Lathe Alignment

by Tubal Cain

DURING THE FAST few weeks "the works" have seldom been without some evidence that lathe alignment was in progress. First, the Lorch had to be moved, and as the shop floor is far from level any machine on its own stand must receive attention even if the move is slight. Then, a vintage Myford-Drummond was overhauled, to fill the gap between the departure of the trusty ML7 and the arrival of a Super 7. This involved alignment of the machine "within itself" as the headstock had been removed, as well as checking that bed, slides and tailstock had been truly re-scraped. Finally, the arrival of the Super 7 involved a third repeat of the exercise. In view of the general interest in this subject, and especially of the remarks and queries in Mr. Beck's first article, it seemed opportune to put a few notes on paper whilst the matter is fresh in mind.

The first matter to be dealt with, perhaps, is "why bolt the machine down at all?" This question has been asked in the correspondence columns of "M.E." certainly back to 1916 — the earliest copy I have seen. Contrary to Mr. Beck's impression, a lathe in conditions of zero gravity would be unmanageable. The law that "When the horse pulls the cart, the cart pulls the horse" is universal, and at every start of the machine the bed would rotate slowly round the contra-rotating spindle. If the work were not perfectly balanced, the headstock end would start to corkscrew ; and, finally, the whole issue would start to precess as a gyroscope. But the point is that the restoration of gravity would not cure these ills unless the total mass of the machine were very large in comparison with the forces involved. The bolting down — or fixing — of any machine tool is necessary to contain the forces due to out-of-balance, vibration, and starting reactions. And, of course, to enable you to rest your elbow on it safely, turn handles, and the like.

Now, certain machines are heavy enough in themselves to contain these forces, and this is especially true of some high-speed lathes, where the work and machine must be fully balanced to ensure that it is not distorted in the turning. Others, like milling machines, must, as a rule, be held down only against the vibration caused by the cutter. At the other extreme, the large shaper, if not securely fixed, would chase the operator round the shop. Note, I have said "fixed". Bolts are not the only means, and I have stuck many a large machine tool to the shop floor with glue. The point here being that unlike the amateur's workshop, machines in production shops and research laboratories must frequently be rearranged to suit the flow of work in hand. Sticking them down saves time and does not leave a lot of holes in the floor when they are moved. So, we "fix" the machine somehow to contain the forces — and, incidentally, as Mr. Beck may have found out, to stop them from falling over backwards. The C.G. of a Myford is not far from the centreline of the rear holding-down bolt!

Second — why level? Only for convenience. Not all machines (lathes, that is) have level beds. Indeed, the vertical boring mill- the "roundabout"- is no more than a vertical lathe, with the headstock in the floor and the saddle running up and down a vertical bed. We had rows of these in the works, machining cylinder heads for 24 in. diesel and gas engines, and some very large ones for the big flywheels. *Some* production lathes have the bed at an angle across the machine, which facilitates chip flow away from the work, and I have seen a lathe design in which the axis was up at about 30 deg., with the headstock at the high end, and the operator in effect sitting on the tailstock.

There is no magic in "level" except that it is by far the easiest angle to reproduce. If the lathe bed is known to be truly level, any subsequent setting up work- on the vertical slide, for example-can be done using no more than a reasonable quality spirit level. Further, it is very useful for erection jobs to have one surface in the shop which is known to be true and, for the amateur, the lathe is the most convenient surface to hand. For these reasons even in production shops machines which were either not bolted at all, or were to be glued down, were all equipped with four jacking screws which bore on steel plates on the floor.

Why four? Repeatedly in articles I have seen the proposal that machines should have but three supports, on the argument that there would then be no fixing strains. Indeed, a ***Model Engineer*** competition, held a good many years ago, to find the "perfect" lathe showed the majority of the drawings specifying two supports at the headstock and one at the tailstock end. This reveals an understandable misapprehension of the purpose of the alignment process. It is assumed that the object is to support the machine so that it is free of all strain. In a perfect world, this might be true, but even then the weight of the machine parts would introduce strains not present when the bed alone was machined. This is especially true of the modern small lathe with a motorising unit attached to the bed as a cantilever structure ; at a guess this unit applies a torque of around 200 lb./in. to the bed of the Super-7, far more than any cutting forces likely to be applied.

