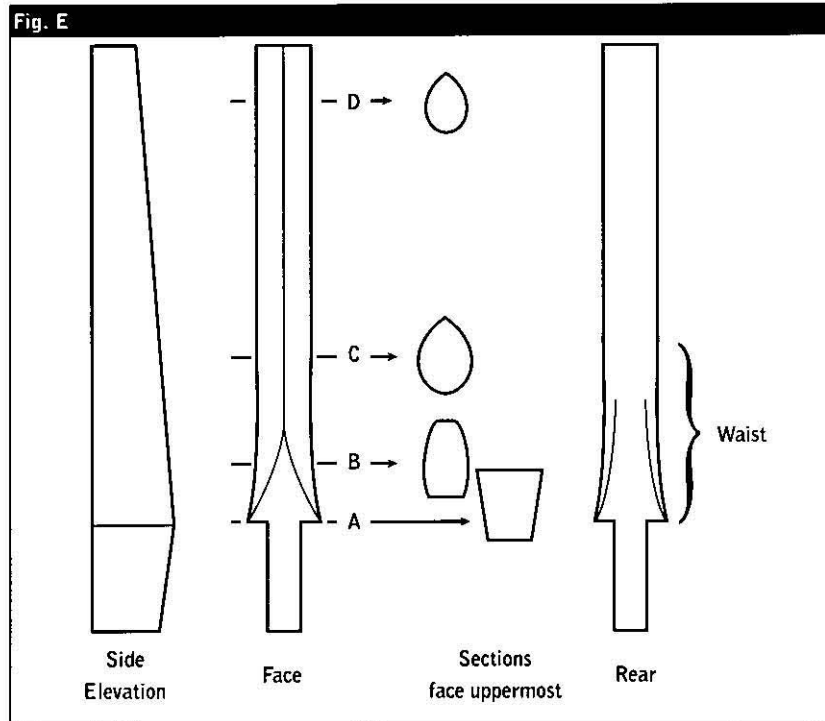


Spokes

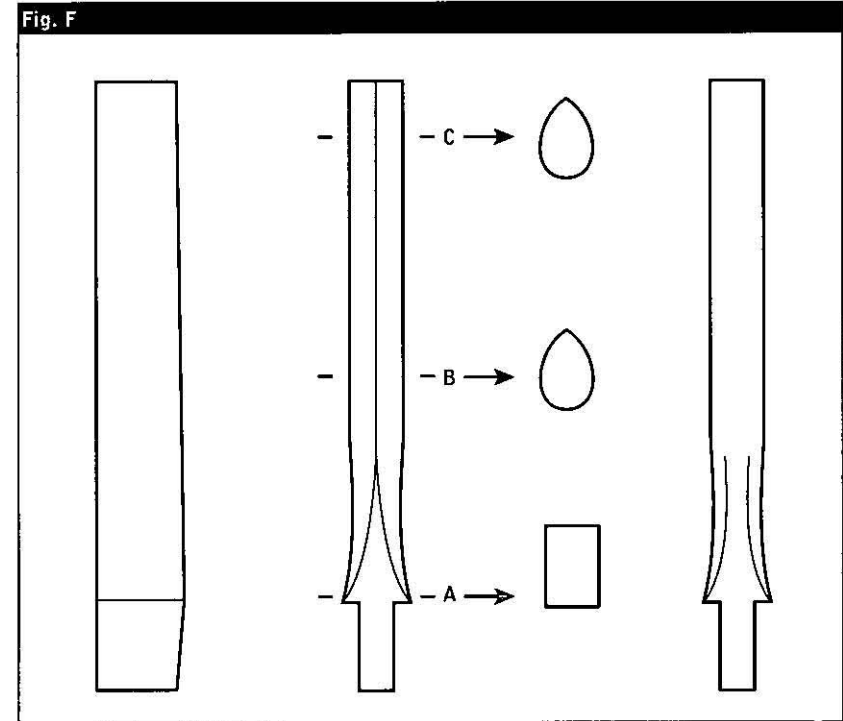
Spokes are required to withstand compression and bending stresses. In former times the material for them was cleft from straight grained oak. The wedge shaped cross-section which this produced influenced the shape which spokes were made. The eventual standard pattern of English spoke is what concerns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



Hand-made English coach pattern spoke.

