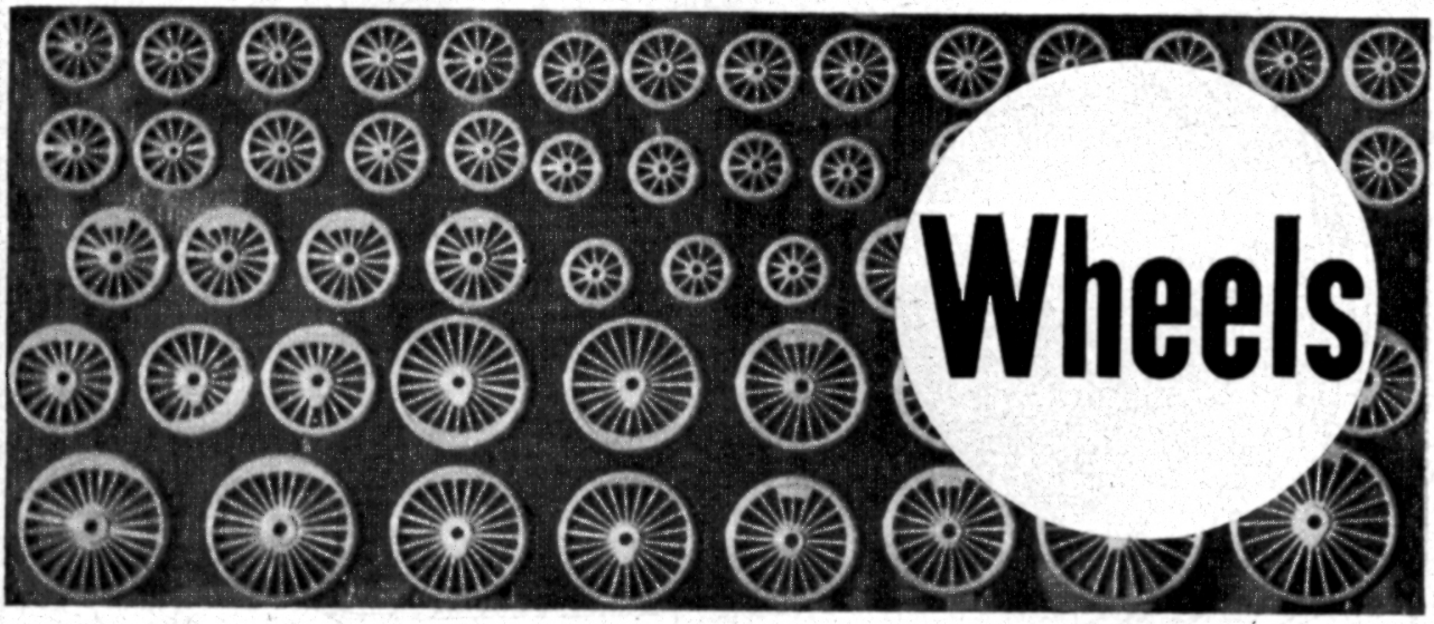
Model Railway News June 1959

MAKING SPOKED Wheels



The first instalment of an article that we believe to be one of the most important published for quite some time—by

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THIS article deals with making spoked wheels in the home workshop. In the main, the methods are used in connection with 4 mm. scale wheels in brass but "O" gauge wheels in steel or cast iron are quite feasible and one modeller known to the author has made a number of gauge "1" steel wheels recently by identical methods. Brass could be used for "O" gauge and even for gauge "1" but a steel tyre should be fitted in the interests of wear.

It is surprising how many modellers do make their own spoked wheels but many readers will undoubtedly wonder why anybody should attempt such a task when there are, already, several makes of spoked wheel on the market. An obvious answer is to mention the single driver engines having wheels 7 ft 6 in. dia. or more, for which no driving wheels are readily available. Indeed, so far as the author can ascertain, there is not even a 28 mm. driving wheel available, thus ruling out the many popular locomotives, with 7 ft drivers, in 4 mm. scale.