The world is not perfect, either, and the best jigs in the world it cannot be assumed that a lathe bed is mounted on the surface grinder entirely free from strain. This did not matter in the days when bed surfaces were all scraped true, as any distortion would be corrected at the second operation. Costs won't permit this nowadays- and in any case, the ground surface is superior. So that it may well be that that the odd bed, ground perfectly true on the machine, will spring a little when taken off.

The object of machine alignment, therefore, is first, to re-introduce any strains that were there when the bed was machined originally, and second to compensate for any which have been added by the attachment of motor, gearbox, taper-turning attachment, and so on. It sounds a formidable undertaking, but fortunately it can be achieved with little difficulty. You do not, in fact, need any instrument more advanced than a really good pair of firm joint calipers, though dial indicators, micrometers, and block levels will help. You can, in fact, get tied in knots because your instruments are too sensitive. When I first moved into the new shop here I borrowed a precision block level in which one division indicated a discrepancy of one part in 24,000; moving my weight from one foot to the other would move the bubble appreciably due to the deflection of the floor! If you can detect 3 thou. per foot error, this is sufficient. But, as I said before, you ***can*** do the job without.

Before dealing with the process of setting up, a few words about bolting down. If you are using a stand designed for the machine, it is only necessary to ensure that this is reasonably level and not strained when screwed to the floor. A carpenter's level is good enough for this job, as the object is simply to reduce work later. If the floor is concrete, simply fit shims under the feet until the stand is level and does not rock. Don't be content with shims on one side of each bolt — let the bolt be supported by shims on both sides; the ideal is to use U-shaped ones, but one is always in a hurry to get the machine working at this stage! If the floor is timber, then I prefer to use really hard plywood (wood-worm proof, please ; you don't want to find the shim has dissolved into dust in a year or so) and always cut a U-shaped slot to pass each side of the bolt or screw. Dry these by the fire, and give them a coat of varnish. Once the stand is level, follow the maker's instructions with regard to bolting the machine to the stand. There is a variety of jacking screw arrangements, and each maker has his

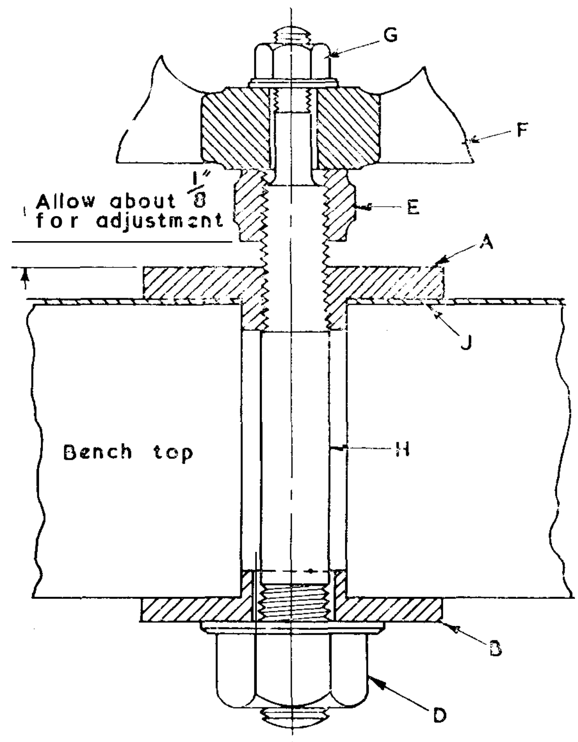


FIG. 1

own ideas. Set the lathe on the supports ; don't bolt it down-leave it overnight for everything to settle, especially if on a wooden floor.

If the machine is to go onto a wooden bench, as mine is, then it is important to provide a supporting and jacking arrangement which will reduce the risk of crushing the timber. If the machine is a modern Myford, then the purchase of the steel drip tray and a pair of raising blocks is a good investment. If not, or if the purse won't stand it, then Fig. 1 shows an arrangement that will serve very well. A and B are large diameter washers to spread the load over a reasonable area of timber — about 2 in. or 3 in. diameter-with a 1 in. dia. collar to centre them in the fixing hole in the bench top. Note that the lower one has a clearance hole for the screw H (which should be at least ½ in. dia.), but the upper one is tapped. The length of the screw is sufficient to allow for the nut D (square for preference) and the jacking nut E. F is the lathe foot, and the screw must either be reduced in diameter at the upper end to pass through, or (as mine always were) a smaller stud screwed into the end of the larger screw. G is the lathe holding-down nut. Don't forget to allow for washers under the nuts. If you intend