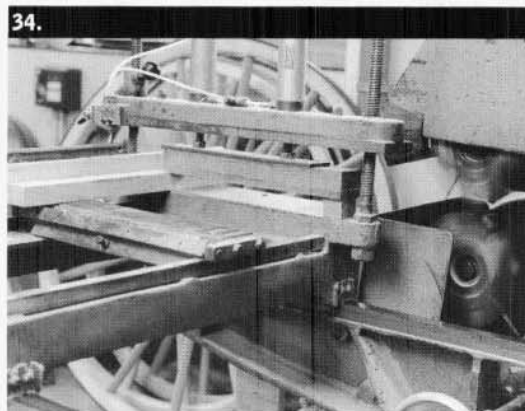


Machine made English coach pattern spoke.

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.

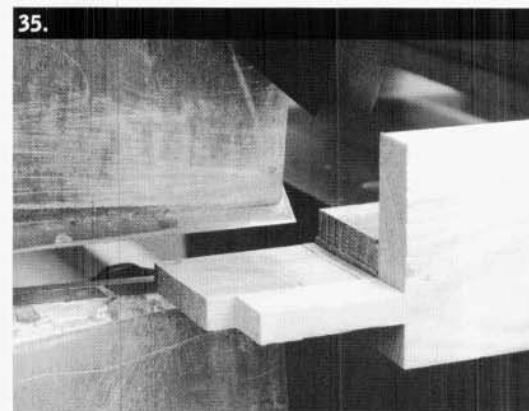
The sizes to which the spokes must be finished will have been determined, and the rectangular blanks are sawn and planed



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.

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.



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

- (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.

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

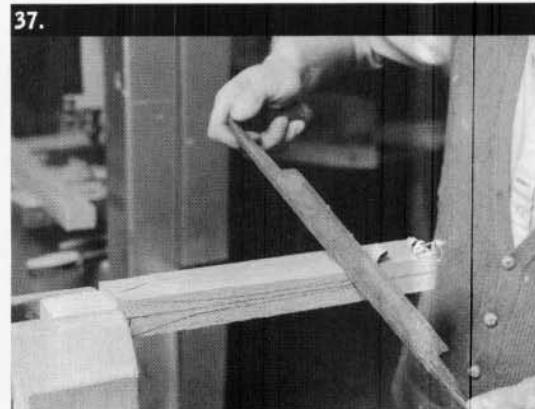
The stock has been carefully prepared for the spokes with mortises of a size calculated to give the right tightness (see pages 9 and 16) and cut at the precise angle to let the spokes lie in line to give the right amount of dish. It is frequently possible to save time by cutting the hole for the box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

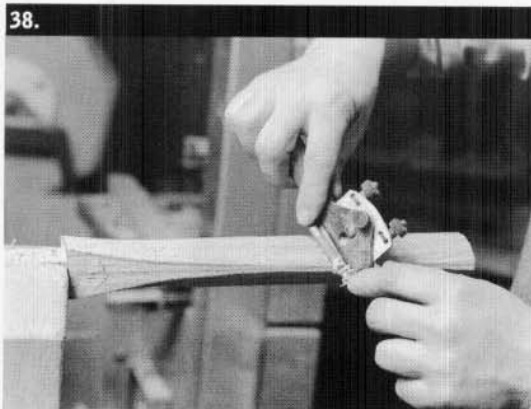
necessary to discourage the stock from splitting. Small stocks can be gripped in an ordinary joiner's vice where the spokes are driven and if the hoops are not fitted this is easier to do. Another advantage in keeping the hoops off at this stage is that the whalebone gauge can be more easily attached 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