A much more compelling argument in favour of making one's own wheels is revealed when one examines a collection of drawings or photographs of locomotives. The usual commercial driving wheel is depicted in Fig. 1a, and it will be seen that the balance weight is of crescent shape and is located at 180 deg. to the crank. Taking the excellent book of locomotive drawings published at one time by the Stephenson Locomotive Society, it was found that, of 140 locomotives where the drawing actually showed the balance weights, no less than 74 (53 per cent.) had square ended balance weights as Fig. 1, b and c, 39 (28 per cent.) had crescent weights as fitted to the commercial wheels, but at some angle other than 180 deg. to the cranks (Fig. 1d), and only 17 (12 per cent.) had crescent shaped weights at 180 deg. exactly to the cranks *but none of these had the same size weights on both driving and leading or trailing coupled wheels.* This latter state of affairs is, of course, brought about by the need to balance the connecting rod and, possibly, inside cranks on the driving axle whereas only the coupling rods need balancing on the remaining axles. There were 8 (5.7 per cent.) locomotives using cast iron "H" section spoke wheels, which are not available commercially in model form, leaving only *one* engine, a G.C. 0-6-0 tank which had identical, crescent shaped weights on all wheels at 180 deg. to the cranks. Too bad they were only 10 spoke, 3 ft 3 in. drivers which are quite unobtainable.

This is not a criticism of our friends in the trade. It would be quite impossible to manufacture, and stock, accurate reproductions of the thousands of different pattern wheels which have appeared since Locomotion No 1 (what wheels she had !), and the wheels which are available undoubtedly suffice for a very large range of models where the owners are prepared to turn a blind eye to minor inaccuracies. If, however, the reader has the good fortune to see a model wheeled with correct reproductions, he will be very conscious of the vastly enhanced appearance which such wheels can impart.

There are other faults to which many commercial wheels are prone, such as too thick spokes and heavy rims, and, of course, one has to accept the crank throw provided which may be quite wrong for the model chosen.

One manufacturer, at least, undertakes correct wheels to special order, but the price is, of necessity, several times that of the wheels one can buy over the counter, and if one has in mind a stud of engines, the cost of such special wheels could equal that of a small lathe with which one could make wheels entirely from scratch as discussed below.

Finally, whilst only driving wheels have been mentioned so far, bogie and tender wheels also present problems. The author has recently made over 80 wheels in connection with a stud of Midland locomotives and such odd-

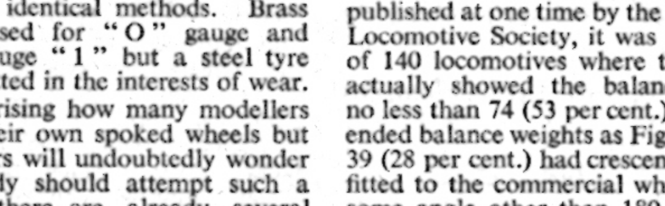

FIG 1

ments as nine spoked bogie wheels were encountered whilst the Midland tender wheel at 4 ft 2½ in. (16.83 mm.) is not available commercially as far as is known.

It has been felt to be worth while discussing the reasons for making one's own wheels, at some length, but, now, to proceed with the methods.

Making the blanks

Fig. 2a shows a wheel in section and elevation and gives some dimensions for 4 mm. scale with 7 mm. scale dimensions in brackets. It is first necessary to turn the blank and it will be appreciated that one cannot turn the pear shaped crank boss at this stage. Therefore, a circular boss is machined on the face of the wheel having a diameter equal to the large end of the crank boss and the actual crank itself is filed up as in Fig. 2b and sweated on later. Fig. 2c shows the section to which the blank is turned and the taper outwards towards the centre of the wheel on the face should be noted. Spokes almost invariably taper in this way.

If a fair number of wheels are to be made, a form tool to machine the complete tread and flange is an asset and such a tool is worth making in any case since all vehicle wheels can be machined with it to a standard profile, a great help to trouble free running on your layout. The wheel profile used by the author is shown in Fig. 3a and it is to near scale standards, but there is no reason why one or other of the recognised standards should not be used instead. It is, however, very necessary to provide the 1 in 20 taper on the tread, the 20 deg. angle on the flange face and the radius between flange and tread and at the top of the flange. Here lies the secret of good running.

