Making a wheel

– how to make a traditional light English pattern wheel

by John Wright and Robert Hurford

RURAL DEVELOPMENT COMMISSION

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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.

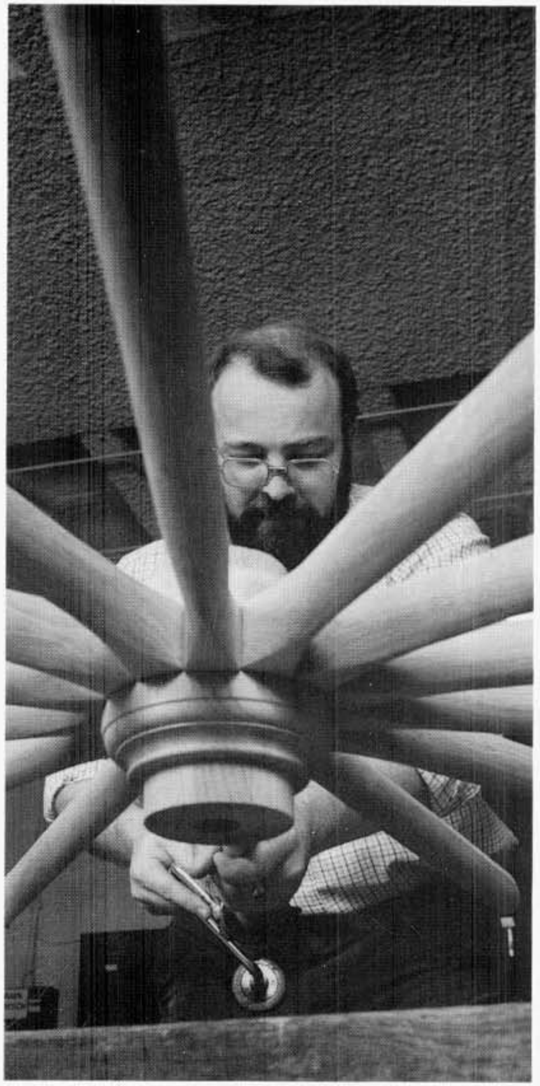
Today, as interest in horse drawn vehicles continues to grow, so the demand for well trained and experienced wheelwrights increases. The Commission and the Worshipful Company intend to keep the craft alive and flourishing well into the next millennium.

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.

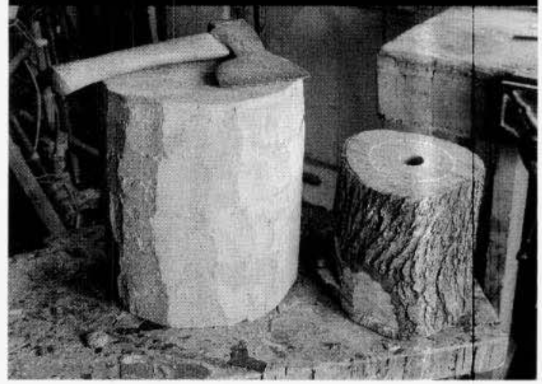
The Procedure

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.

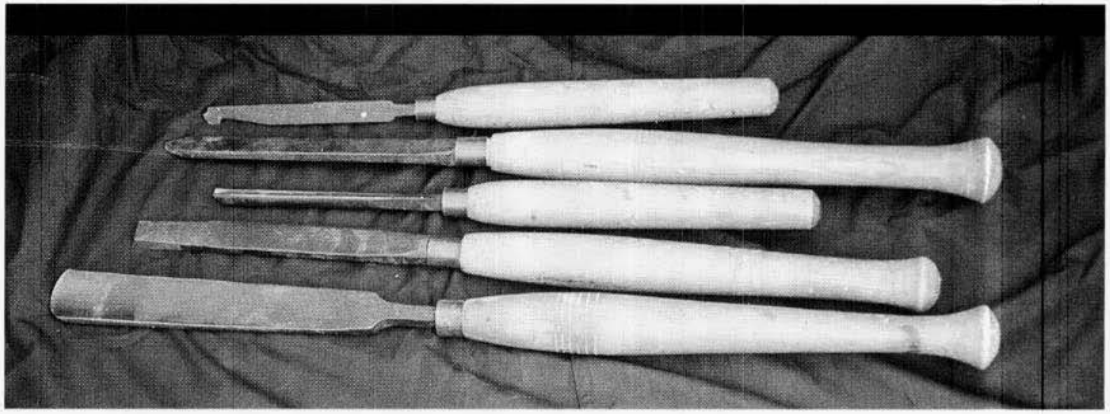
1.