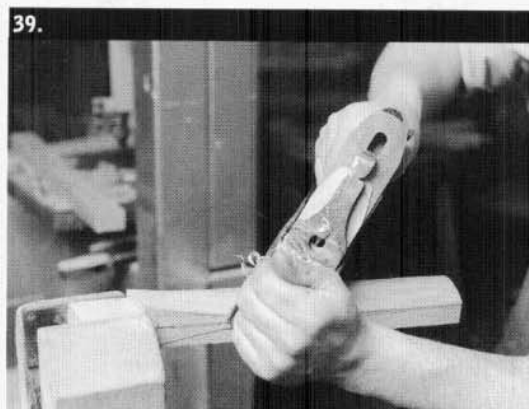
37. A drawknife in use. The first rough shaping of the spoke is most quickly achieved with a draw-knife. With practice, a draw-knife and plane can be used for all the shaping work on timber with a straight grain. Cut out the waist first, then shape the shank of the spoke.

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.

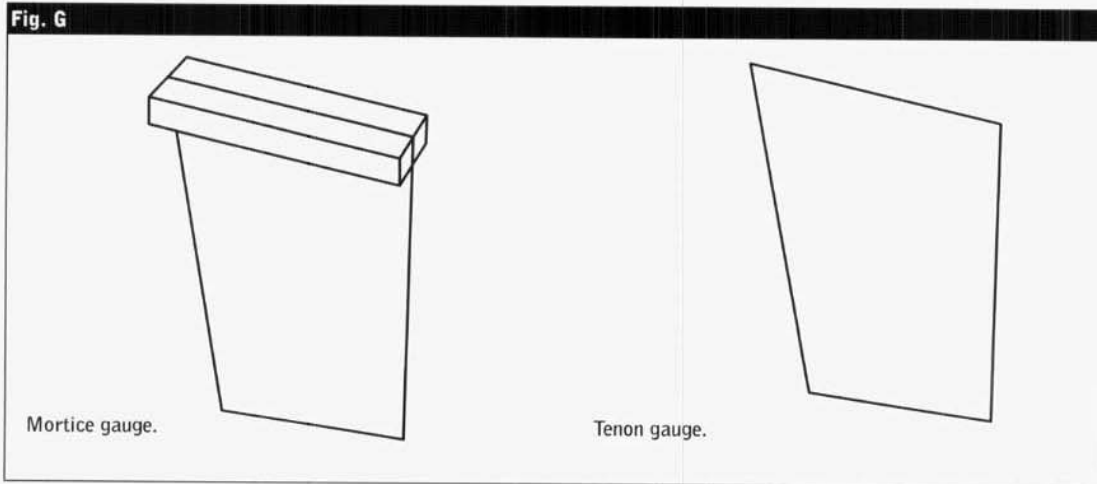


40. A rasp in use to shape the curves at the waist, this requires less practice than the draw-knife to give the required subtle shapes.

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.



The tenon gauge matches the mortise 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 11lb 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 $\frac{1}{3}$ 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.