To proceed with manufacture of the tool, take a piece of ⅝ in. or ¾ in. dia. silver steel bar and turn and part off a plain wheel with a $\frac{3}{16}$ in. dia. bore, taking great care to bring the profile of flange and tread to a high finish by the use of sharp tools and a final polish with varying degrees of emery down to the finest grade. Fig. 3b shows this wheel and also the shape of the tool end for turning the profile. The 1 in 20 taper on the tread is obtained by setting over the top slide and a fine file attends to the radius on the top of the flange.

The wheel is then hung on a loop of iron wire through the bore and suspended, from a pair of pliers, in the fiercest flame of the gas stove or Bunsen burner, or placed inside a tin in a hot fire, until it becomes bright red hot. You cannot overheat it in any of these flames. Once red-hot, drop the wheel in a tin of cold water and it should become glass hard, so much so that if it is filed with an old file, the teeth of the file will be damaged without affecting the wheel. Mount the hardened wheel on a $\frac{3}{16}$ in. bolt with a nut tightened on, to trap the wheel against the bolt head, and, gripping the shank of the bolt in the lathe chuck and running at top speed, polish the slight scale off the profile with emery and oil. Then, bring the profile to a high finish with metal polish or lapping paste on the soft end grain of a piece of wood pressed hard against the rotating wheel. Finally, grind a gash in the wheel as at Fig. 3c to leave the profile exposed as a cutting edge, of the shape of a wheel rim. Bolt the wheel to a piece of ½ in. steel, preferably using a high tensile Allen screw as at Fig. 3d and, when the whole is mounted in the lathe toolpost, it becomes a turning tool.

Once more take the initial piece of ⅝ in. or ¾ in. dia. silver steel and proceed to feed your newly made form turning tool into the bar of silver steel held in the chuck using the back centre, a slow speed and copious amounts of cutting oil. Again drill a $\frac{3}{16}$ in. bore, part off and we have our final wheel profile form tool, ready for use when mounted on the ½ in. square bar after hardening, polishing and grinding the gash as before. Fig. 3e shows this tool and it will be seen that it has "prongs" each side of the actual profile which settle the width of the wheel rim automatically. Note that the gash must be ground below centre to give front rake to the cutting edge. If you have no grinding wheel, file in the gash before hardening and stone up the edge afterwards. Keep dipping the tool into cold water whilst grinding the gash, as heating will soften it. Finally, for "O" gauge, the form tool should be about 1¼ in. diameter and the bore should be $\frac{5}{16}$ in.

Having made the profile form tool, which will last a lifetime as it can be ground away right round the periphery to bring up a new cutting edge as it becomes blunt, wheel blanks can be machined in a "stick" by feeding the tool in at intervals along a bar of brass, turning-down to a given setting each time to ensure that all wheels are of the same diameter. Turn the bar between centres or support with the back centre if mounted in the chuck, because the forming operation is quite heavy cutting on a small lathe. Use a slow speed if the lathe tends to "chatter" and feed slowly but firmly. Use plenty of cutting oil if steel is used for "O" gauge.

With the turned bar in the chuck, and running truly (very important if the initial forming was done between centres), centre the bar with a Slocombe centre drill and run in a number 31 drill a little way, then part off the end blank between the formed profiles;