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.

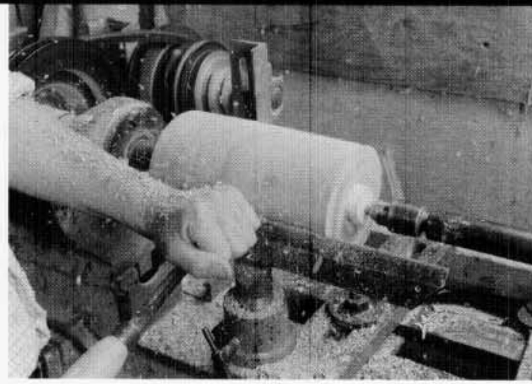


Several types of turning tools.

3.

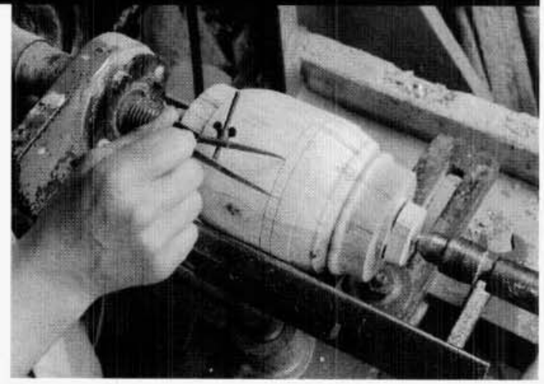
The chopped stock is mounted on the lathe, here a turned plug is inserted to the pilot hole.

4.



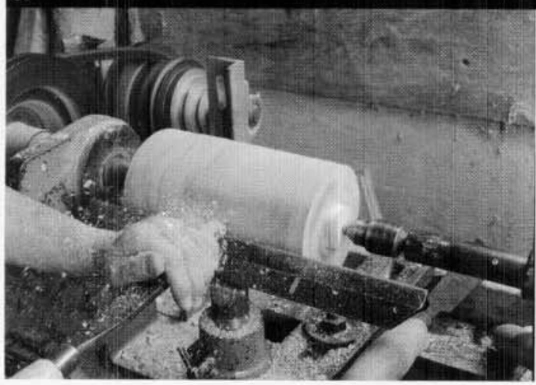
The stock is turned with gouges and scraping tools.

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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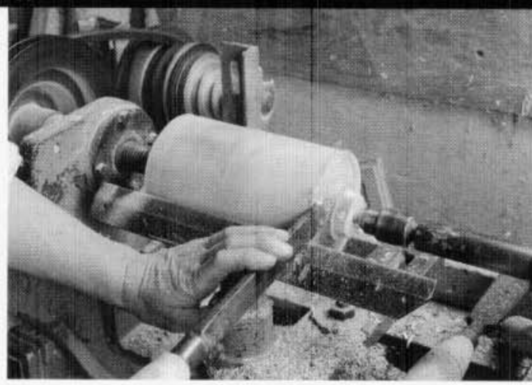

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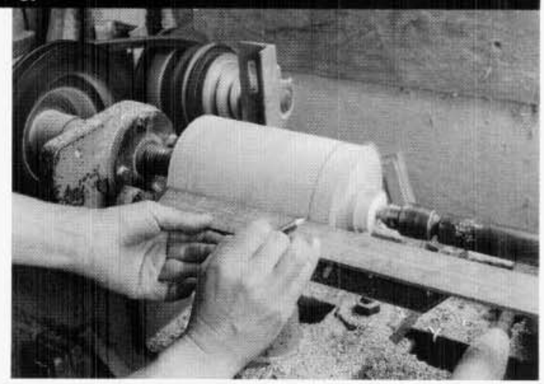
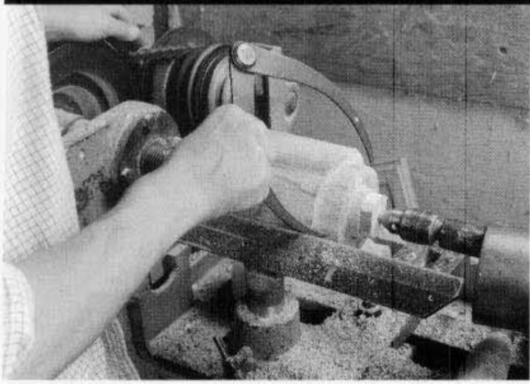


