk mark, leaving a trace of chalk on its surface.

This mark is emphasised, and the number of revolutions together with the distance from the notch to this mark is the extended length of the outside of the felloes.

72.



The tyre rolls. A channel tyre is being bent.

Next the measurement is transferred, measuring around the inside of the tyre. The traveller **must** rotate in the same direction, which has the effect of making its user walk the other way about, and the arrow on its surface will indicate in this. The chalk mark is transferred to the inside of the tyre. The shrinkage measurement must next be deducted from the length of the tyre and it is cut to the resulting length.

73.

Beginning measuring the tyre.

Shrinkage

The tyre is made smaller than the wheel by an amount sometimes known in old workshops as the "nip". When shrunk onto the wheel this allowance enables the tyre to draw the felloes together and the felloes are arranged with slight gapes between them at the joints. These gaps in closing reduce the circumference of the felloes and consequently press them more tightly onto the spokes, so that all the joints in the wheel, between the felloes, felloes and spokes, spokes and stock, are drawn tighter. In making the wheel the joints at each end of each spoke are made as tight as possible so that this compression has the most effect. The joint gap (or amount of "joint") in the ring of felloes is difficult to measure, since there will usually be some compression possible between felloes which appear to the eye to be tight together, until they have once been drawn together by a tyre. The total will be related to the amount of pulling together of the joints at either end of the spoke which is required, and the wider the spoke, the greater this will be. The wheel shown in these photographs will need a joint gap about ¼" to ⅜" in total.

There is a close relationship between this joint and the amount of shrinkage given to the tyre, one way of expressing the tyre shrinkage is to make it enough to take up all this joint and give an extra ½" to keep it tight on the felloes after it has done so. This gives a total in this case of ¾" to ⅞".

It is sometimes said that a traditional rule of thumb is to take ⅛" of shrinkage for every foot of circumference. This gives a measurement of about 1½" for a 4 ft wheel, which is much higher than the assessment which we have just made and might be suitable for a new, heavy wheel with spokes 2½" to 3" wide, although rather tight for most purposes even at that size.

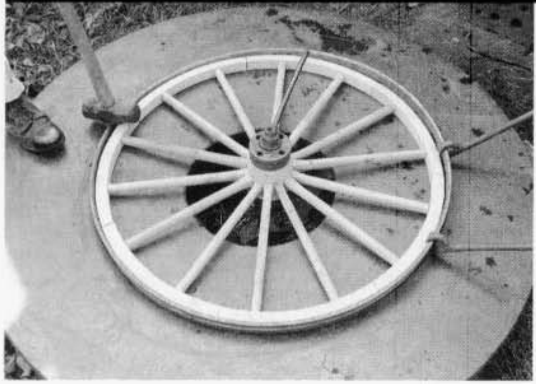
It can be seen that, in assessing the amount of shrinkage, several factors must be taken into account and a degree of confusion is possible. In an attempt to clarify the position we will express it as follows: take the normal shrinkage allowance for a wheel to be ¾".

The upper extreme rarely exceeds 1¼" and the lower is rarely less than ½". The range of choice is therefore very limited. Make a decision within these limits based on the following factors:

1. How loosely constructed is the wheel? If it is an old one whose joints have already been drawn together, there will be less to draw up with the tyre. A new wheel may well need some drawing together, the need for this being greater, as mentioned before, as the size of the spokes increases.
2. The height (ie diameter) of the wheel - a tyre of a small diameter will be incapable of expanding in the same total amount as a large diameter one.
3. The section of tyre and felloe has an effect. Larger section tyres will not necessarily expand more than small ones (the metallurgical nature of the steel or iron will affect the linear expansion but not its sectional size), but a heavy tyre and large felloe will more readily withstand the hammering necessary to drive the tyre on if it is tight.
4. Long thin spokes and slender felloes will not withstand too much compression, the spokes may bend unduly and the felloes may distort, not infrequently bursting at the points where they are bored for spoke tongues.

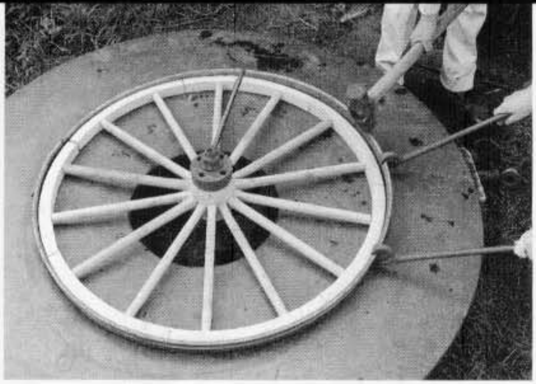
Shrinking the tyre

74.