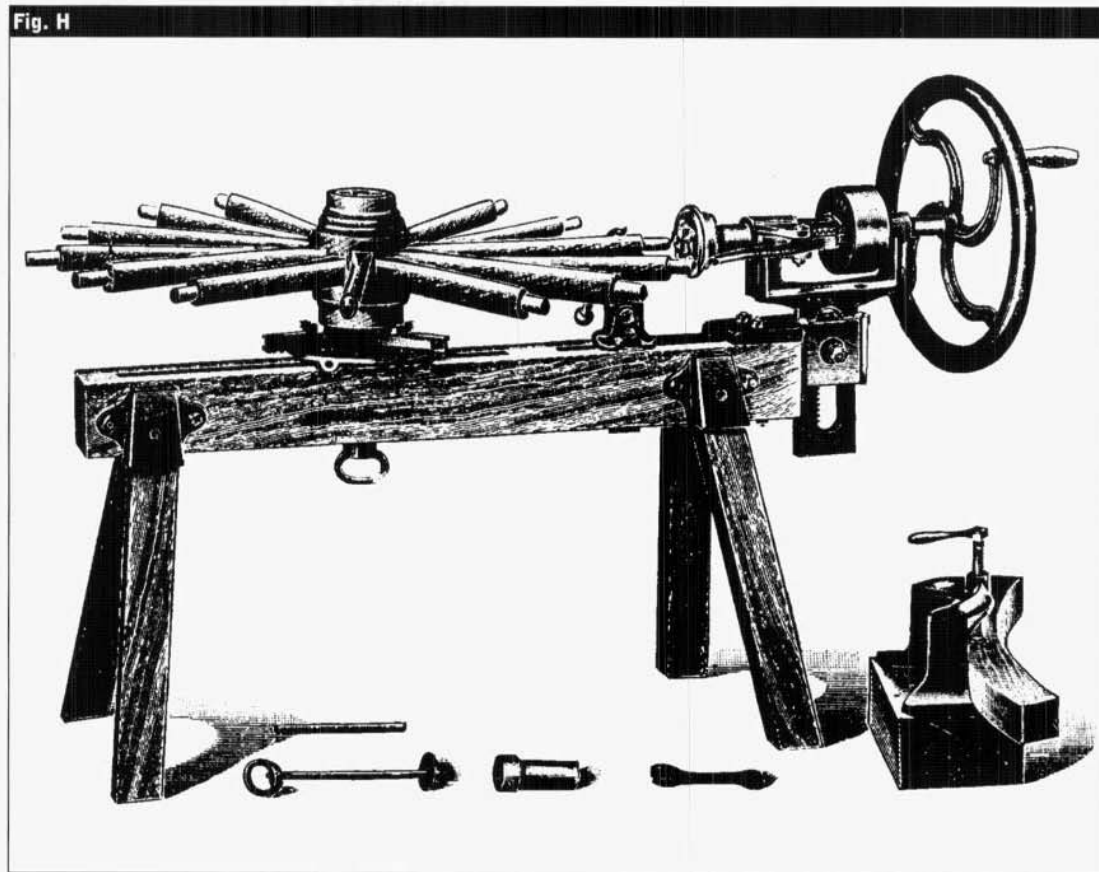
The spoke angle can only be corrected as it is being driven, once housed in its mortise it cannot be altered.



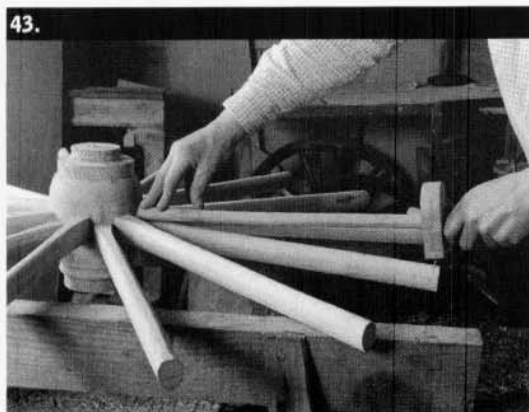
42. The spoke bridle in use, here it is pulling the spoke which is being driven forward.

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.

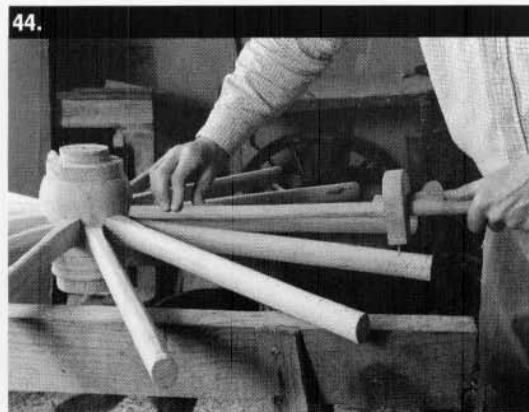


The horizontal borer.



The spoke trammel in use.

The spoke trammel (or "length gauge") marks the extreme length of the spoke. This point is arranged to fall $\frac{1}{8}$ " 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 fellow down onto the nock of the spoke without fouling the end of the tongue.