A sequence of pictures showing the stock hoop lands being formed.

9.



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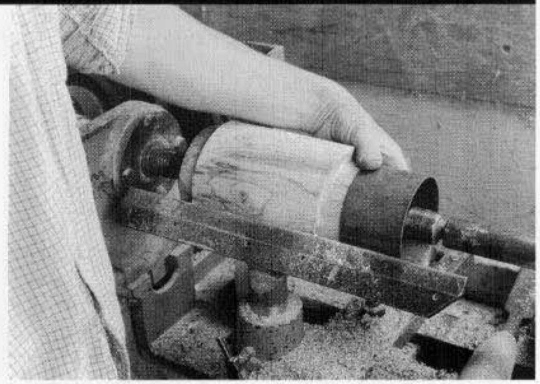


Here the diameter of the land for the front stock hoop is checked. The hoop itself is placed over the tailstock in readiness to try on to the stock. It should be a fit just capable of being driven on with a hammer when cold, the taper in the hoop will tighten it.

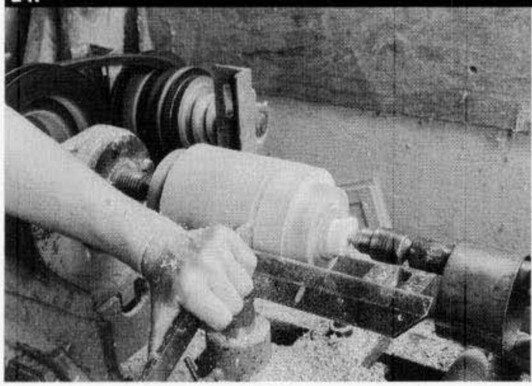
When the stock hoop lands are turned to size, the position of the spoke mortises are marked. Usually the spokes are arranged to straddle the halfway point between the inside edges of the two stock hoops – marked by measurement (Fig.11).

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 ⅝" 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.

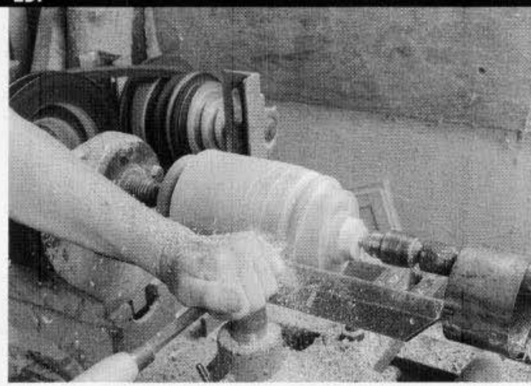
The following sequence shows the traditional English coach pattern beads being formed on a stock.

14.



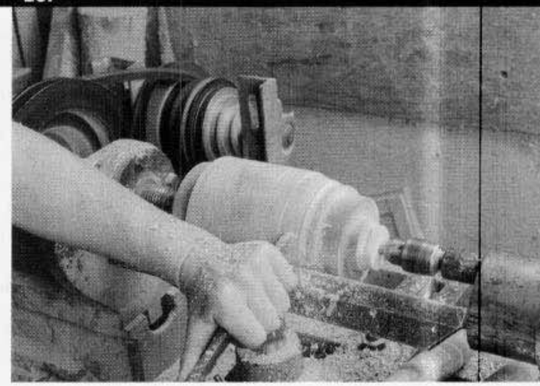
The step in front of the spokes is cut with a chisel.

15.