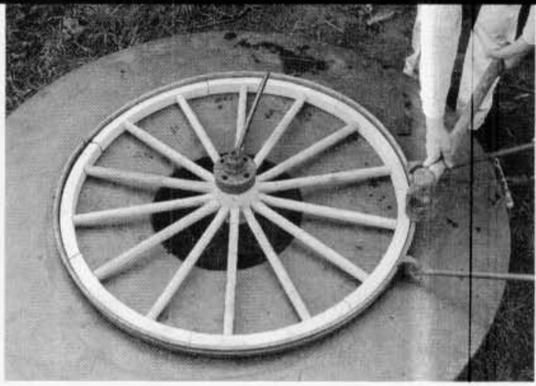
The tyre dogs are applied to the tyre and one sledge hammer holds the tyre steady and over the felloes.

75.



The sledge hammer drives the tyre on over the edge of the felloes, working towards the dogs, assisting the dogs which are levering the tyre over the edge.

76.



The sledge hammer strikes between the two dogs to drive the tyre down at the last point. The dogs are now put aside.

When cut to length the ends of the tyre are welded together. Preparations are made to shrink it onto the wheel.

The fire is laid to burn to heat the tyre to near red heat evenly around and without putting pressure on the tyre to distort it which happens all too easily when the tyre is hot. It is naturally economical to heat several tyres at once and dry wood is usually be most convenient fuel, bottled gas may be used but several burners are needed and even then only light tyres can be heated.

The wheel is clamped through its centre to the tyring plate. At least one sledge hammer is needed and a pair of tyre dogs, watering cans or buckets and a supply of water to re-fill them - a tub is quick whereas a hose would be too slow. A hook or pair of tongs is used to take the tyre from the fire when it is hot and it is dropped over the wheel.

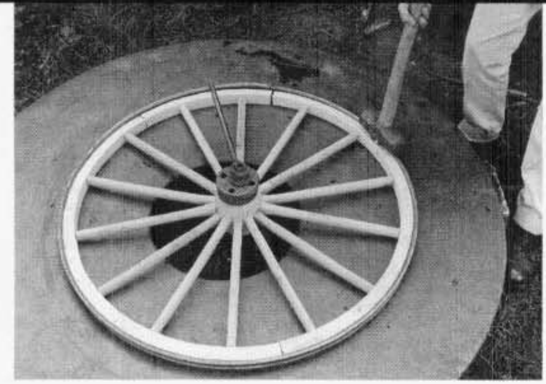
The hot tyre must be cooled as quickly as possible in order to avoid burning the felloes which will loosen the tyre.

Water cans direct the water onto the tyre more accurately and effectively than buckets. Several used at once have the desired effect.

When cooled the tyre may need to be "set" to the right position on the felloes. A wooden block, best used with the grain end-on, is applied to the felloe and struck with a hammer while the edge of the tyre is placed on a steel dolly or anvil. If the tyre has a little residual warmth in it from being shrunk on it will be easier to move on the felloes (see 79).

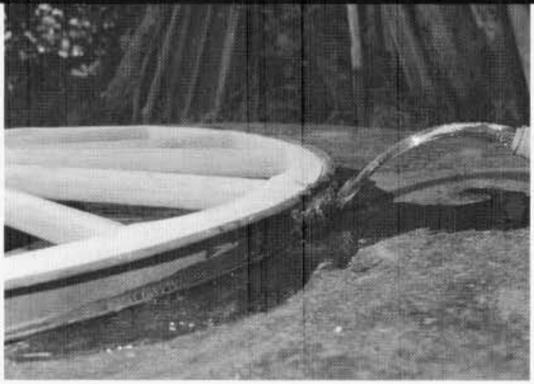
In setting the tyre, the front edge is usually allowed to over-hang the face of the felloes by perhaps ⅛"; this protects the painted face of the felloes from abrasion against obstacles such as kerbstones.

77.