to fit a metal drip tray or even just a metal surface to the bench, then arrange it as at J. In use, the large washers and the screw are loosely assembled in the bench and the nut D finger tight, till you have established that the centres are correct. The large nut D is then tightened up, really hard, and the jacking nuts E run on. Mount the lathe, but don't tighten it down- just slip the nuts on sufficient to prevent it toppling over. Leave overnight for things to settle. Then, if need be, tighten the big nuts a little more. You now have a four-point jacking system as good as any. One point, however, is worth attention. Use a coarse thread- Whitworth — for the nut D and BSF for A and E, and make sure that A is at the end of the thread before assembly.

Now to the setting up, the procedure being the same, however the machine is fixed. I shall refer to "jacking screws" throughout ; this means a jacking nut as well, or to the insertion or removal of shims if no jacking arrangement is available. The word "level" refers to a block level of sensitivity about 3 thou. per foot. If you haven't got one, you may be able to borrow one from the local Technical College provided that you sign for it — and are able to pay for it if you drop it! Any other sort of level will be mentioned as such. Dial indicator (or DTI) means one reading in thousandths -it just isn't worth messing around with the more sensitive ones ; they are great liars, very prone to stick — and similarly a .001 in. (or .01 mm.) micrometer will do. If you have none of these, then you must get a good pair of firm joint calipers; without these you cannot manage; with them you can do well. If you are going to use a dial indicator, then you will also need a parallel test bar. You should have one of these handy anyway ; here again the local Technical College may oblige- it is the sort of exercise carried out by some of the Craft and Technician classes. Get them to make you one about 1 in. dia. and a foot long ground between dead centres. The diameter doesn't matter at all provided it is parallel and round. Such a bar is very helpful in setting up the tailstock back to parallel after taper turning. Failing this, use a piece of ground stock not less than ½ in. dia., and preferably larger. Make sure it is straight ; much silver steel is true to diameter, and round, but not always straight.

Levelling method

Adjust all the jacking screws until the lathe does not rock, and then set the level across the bed at the headstock end. Adjust the screws at the headstock only to level the bed. Set the level along the bed, and adjust the tailstock screws until the level bubble is central. Do this adjustment with the front screw and follow with the rear, taking out the rock. Now set the level across the bed at the tailstock end, and adjust the two tailstock screws. Return to the headstock again, and repeat the whole process. Now tighten all four lathe holding-down nuts, reasonably but not fully tight. Start again at the headstock, but this time you must first slacken the holding-down nut before altering the jacking screw, and then retighten. Carry on again as before. You may have to do this several times. If you find inconsistent results check (a) that the level is true ; it should read the same whichever way round it is used. If not, use it both ways and split the difference (b) that your floor is not so flimsy that your weight moving around is deflecting the level, (c) that the bench is not being rocked by your leaning on it. In the case of (b) or (c), add more stiffness!

If your lathe has raised Vee guides, then you will either have to apply parallels under the level to clear the guide rib, or set it on the cross-slide and run the saddle back and forth along the bed. The former is the better method if your parallels are to be relied upon. Try them both ways round, as suggested for the level. Once you are satisfied, tighten all the holding-down bolts, and check the job once more. Note that you may have to repeat the process in a few weeks time, especially if you have a wooden floor, as things may shift a bit under the vibration of the machine. I usually check my machines at pension time- once a quarter!

Dial Indicator Method

Thoroughly clean the mandrel nose and the three-jaw chuck, both on the screw and the jaws, and fit it carefully. If you don't know which is the "preferred socket" for the chuck key, check it now. Set your test mandrel in the chuck, gripped full length of the jaws, and set up the DTI with the absolute minimum of overhang of the pillar, etc., in the toolpost. Apply the indicator to the bar as close to the chuck jaws as you can get, disengage the bull-wheel from the pulley, and spin the chuck slowly, noting the variation on the indicator. If it is more than ±0.003 in., send it back (or clear out the dirt!). Now, slacken the chuck, and retighten at socket No. 1. Note the reading. Slacken, tighten at No. 2 socket, and note; repeat for No. 3 socket. The socket which gives the smallest runout is the one to be preferred for accurate work *on that diameter.* Unless the chuck has a ground scroll, it may well do better or worse on another size of bar. (I mark my own chucks with yellow paint on the sock& that does best at 1 in. dia.)