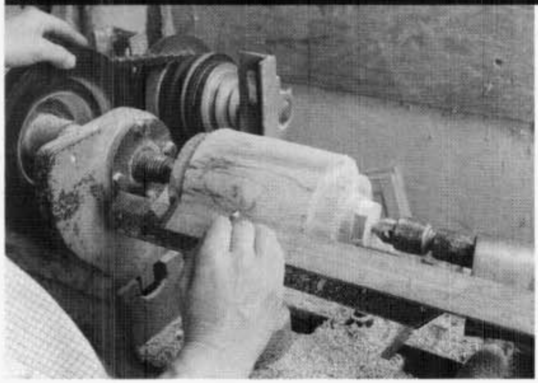
The beads are roughed out with a chisel.

16.



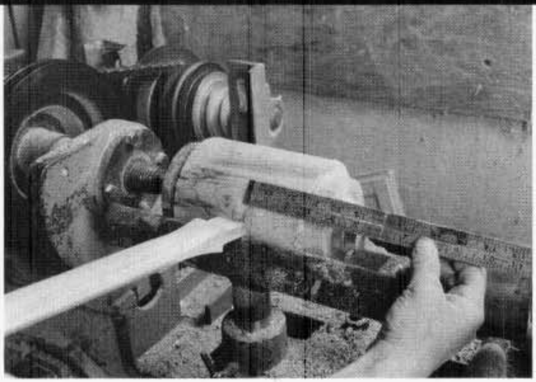
The main convex ovolo is formed with a narrow chisel.

11.



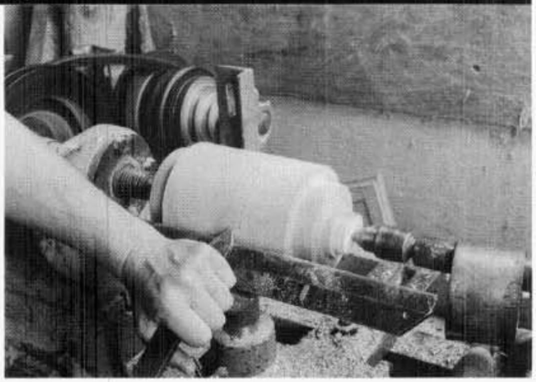
Marking position of spoke mortices.

12.



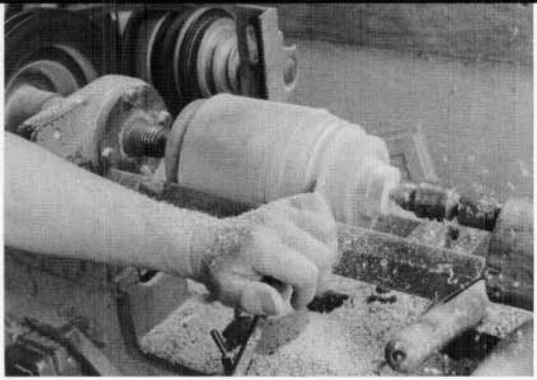
The spoke is positioned to straddle the mid-point.

13.



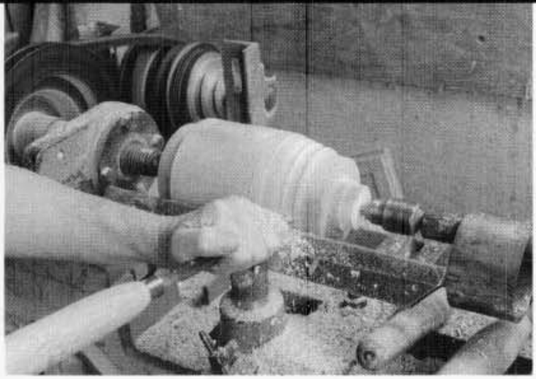
The breast marks are cut into the stock .

17.



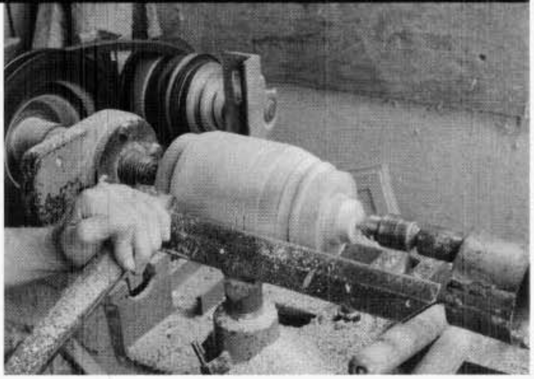
A narrow chisel forms the front bead.