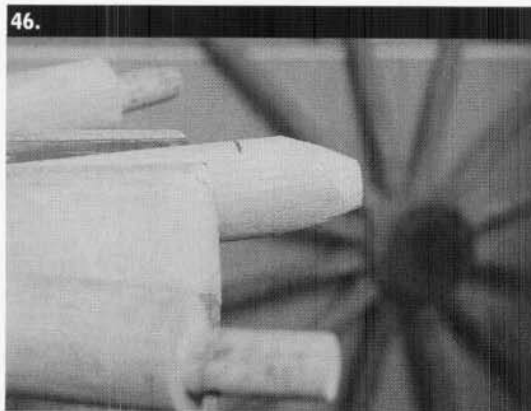
The nocks being marked.

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 in use.

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.

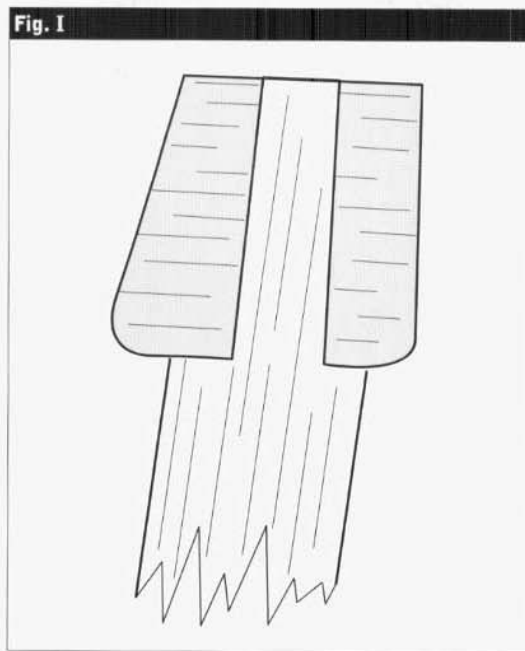
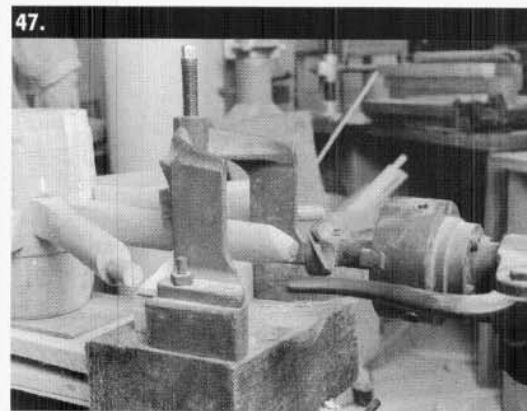
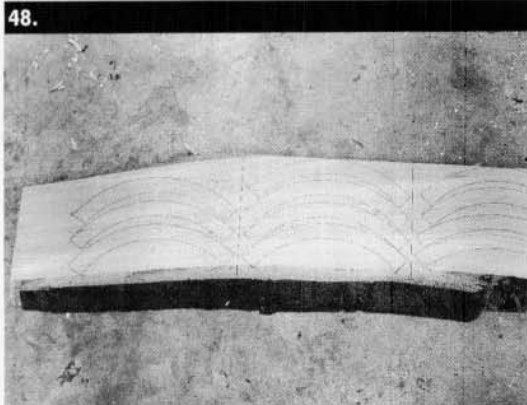


Fig. I
Cross section of wheel at spoke junction with felloe, showing the bevel of the felloe. This bevel is the reason for arranging the tongue towards the face of the wheel.

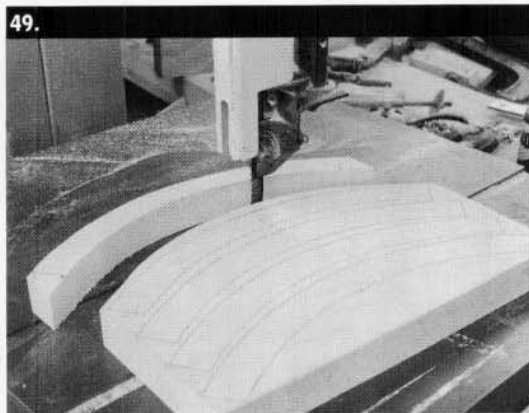


47. A wheel arranged in the borer for the tongue to be cut.

Felloes



A plank marked out to cut felloes.