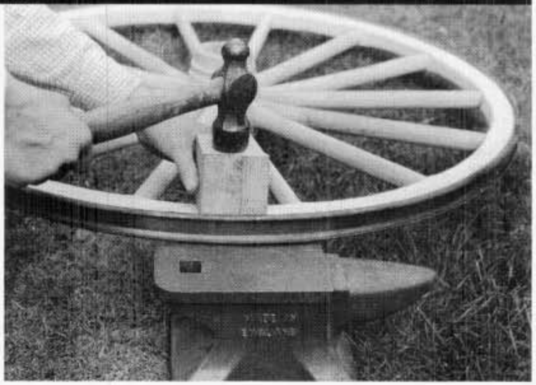
The sledge hammer taps the tyre down to touch the tyring plate all round the wheel.

78.



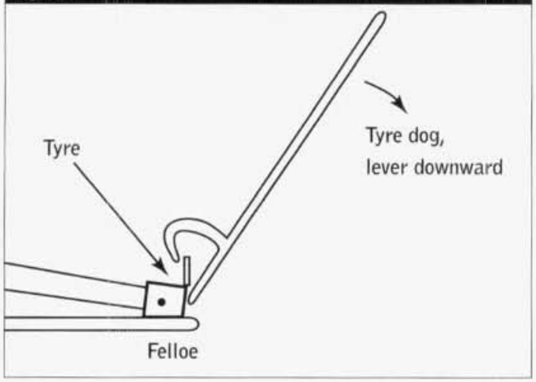
Water cans direct the water onto the tyre.

79.



A wooden block, best used with the grain end-on, is applied to the felloe and struck with a hammer.

Fig. K



Application of tyre dogs.

The felloes will need to be sanded and champhers worked on the arrises between the spokes. The champhers are rounded and normally stopped before they pass in front of the spokes. For wheels which require a continuous rounded edge to the front of the felloes, the round champhers in front of the spoke faces will need to be worked on the felloes before the felloes are fitted to the spokes.

Tyre nails

The tyre is secured to the felloes by one of several methods. Most agricultural vehicle tyres are fixed with nails, one per felloe, of a special form with tapered heads fitting into a tapered hole in the tyre. Carriage tyres were fixed with rivets in English practice, most frequently with two per felloe, fixed either side of the dowelled joint between the felloes. Small diameter wheels may only be fixed with one rivet per felloe. A common modern practice is to use countersunk woodscrews. Continental and American practice uses tyre bolts for carriage wheels.

Glossary of expressions used in the wheelwrighting

Arris : the sharp edge of a piece of timber.

Belly : the concave radius inside surface of a felloe.

Bender : a machine for bending tyres.

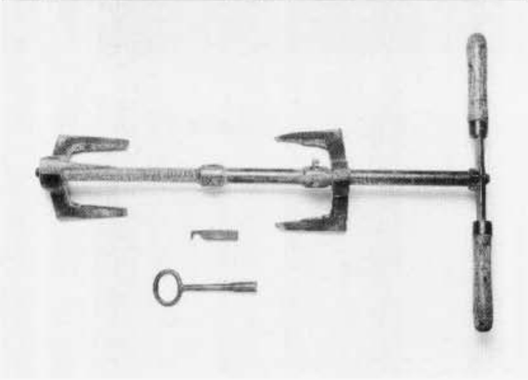
Bevel : or sliding bevel, a marking tool with a stock in which a blade is able to pivot and slide. It may be clamped at angles to the stock and is used to mark out angles.

Bond : a tyre, a ring of iron which is fitted around the wheel. It serves to bind the joints of the wheel tightly together. Smaller diameter bonds are fitted around the wheelstock to strengthen it and keep it from splitting.

Box or Bush : the metal bearing in the centre of a wheel which runs on the axle arm.

Boxing Engine, Boxing Tool, Bushing Tool : a machine, usually hand powered, used to enlarge a pilot hole through the wheelstock to the point where it is large enough to accommodate the axle box.

Breast Mark : a lightly incised groove around the wheelstock which marks the face edges of the spoke mortices.



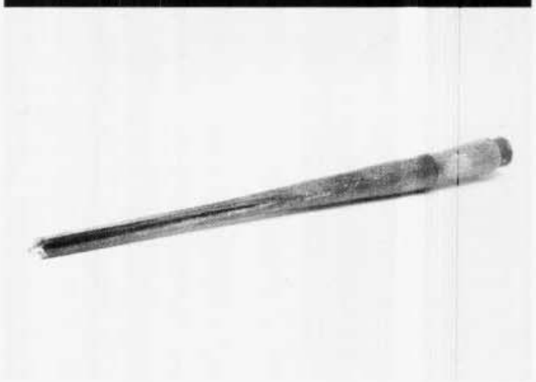
Boxing Engine, Boxing Tool, Bushing Tool.