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

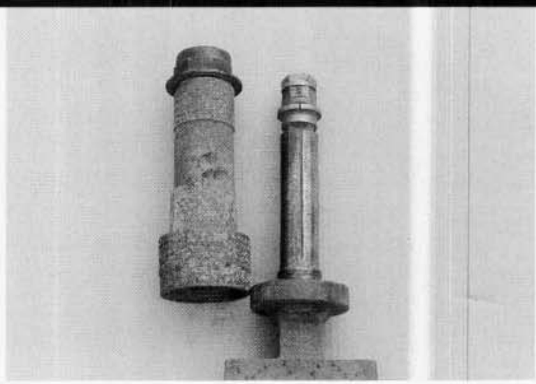
20.

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

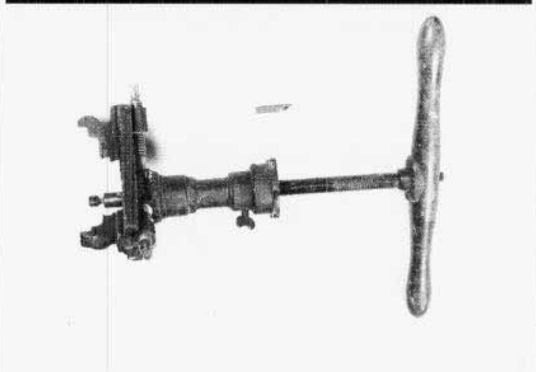
Stock hoops are bent in several ways, for example a strip of steel may be wrapped around a large diameter steel pipe after one end is welded to it. Alternatively, a strip may be knocked into a curve using a hammer and striking between two firm edges, perhaps a channel in a swage-block. Another way is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

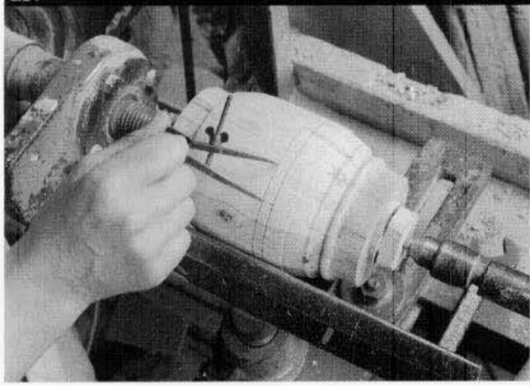
24.



Self-centring boxing engine.

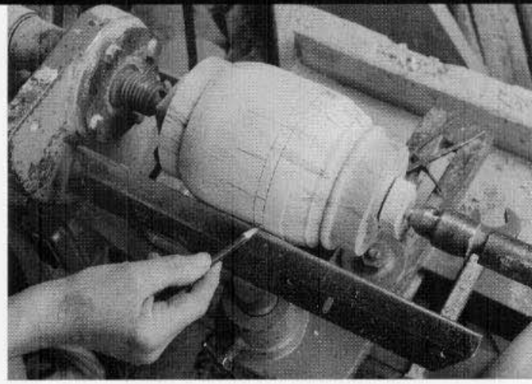
Marking out the spoke mortices

25.



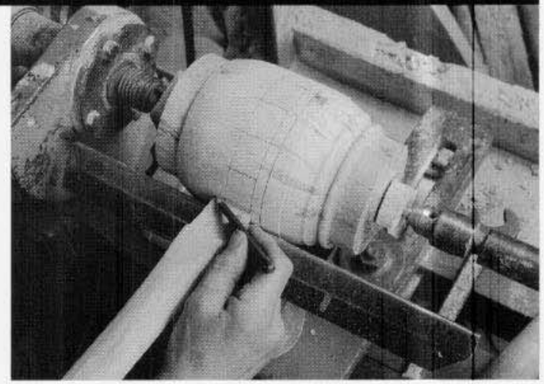
Spacings.

26.



Stepped spacings.

27.