Now set the bar with about 5 in. or more stick-

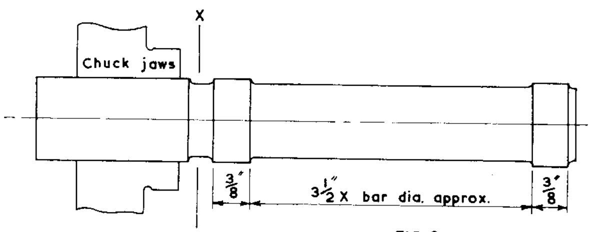


FIG. 2

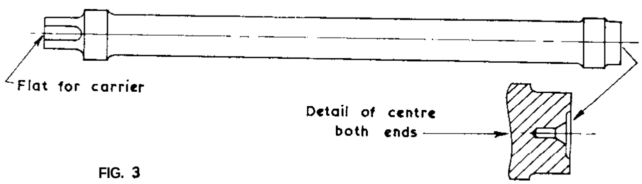


FIG. 3

ing out, tighten with the preferred socket, and find the high and the low point under the dial indicator. Midway between these should be "correct". Mark the chuck, traverse about 4 in. away and repeat. The "correct" position should be the same, or nearly. If it isn't, the bar is bent. (You must then get another ; this method won't work with a bent bar.) With the bar in the "correct" position, the DTI should read the same both close to the chuck and 4½ in. away, if the bed is true. But it may read as if the bar were .0003 in. towards the DTI at the 4½ in. position. If so, leave it alone. This is not only permissible, but desirable ; it means that the work is leaning towards the tool about quarter of a thou. in 4½ in.-and when cutting, the workpiece will bend away from the tool, so that a parallel cut will result. If the deflection is bigger then you must adjust the tailstock jacking screws. Front jack up if the free end leans ***away from*** the DTI ; rear jack up if it leans ***towards*** the DTI. You should, of course, have levelled the machine as well as you can with an ordinary level, so that you have the convenience in setting up later, before you carry out this procedure. As before, it will be necessary to repeat the check after a little while.

Turning Test Method

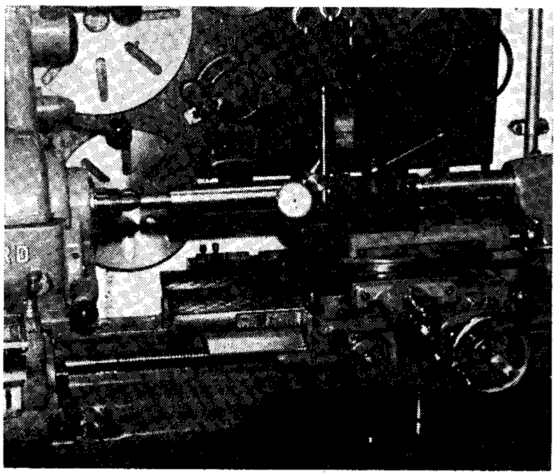
I always use this method after having set up the machine by one of the other means ; it is, after all, the final arbiter-that the machine turns parallel. Fit the three-jaw as before, and find a piece of stock about 6 in. long and large enough just to fit right inside the chuck jaws ; the larger the better. (Sorry! First set the machine up as level as you can, and take out the rock in the jacking screws. Tighten the holding-down nuts finger tight or a little more.) Get a good hold of the bar, but don't strain the chuck. Take a cut along the middle length of the bar to reduce it about 3/32 in. less in diameter than the ends, so that it appears as in Fig. 2, where the line XX is the closest the tool can come safely to the chuck jaws. This need only be a rough cut. Now, with finest power feed, take a cut along the two bobbin ends, to take out any ovality. Say about .005 in. or so. Remove the tool, and resharpen, honing the cutting edge on an oilstone to a fine finish. Set it up at centre-height and take a very fine cut -not more than .003 in.- across each bobbin. Use the finest power feed you can get with your change-wheels. (If you experienced any chatter in the preliminary cuts, you must reduce the speed till it goes before doing this final cut.) Measure the two bobbins with the micrometer. If the free end is large, jack up the ***front*** jacking screw at the tailstock end ; if ***small*** jack up the ***rear.*** Again, if the free end is only a few tenths large at this light cut, you may do better to leave it alone, but it should not be more than .0002 in. Now tighten the machine down properly, and repeat the test, adjusting as necessary.