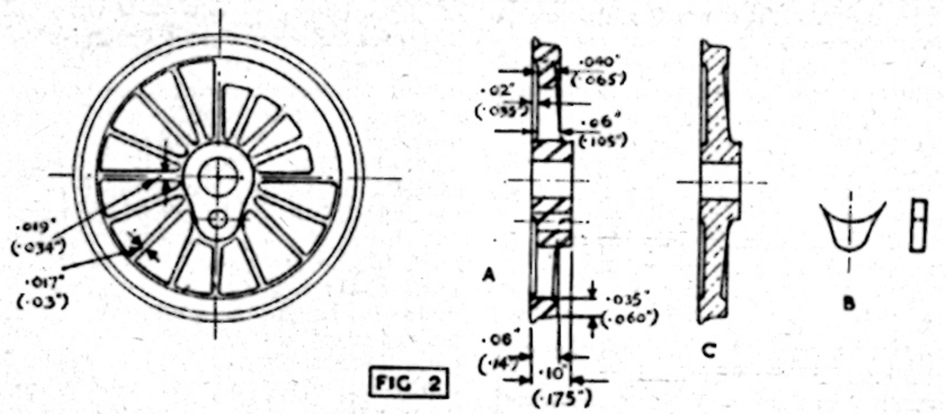

FIG 2

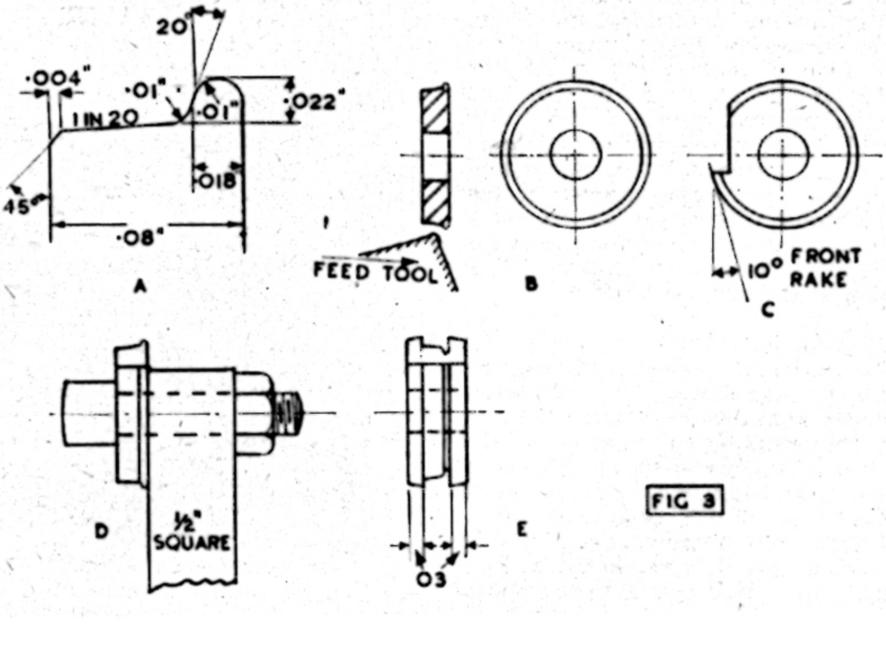

FIG 3

drill and part off the next blank and so on. Fig. 4 shows the process so far.

Mount each blank truly in the chuck and face back to the edge of the rim,

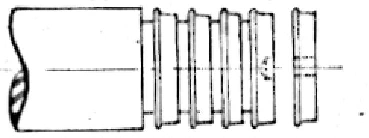

FIG 4

then turn under the rim and down to the boss, finally facing the boss which stands proud on the front of the wheel, but flush with the flange on the back. Turn round in the chuck and finish the other side. This part of the job has been left a little vague deliberately, as the exact method depends so much on one's own preferred method and equipment but, if the lathe is fitted for collets, which are a "must" for a serious modeller, step chucks can be had which will grip wheel blanks absolutely truly. Failing these, a ring can be machined in the chuck from brass with a recess to take the wheel tread exactly and, having put a pop mark on the ring against number 1 jaw of the chuck, it can be removed, split with a fine sawcut and, when replaced in the chuck with the mark against number 1 jaw, it can be tightened down to grip the wheels true whilst the back is turned. A similar ring, recessed to take the flange, holds the wheels for turning the front. Alternatively, a small screwed stub shaft can be made on which to mount the wheel which is held by a nut, or finally a piece of bar can be gripped in the chuck with its end fractionally below the level of the chuck jaws and, having drilled and tapped a true hole in its centre, a 6 B.A. bolt, with a short length of 0.120 in. diameter below the head, can be screwed in to bolt the wheel back against the face of the chuck jaws whilst you operate on the front. All these methods are made clear in Fig. 5, and dimensions quoted are for 4 mm. scale. Revise for larger scales.

If a form tool is not made, the blanks should be turned oversize and without the tread profile at this stage, but all other machining of the faces and bosses, together with boring, should be carried out. The turning of the tread profile will be carried out on a stub mandrel after the initial holes for the spokes have been drilled. This drilling is the next operation.

Drilling for the spokes

As will be seen from the photograph Fig. 6, it is next necessary to drill a series of holes immediately beneath the rim and corresponding in number to the number of spokes in the wheel. It is also necessary to make the holes follow the contour of the balance weights, and this is seen in photos, Figs 6 and 7. Note that, since the holes at the balance weights are drilled nearer to the centre of the wheel, they will be smaller as the space between the spokes becomes less. The drill size for the holes is obtained by measuring the space between adjacent spokes from a good scale drawing or by calculation.