Boxing Engine, Boxing Tool, Bushing Tool (self-centring).

Bridle or **Spoke Bridle** : a crooked piece of wood, or a whippy piece, used to press against a spoke by levering on its neighbours. This may help to drive it into line with the others.

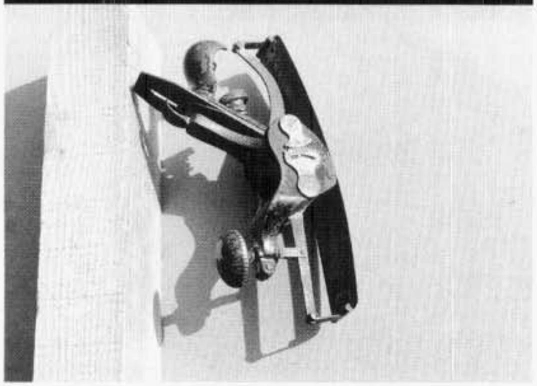
Bruzz or **Buzz** : a v-section chisel used to cut the corners of spoke mortices.

Clincher Channel and Rubber : a rubber tyre system in which the tyre of the wheel is a channel section with over-turned lips, which clasp a rubber insert whose purpose is to silence the running contact between the wheel and road. Other systems exist which use wire to hold the rubber into a channel of a simple section.

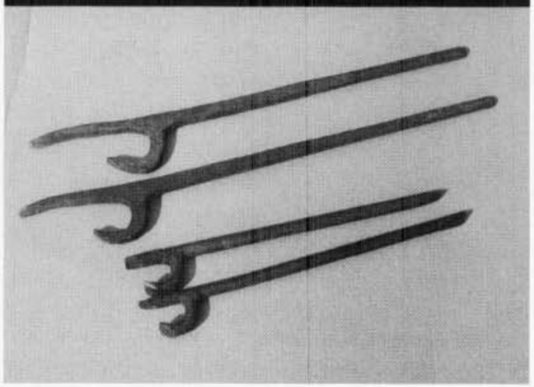


Bruzz or Buzz.

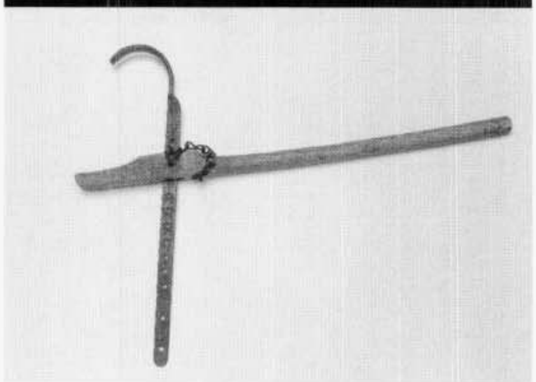
trade



Compass Plane.



Tyre dogs.



Spoke dog.

Compass Plane : a plane with a curved sole used for planing inside curved surfaces, such as the bellies of felloes.

Cutting and Shutting : the operation of cutting a tyre from a wheel, shortening it and re-welding it and shrinking it back onto the wheel to tighten the joints of the wheel. Blacksmiths use the word shutting to describe fire welding.

Dish : describes the saucer-shape of wooden wheels, achieved by setting the spokes in the stock at an angle.

Dogs : this is a word used to mean levering tools. A spoke dog levers two adjacent spokes together to facilitate the fitting of the felloe. Tyre dogs lever the tyre over the felloe during the process of shrinking the tyre onto the wheel.

English wheel : a wheel with certain stylistic features traditional in England, but basically a term used to describe a carriage wheel with a stock hoop at the front and one at the back. It distinguishes this wheel from other arrangements of stock hoops used on the Continent and in the USA.

Felloe : one of the wooden segments which make up the ring of wood which forms the rim of the wheel.

Felloe-Bound : the situation when the joints between the felloes have been drawn up tight before the joints at either end of the spoke. The spokes are therefore too loose in their joints and the wheel will work loose.

Gedge's Bit : one form of auger bit with back-curled cutting wings. Gedges bits are particularly useful in cutting elm, but suit all wheelwrights' work well.