It is not essential to use steel for this job, though I always try to use free-cutting steel. Brass will be just as good, but don't use aluminium, which may build up a "nose" on the tool, and interfere with the cutting. I usually run the tool dry, and it is important to keep your hands off the machine whilst the bobbins are being cut. Lean on the tailstock, and it will upset things!

Using Calipers

The above method can be used perfectly satisfactorily, though not absolutely perfectly, if you see the difference, without a micrometer. It may be difficult for the "Mike Brigade" to believe, but if you use it properly, a caliper will detect less than half a thou.! Note- I said "detect", not "measure". I doubt if the rule and calipers can be set to better than .01 in. — ten thou. — but in this case we are concerned not with the actual diameter of the bobbins but that they should be the same diameter. Make this simple test. Chuck a piece of 1 in. stock in the three-jaw and take a light cut with fine feed to true it up. Set the top-slide over to 11 deg. ; hone up the tool edge and set it so that it presents to the work at the correct attitude. An advance of 1 thou. on the top slide will now advance the tool about .0002 in. Bring the tool close and lock the cross-slide. Take a very fine cut with power traverse-about 10 divisions on the top slide-over a length of about ¾ in. Traverse back with the saddle and put on a cut of one division on the top slide, and machine about ⅜ in. of the bobbin at this setting.

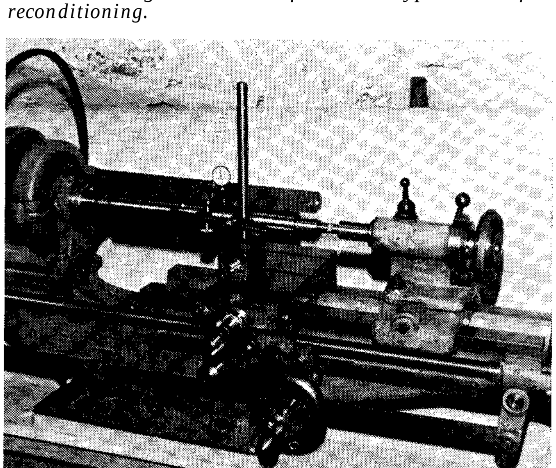
This will give you a workpiece with two diameters, one .0004 in. smaller than the other. Set the calipers to the large diameter, and then try them on the smaller. If you have set them in the correct manner, you will easily notice the difference. The tool must, of course, be really sharp and honed to a fine finish, or it will not cut this small amount.



Aligning the tailstock with a mandrel between centres.

What? The correct manner? Very well, here it is. To open the calipers, tap the hinge on the top of the tool-post; the lighter you tap, the less it will open. To close, tap the back of one of the caliper blades, holding the calipers at the hinge. It is as simple as that, and it always curls my toes up to see chaps "setting" calipers by ramming them across the workpiece, and then applying them to the rule. They will be reading from 1/64 in. to 1/32 in. out that way. Mark you, they must be good calipers, and frankly, I find the old "firm joint" type far better than the screw adjusted ones. My own Sunday best pair are part of a little set which were given away by Messrs. Chesterman at Christmas over 35 years ago-a set of feelers, a folding rule, and a pair of calipers, all in a little pocket case. They have been in continuous service since then, never needed adjustment, and have a lovely feel about them. (My "second set" were made by my grandfather, about 100 years ago. Made, he told me, from the blade of a worn-out iron-ore shovel, with brass washers on the rivets. These, too, work very smoothly still.) You have to develop the feel, of course, but this comes quite easily. The tool must be held very lightly by the hinge, and when properly set will just hesitate and then fall over the work almost by its own weight. The workpiece two-tenths small, and they won't hesitate, if properly set before. True, if unbelievable!

Below: Testing the shears of an "M" type lathe after reconditioning.



After which diversion, to return to the setting up. The procedure is exactly the same as with the micrometer, except that you use the calipers to test the diameters of the bobbins.

It may take a little longer, as when the job is nearly right the need to detect by feel will mean several checks on each bobbin. Incidentally, I always find it helps to develop increased sensitivity if I close my eyes when applying the calipers. (Similarly when fitting a nut or some other object which is out of sight!) If in doubt about the sizes of the two bobbins, aim at getting that at the free end slightly the larger of the two, for the reasons mentioned earlier.