In the latter case, make a rough estimate of the drill diameter, measure the diameter under the rim of the wheel and deduct the drill diameter, as estimated, from this figure. This gives the pitch circle diameter of the circle of holes to be drilled and this figure, multiplied by our old friend π (3.142) gives the circumference of the circle on which the holes are drilled. From this figure, take away the total thickness of all the spokes noting that real spokes are only about 1¼ in. thick at the rim although this figure varies and the actual loco being modelled should be checked. For 4 mm. scale, this makes the spokes about 0.017 in. thick, i.e. *less than ½ mm.*; for 7 mm. scale 0.03 in. (1/32 in. bare), and for 10 mm. scale 0.042 in. (1 mm. full). These figures will surprise many modellers, and one well respected modeller, faced with such fine spokes, promptly dubbed the wheels "bicycle wheels," but the details are correct and this only serves to show, once more, how, if one sees enough of the wrong thing, the correct practice, when first met with, seems all wrong.

To return to the job in hand. Having deducted the total thickness of the spokes, we are left with the total value of the drill holes and this divided by the number of spokes gives the correct drill diameter. Select the nearest drill *below* this, or perhaps, for safety, a size below that. You can always file out the drill hole when filing the wheel spokes later, but if the drill is too big, or a bit out of correct spacing, the resultant hole will not clean out, but will remain as a "half moon" cut away in the spoke. Perhaps a sample calculation will make all clear.

Assume a 4 mm. scale wheel having a tread diameter of 21½ mm. (5 ft 4½ in.). The under rim diameter scales ¾ in. (0.75 in.). The rough estimate of the drill diameter is 0.10 in. and deducting this from the under rim diameter of 0.75 in., we get a pitch circle diameter, on which the holes are drilled, of 0.65 in. which, multiplied by π becomes 2.042 in. There are 17 spokes and if each is taken as 0.017 in. thick, they have a total thickness of $0.017 \times 17 = 0.289$ in. which must be taken from 2.042 in., leaving 1.753 in. to be divided into 17 drill holes. This gives a drill size of 0.102 in., and a number 38 drill is the nearest below at 0.1015 in. To be on the safe side and to utilise a common size of drill, select a 3/32 in. drill measuring 0.0937 in.

The question of how to space and drill the holes now arises. If the modeller is the fortunate owner of a dividing head for use with his lathe, the matter is quite straightforward. Slap the wheels one at a time (or even several at a time) on the dividing head and drill the holes, but note that it is advisable to go round first with a short "Slocombe" centring drill, fol-