Sawing the felloes.



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

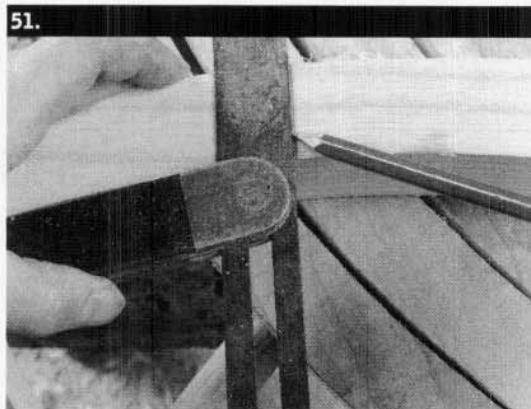
Dry ash is selected for the felloes which are marked from a pattern cut from hardboard or thin plywood. The sawing may be more accurately square from the face of the timber if planed first and cut with the planed face on the saw table or, if the plank will finish thick enough, both faces can be planed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

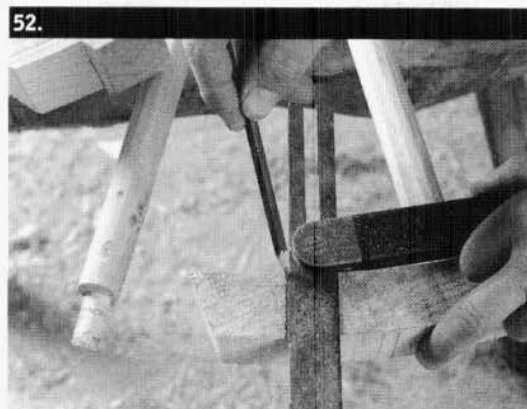
The wheel is placed face down on the wheel stool and one felloe is marked with the bevel for a cut to be made midway between alternate pairs of spokes.

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.

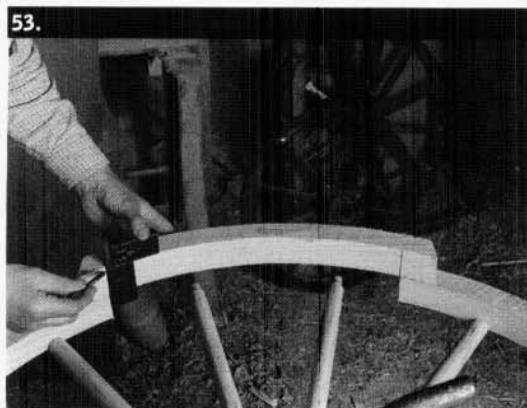


51. The sliding bevel being set to strike a radial line on the felloe.

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.



52. Marking the end to cut off from the felloe.

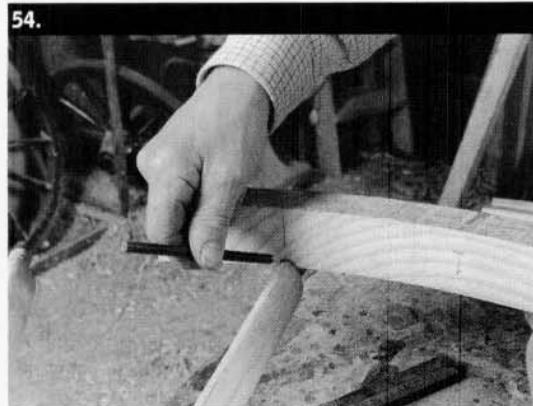


53. Marking the last felloe.

“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 felloes to jar them will push all the other joints together. On most new carriage wheels this gap will vary between $\frac{1}{8}$ " to $\frac{3}{8}$ ", 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-tying 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.