The "No Strain" Method

This is the method advocated in a number of books on Amateur Turning, and in some lathe makers' leaflets. The machine is set up with the mandrel locked and a bar about 1 in. dia. and 8 in. long in the three-jaw. This bar need not be true -a piece of normal b.m.s. will do. The bed is set as level as is possible with whatever spirit level is available, using the jacking screws and the procedure as for setting up with a precision level. It is *not* bolted down at this stage. A dial indicator is set up in the tool-post, about 6 in. from the chuck, and carefully set to zero.

The cross-slide should then be locked and the saddle too, to avoid accidental movement, but only a very gentle application of the locking screws. Recheck the DTI. Now tighten the holding-down nuts. The dial indicator will almost certainly deflect.

To be continued

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ADJUST THE JACKING SCREWS at the tailstock end until, when all holding-down nuts are tight, the DTI still reads zero. The bed will now be held in exactly the same geometry as applied when it was free under its own weight.

If this method is used, it is essential that it be followed by a recheck using the Turning Test. As mentioned earlier, it is not safe to assume that the free bed will not be twisted if the motor and motorising unit is attached to the bed itself. You can check this for yourself by setting up the test as above, with the DTI at zero. Now remove the motor belt, and set a block of wood under the motor so that it is just taking the weight. Release the motor support platform arms, so that the motor rests on the block and is not restrained by the tension arms. Observe the DTI. The deflection indicated is that caused by the motor-or part of it, for some of the weight of the motor is still taken by the hinge of the platform. The actual twisting of the bed will be greater still, for there remains the weight of the countershaft and associated components hanging on the back of the machine.

Setting the Tailstock

Whilst the gear is about, it is worth spending a little more time setting the tailstock true — though with a new machine you will usually find it pretty close when delivered.

First check that the headstock centre is true; if in any doubt, set the top-slide over and machine the centre to 60 deg. If you have a test mandrel that is centred at both ends, and a DTI it is only necessary to set up the latter and take readings at both ends of the bar, adjusting the tailstock until the readings are the same at both ends. Again, if that at the tailstock is a few tenths *towards* the tool, let it be ; the tailstock will deflect a trifle under cuting loads. (You don't believe it? Just try leaning on the tailstock as if you were tired, and observe the DTI whilst you do so!) If you have neither DTI nor mandrel, then you must use the bobbin and turning method, and whilst you are about it you might as well make a proper bobbin bar for subsequent use after having set over the tailstock for taper work. Use stock between 1 in. and 1¼ in. diameter, centre both ends -make it about 12 in. to 14 in. long, no more or you may suffer chatter -and turn ¾ in. down at one end to take the carrier; file a flat on this for the pinching screw. Face the ends, and turn a little recess to protect the centre holes. Relieve the bar as shown in Fig. 3. about 3/16 in. on the diameter, leaving the two bobbins which should then be turned with a fine cut. It is worth making the inner edges of the bobbins an exact (or "aliquot") dimension-say 10 in. to 12 in. — as you can then use the bar to set up tapers with the minimum of calculation. The procedure is then quite simple — just take a very light cut over each bobbin and adjust the tailstock until they are the same diameter after cutting. When this has been done, it is worth taking a few thou. off the body of the bar, which will then be parallel, but take only light cuts, as the bar itself will tend to deflect under tool pressure.