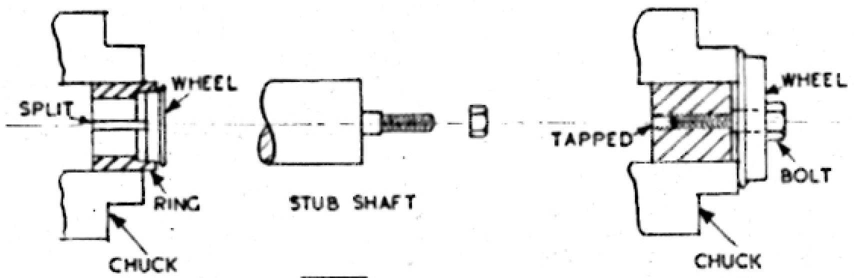

FIG 5

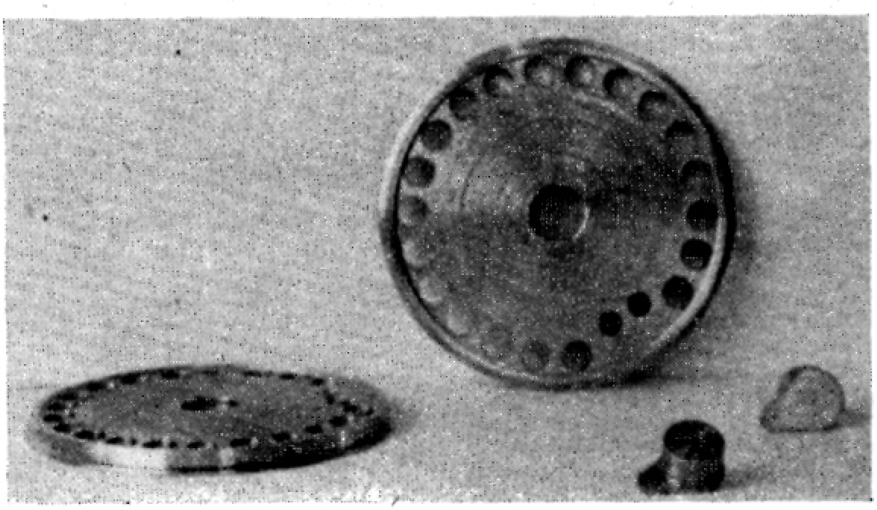

Fig. 6

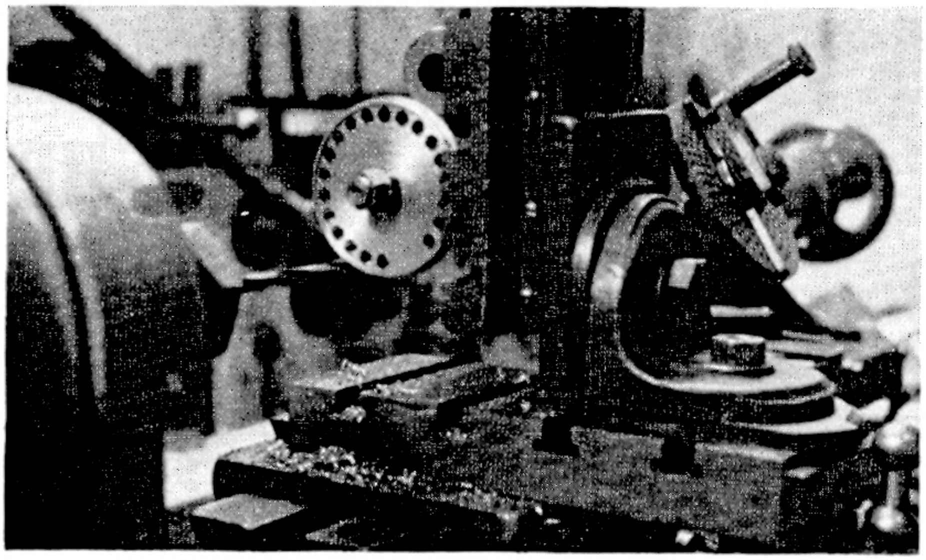

Fig. 8

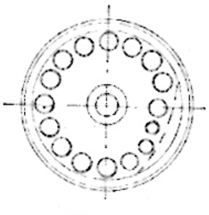

FIG 7

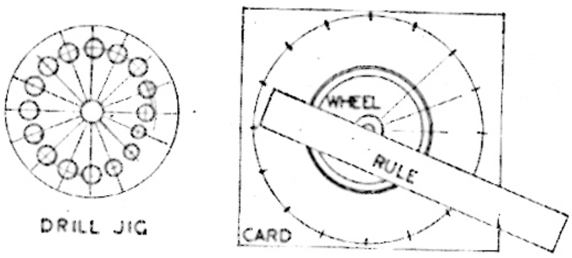

FIG 9

lowing up with the normal twist drill. This prevents the holes "wandering." Do not forget to shift the slide carrying the head when you come to the holes where the balance weights are and use a correspondingly smaller drill. Photo Fig. 8 shows a pair of 7 mm. scale drivers in steel mounted back to back on the author's home-made dividing head for drilling and Fig. 6 is the final result. It might be quicker to divide one wheel only and use this as a drill jig, clamping the others to it in turn and drilling off the first one.

If a dividing head is not available, a drill jig can be marked out on the lathe by chucking a flat disc of steel and fitting a change wheel from the screw-cutting gears to the other end of the mandrel. This change wheel is selected to have the same number of teeth as the number of spokes desired or a multiple, i.e. a 20-tooth change wheel would give 20 spokes by indexing one tooth at a time or 10 spokes by indexing two teeth at a time; a 60-tooth change wheel would give 12 spokes (five teeth) or 15 spokes (four teeth), and so on.