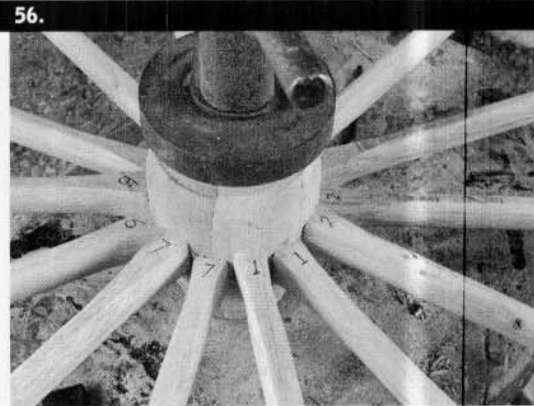
Marking the felloes for the borer

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.



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

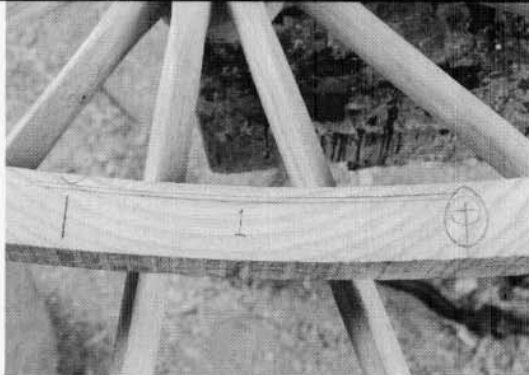
Each felloe is numbered and at least the first two numbers are repeated on the pairs of spokes to which each of these two felloes is fixed. This ensures that the felloes, when returned to the wheel after boring, can be fitted in the positions which they had while being marked. Next a line is struck across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



56. The felloe numbers transferred to the spokes.

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 $\frac{1}{8}$ " back from the face of the felloe. In setting the height of the borer, between $\frac{1}{8}$ " and $\frac{1}{4}$ " 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.

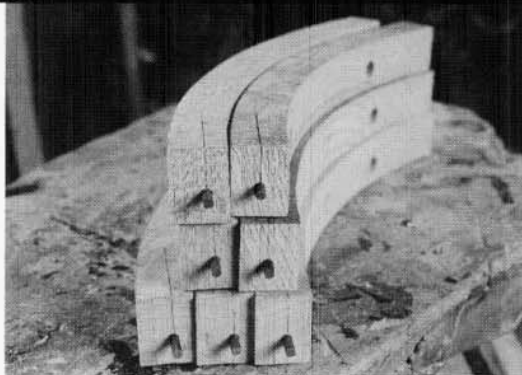


The inside (the belly) of the felloe.

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 $\frac{1}{8}$ " 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.

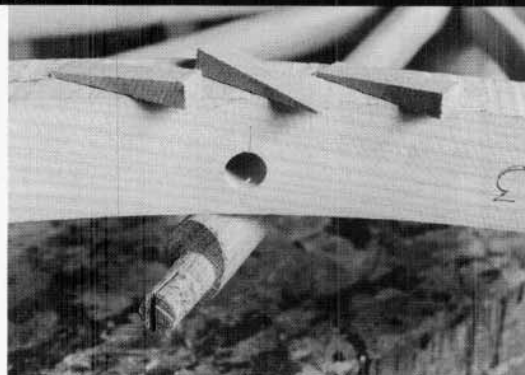
58.



The felloes, bored ready for fitting to a wheel.

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.

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.

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 $\frac{1}{4}$ " or so in diameter arranged so that they have about 1" of length entered into each felloe (wooden ones are usually longer).



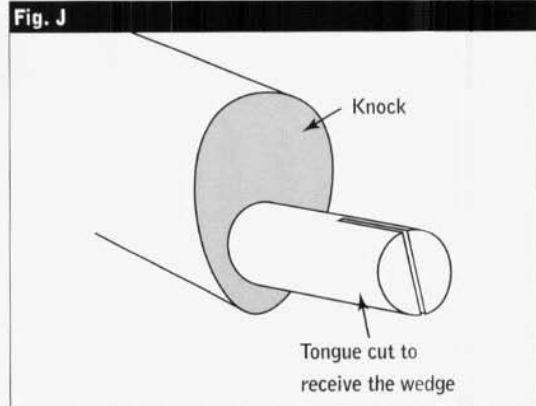
60. Here the spoke dog is seen in use.

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.



61. The wheelwright fits each felloe to the spokes.

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.



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