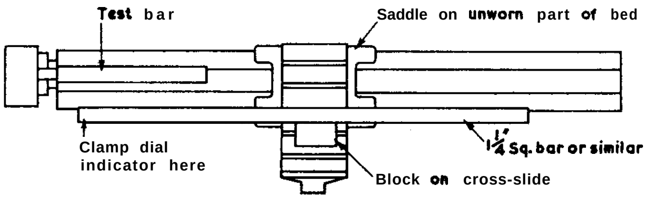

FIG 4

Setting up a Worn Lathe

This is the problem which exercised Mr. Beck, and has worried many thousands of others, too ! Fortunately, most of the wear will be on the back and front, and on the underside of the shears, not on the top, so that if the first few inches of the bed nearest the headstock is avoided, the machine may be set up using the levelling method with reasonable confidence. The machining method is unsafe, as both bed wear and headstock bearing wear may mislead. Fig. 4, however, shows how the DTI method may be applied. First, lubricate the headstock with thicker oil than usual, to take up bearing clearance. (Don't forget to wash the bearings out and re-oil afterwards.) Set up a hefty bar (clamp it to a block on the cross-slide) so that the DTI may be applied to the mandrel in the chuck whilst the saddle is sitting on a part of the bed that is less worn. Most of the wear on an amateur's lathe is on the first few inches of the bed -indeed, I think many model engineers have the drill chuck stuck fast in the tailstock, and would be hard put to it to find their tailstock centre ! Now, the main snag will be wear in the saddle itself. This will mean that as the saddle is traversed it will rock, bringing the DTI nearer the mandrel as it is traversed towards the headstock, and vice versa. To reduce this effect, first take up some of the slack in the gibs, but not so much as to make the saddlestiff in the ways. Then before taking each DTI reading, traverse the saddle a little towards the tailstock, using the leadscrew handwheel or rack handwheel to choice, whichever suits you best. This will rock the saddle over the same way each time a reading is taken. One important point will be observed in Fig. 4. The bar holding the DTI is shown hanging over *both* sides of the saddle. This is to prevent the weight of the bar from rocking the saddle over in the vertical plane, the free end acting as a counterweight.

Once you have set the machine up in this fashion, it will pay to make a test cut on (say) a 1 in. dia. bar in the chuck, just to see how far out it is. You may well find that the main trouble is slackness in the gibs causing chatter, rather than taper turning. Of course, the proper thing to do is to correct the wear — which, with a flat bed lathe, is not too difficult-but that is another story!

Other Tests

You can make a complete check over the geometry of a lathe in an evening, if you have the mandrel, a DTI and a ground flat parallel. These tests should be:

Spindle Arose: Internal taper true. External register true. Face of shoulder true. End float in spindle, nil.

Headstock: Mandrel in taper hole, or held in chuck. Truth in horizontal plane. Truth in vertical plane.

Centres: Bar between centres, checked for truth in both vertical and horizontal planes.

Saddle: Top-slide traverse parallel with bed in vertical plane. Cross-slide at right-angles to spindle across the bed-concavity only permitted. For this test clamp a parallel in the faceplate — the latter should be concave.

Tailstock: Truly aligned to headstock. Spindle when extended and clamped to be parallel to bed in vertical plane. Parallel to lathe axis in horizontal plane.

In all cases you should expect to find a tolerance -- it would be prohibitively expensive to manufacture machine tools so that it passed every test "spot on". The makers' tolerances for the Lorch precision lathe were: Spindle nose — .0004 in., end float zero. Headstock — .0004 in. per foot, mandrel not to lean away from the tool or towards the bed. Centres — .0004 in. towards tool at tailstock permitted in full length of bed. Saddle — top-slide parallel to bed to .0008 in. per foot ; cross-slide — concavity not to exceed .0004 in. on radius of faceplate. Tailstock — .0004 in. rising in vertical plane or towards tool in horizontal, in its length. On the recent check test, all measurements were within these tolerances. A 6 in. centre-height commercial quality centre-lathe would be expected to hold figures about twice those above, except those for the spindle nose, where the normal tolerance is about .0005 in. In passing, it should be noted that that maid of all work, the 3-jaw chuck, will have a tolerance no better than .003 in. in manufacture, over the range of effective diameter. The *accurate* work holding tool for concentricity is always the 4-jaw chuck ; even collets are made to a tolerance!

One final word about the mounting of lathes on wooden benches. There is no doubt at all that these can, if precautions are not taken, warp sufficiently to throw a machine out of alignment in a matter of hours, but in my own shop, very little movement takes place. First, the timbers are very robust — the top is 3 in. thick. Second, all joints are glued as well as bolted, and the triangulated struts make a very rigid structure. Most important, however, the wood used was all stored in the shop for several weeks, under the normal heating conditions, *after* being cut for joints etc. The whole was then varnished — three coats in all — after assembly. Geometric changes in the bench itself are very small; the chief trouble is floor deflection when, for example, a heavy piece of equipment is moved in or out. If I were doing the job again the only change I would make would be to have the lathe on a separate bench. This would have enabled me to assemble the machine with access to the rear, and then move bench and machine into place — far easier than leaning over bench, machine, and tool rack to get at an inaccessible Allen screw in the motor platform!

At the Guildford Rally: Mr. Smith of Wickford, Essex drives his 3 in. scale Wallis & Steevens traction engine.