Ideally, for use with this method, a spring-loaded plunger to fit between the change wheel tooth flanks, and thus position it accurately, is desirable and my own lathe has one fitted to the reverse stud bracket, but the change wheel banjo plate could just as easily be utilised. Failing a special plunger, a pointer, set close to the change wheel teeth would serve just as well and this suggests still another use for the scribing block.

Whatever method is used to index the change wheel, the procedure on the disc for the drill jig is the same. Locate a scriber in the toolpost at centre height with the point facing the disc and, bringing the scriber point in contact with the face of the disc, wind the cross slide across the face and thus scribe a line radially on the disc. Index the change wheel to give the required division and repeat the scribing process until a set of scribed lines, equally spaced round the disc, and equivalent to the number of spokes, has been marked. Next, set the scriber to touch the disc at a radius from the centre equal to the radius of the circle on which the holes are to be drilled and rotate the lathe a full revolution so that a circle is scribed cutting all the radial divisions. Finally, drill a hole in the centre of the disc, equal to the bore of the wheel blanks. This is to take a screwed locating bolt with which the blanks can be positioned relative to, and bolted to the newly made jig. All that remains is to centre pop, most carefully, the intersections of the scribed lines and the circle but do not forget to move inwards a bit from the circle where the balance weights are to come. Now drill the disc at each centre pop using a "Slocombe" centre drill to begin with and opening out with the final drill last. Each blank is then bolted to the jig and drilled from it.

If one cannot obtain the desired number of divisions from existing change wheels, a card can be marked out using dividers, and then stuck to the face of a change wheel with a blob or two of adhesive as a temporary measure.

Make this card as large as possible in diameter to minimise errors (think in terms of 6 in. or more), draw a circle on it right at the edge and, setting the dividers from your drawing set to a distance equal to the circumference of the circle divided by the number of spokes, start off from a given point on the circle and lightly step off round the circle, counting the number of steps. If the dividers are set just right, they will come back exactly to the starting point having paced out a number of steps, or divisions, equal to the number of spokes, but it is unlikely that this will happen first time, so make a small adjustment to the setting of the dividers and try again until the division is exact. Mark the circle by pressing the divider points into the card, join these marks to the centre by a pencil line and there you are !

If the lathe is not a screwcutter, it is still possible to fit these discs to the end of the mandrel for making a jig or, the card can be placed on the bench, a locating pin equal in diameter to the bore of the wheel, driven through the card at its exact centre and into the bench top, and each wheel blank in turn can then be slipped onto the locating pin and the divisions marked off the card below on to the blank by means of a scriber and steel rule. You will need an accurately centred pop mark in the head of the locating pin to set the rule against and to put the divider point into when scribing the necessary circle to intersect the divisions. Having done this, drill as before. Instead of scribing out each blank, a jig can be made as stated or, one blank can be marked and drilled and then used as a jig for the remaining blanks. Fig. 9 shows the scribed blank or jig disc and the method of setting out by hand using a rule and card.

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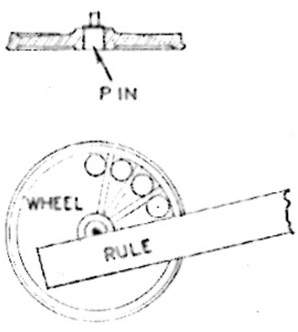

FIG 10

MAKING SPOKED WHEELS

(*Continued from page* 133)

Marking the spokes and fitting the cranks

Having drilled the blanks, the spokes require marking out on the face of the blank to provide lines to which one can cut when sawing out. Fig. 10 shows a pin turned to fit into the bore of the wheel blank and having a small extension equal in diameter to the spoke thickness. The pin is placed in the bore of the blank which is laid on the bench with the face, and the pin extension, uppermost. A steel rule can then be held with its edge against the pin extension, and against the edge of each drilled hole in turn, and the spokes scribed accurately.

Having marked in the spokes, the balance weight shape can also be scribed and the cranks sweated into position against the turned bosses using plenty of solder or solder paste to get a good fillet and to give the impression of a casting. These cranks should be of such a thickness that they stand well proud of the boss when they are soldered on so that they may then be filed down level with the boss leaving no indication that they are separately applied. The fitting of the cranks is left to this stage so that they may be located accurately relative to the balance weights and to the spokes themselves.

(*To be continued*)