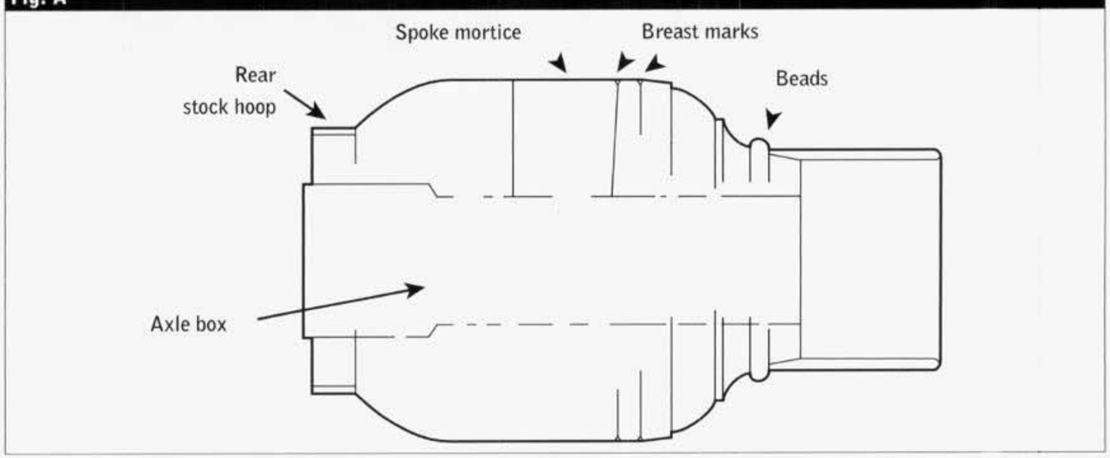
The back of the mortices being marked.

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

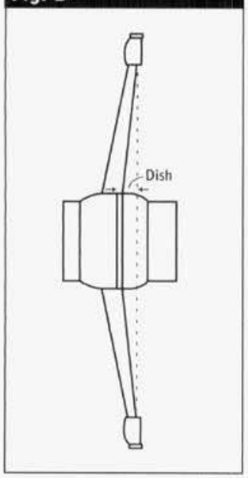


Sketch showing cross-section of a typical English carriage wheel stock. Note internal taper in the stock hoops and the angles of the morticers.

"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

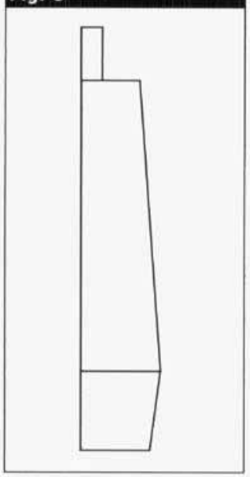
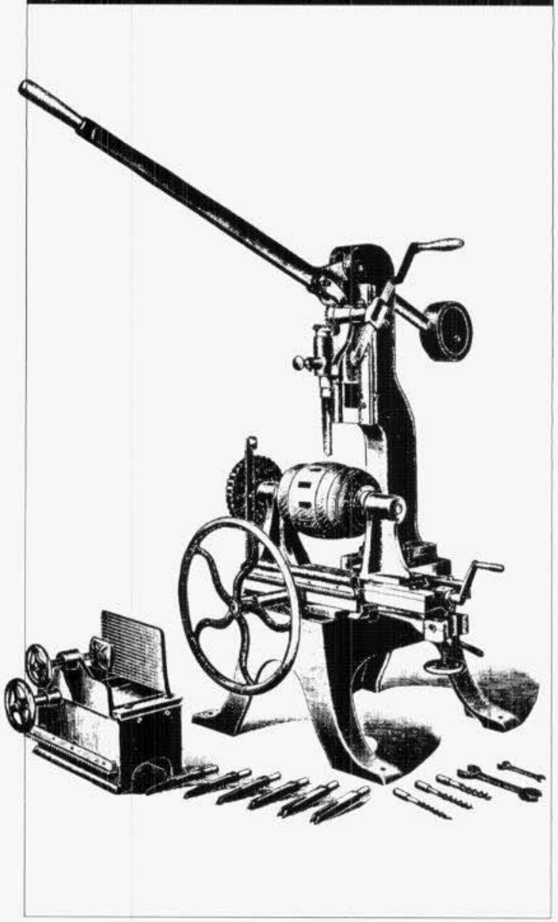


Fig. D.