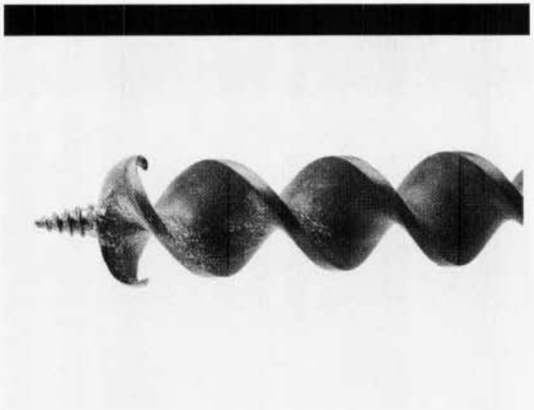
Hollow Auger : tonguing bit, hollow bit - a bit used with a brace or machine borer for cutting tongues onto the ends of spokes, after they have been driven into the stock. There are various types of adjustable tools and fixed size ones comprising a casting approximating in form to a very deep top hat with two cutters, set at an angle like a plane blade, in the brim. They cut the knock of the spoke and leave the tongue inside our imaginary hat.

Hoop : see Bond. Stock bonds are often called stock hoops.

Hub : one of the names for a wheelstock, stock, nave, naf, nut etc, but it usually refers to the stock with bonds and box fitted.

Jervis : a plane or shave, similar to a large spokeshave, with a blade about 2" wide, ground to a convex curve and a sole curved to suit. A useful tool in forming spokes, shafts and other workpieces with a rounded section.

Joint : the word joint describes the gaps between the felloes of a wheel which are provided to enable the tyre to compress the components of the wheel tightly together.



Gedge's Bit.

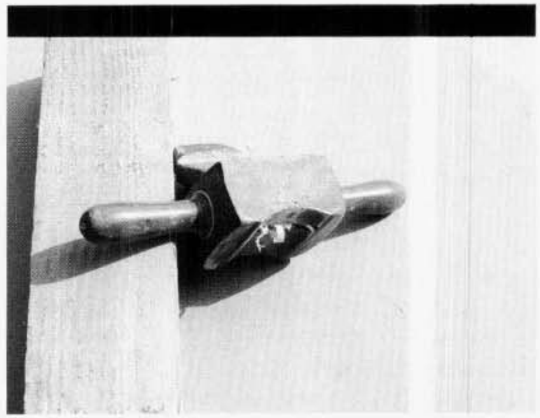
Knock : the flat surface left at the back of the spoke after cutting the tongue into its end, on which the belly of the felloe abuts.

Land : the surfaces turned onto a stock where the stock hoops are fitted.

Nip : the contraction allowance between the dimensions of the tyre and wheel.

Naf, Nave, Nut : names for the stock.

Pencil Gauge : a marking gauge made to hold a pencil.



Jervis.

Post Vice : a vice comprising a vertical post, generally set in the floor and a wooden bar, vertical and parallel to the post. The screw of the vice passes through bar and post to a nut fixed behind the post. The jaws are at the top of the bar and the post.

Rolls : a machine equipped with rollers for bending iron bar into rings for use as tyres.

Rounder : a hand tool for making the spoke tongues round and an exact size.

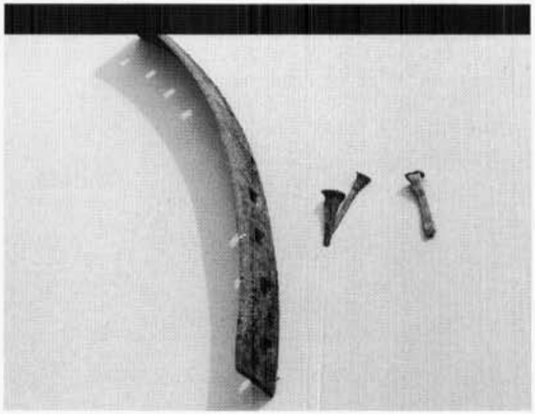
Samson : a clamp used for bringing the ends of the felloes together when strakes are being fitted to a wheel.

An English stock.

Set : the ends of an axle are inclined downwards so that the wheels lean outwards at the top, this is called the set of the axle. The word is also used to describe the process of moving the tyre into the right position on the felloes after the tyre is shrunk on.

Shoulder : that part of a tenon, usually at right angles to the axis of the tenon, which buts against the timber into which the tenon fits, hence the shoulders of a spoke but down onto the wheelstock.