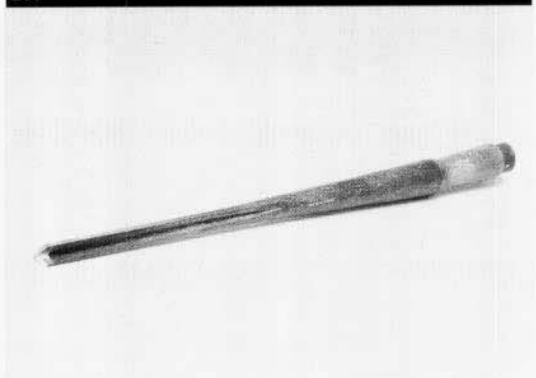


Stock morticing machine.

28.

Morticing by hand (see text).

29.



Bruzz.

30.

Whalebone gauge.

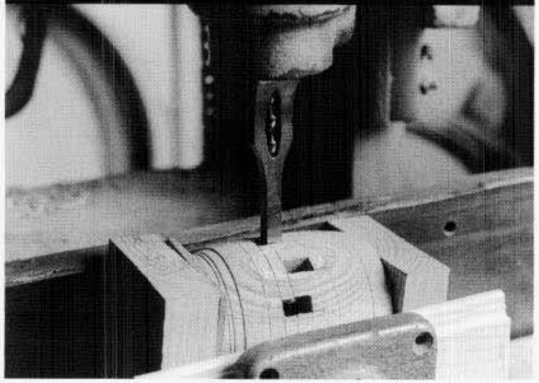
Morticing the stock

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.

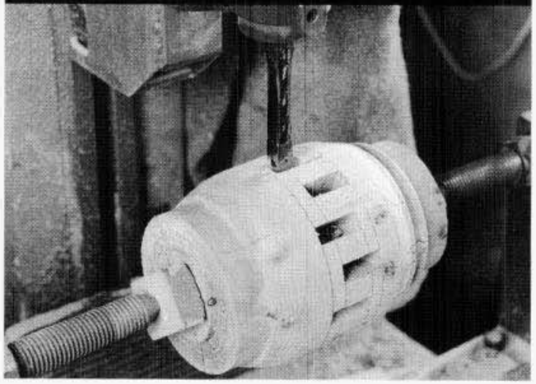
31.



A jig used in a morticing machine.

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).

32.



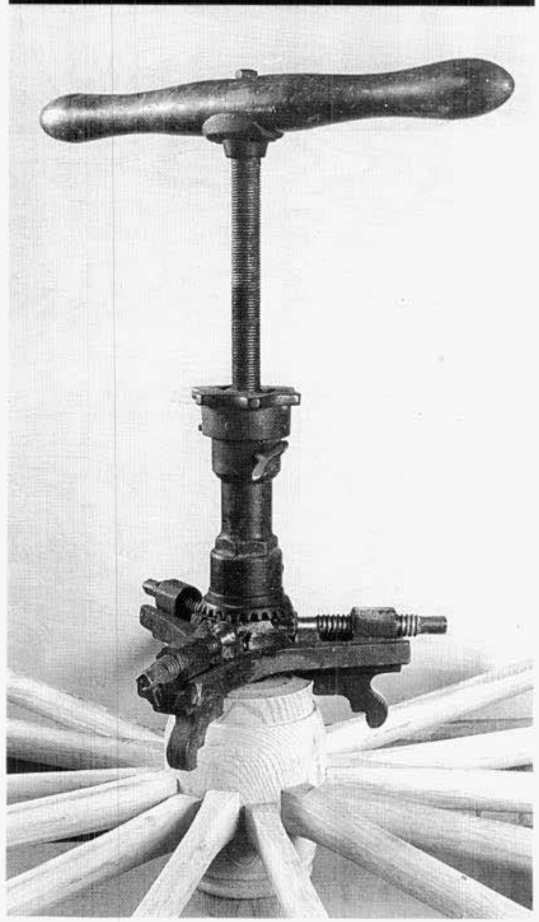
A morticing machine with a centring cradle for wheelstocks.

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.