Sole : the concave curved outside surface of the felloe, against which the tyre fits.



Strakes.

Speech : a name occasionally given to a wheel without its felloes, also known as a wheel of stock and spokes.

Spoke Fiddle : a holding device used in shaping spokes.

Spokeshave : a small planing tool held in both hands used to give the final finish to spokes and in numerous other situations.

Spoke Trimmer : a bit which cuts a conical end on a spoke, acting very much like a pencil sharpener, in preparation for a tongue to be cut with a hollow auger.

Strakes : short lengths of iron fitted around a wheel performing the same function as a continuous tyre. They are about the same length as the felloes and overlap the felloes across the joints.

Strake Nails : the nails which fix strakes to felloes. They have tapered, square or rectangular shaped heads which fit tapering holes in the strake. Each strake has normally eight.

Stagger : in 19th Century English practice alternate spokes were morticed to alternating face lines (the breast marks) when the spokes are said to be staggered with alternate ones set one behind the other.

Stock : the central part of the wheel into which the spokes are morticed.

Stock Hoops : see bonds.

Stool : a piece of standing equipment in a workshop found in many forms for a variety of operations, usually lower than a bench and generally standing on legs.

Tenon : in a wheel the spokes are given tenons, which fit into mortices in the stock. They always taper in at least one elevation in wheelwork.

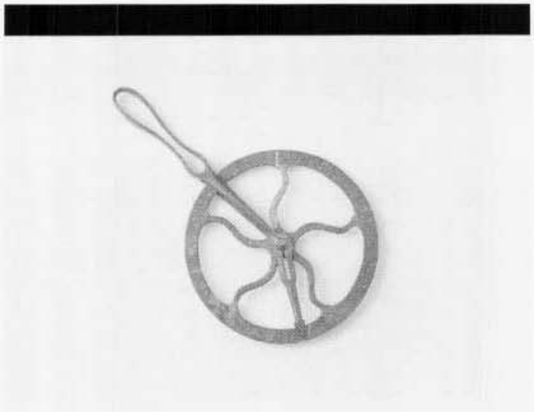
Tongue : the tenon at the outer end of the spoke.

Traveller : a measuring instrument consisting of a wheel, usually with a notch in its run, it is arranged to pivot on a handle. The edge must be thin to avoid misleading readings and it is used to measure the circumference of wheels and their tyres, the process known as "running the wheel".

Tyre : the same as bond, the iron ring which surrounds the wheel, it tightens all the joints and therefore ties or binds the wheel together.

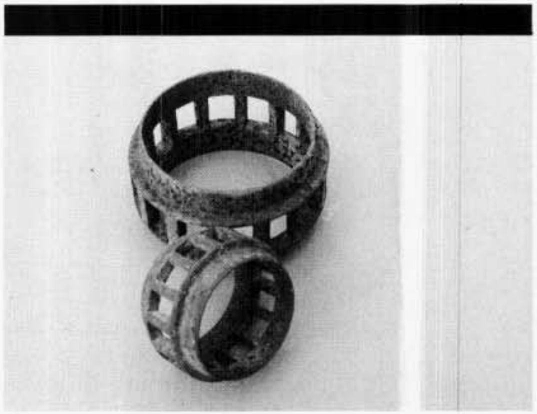
Tyre Bar : iron bar was once rolled in a variety of sections known as tyre bar, specifically for the purpose of being used for tyres. One form had one flat edge at right angles to the face and the other a half-round radius. This radiused edge was arranged to overhang the face of the wheel felloes, pushing the wheel away from obstacles such as kerbstones and thereby protecting the painted surface from abrasion.

Viller : a felloe in some parts of the West Country.



Traveller.

Warner Wheel : an American invented system in which the wooden wheelstock was bound by a band of iron which had mortices formed through it to receive the spokes, which had a tenon formed to fit through this mortice and into a smaller mortice in the wooden stock. There were several variations on the theme by other inventors, Sweet and Sarven among them.



Warner wheel.

Whalebone Gauge : a bar of wood with a series of holes through it, a spring pointer (formerly a piece of whalebone) is set through the holes with a wedge and the bar is fixed across the face of the wheelstock. The pointer is used to set the angle for cutting the face of the spoke mortice and for driving the spoke in to ensure that the wheel runs true.

Wheel Horse : a post with a nearly horizontal bar fixed at its top on which a wheel can be placed for painting.