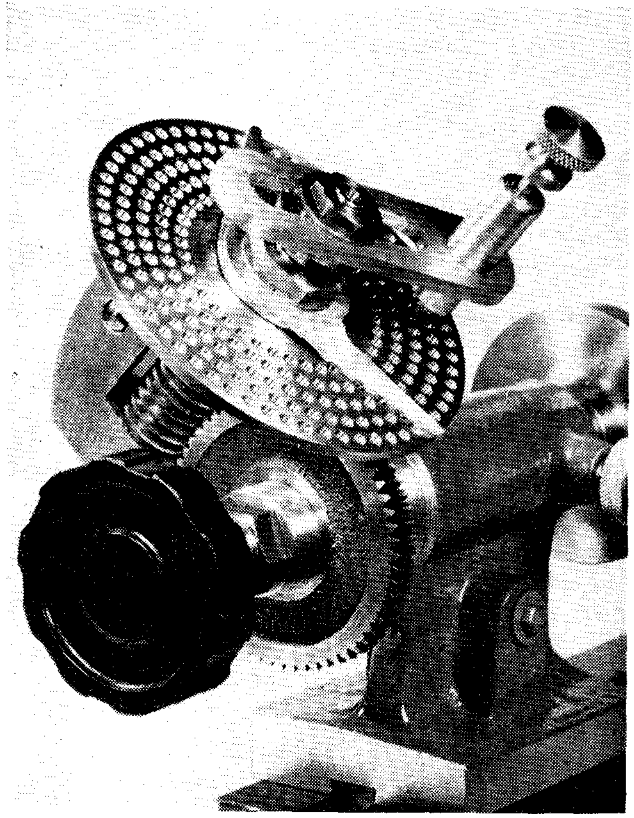
Continued from September 1



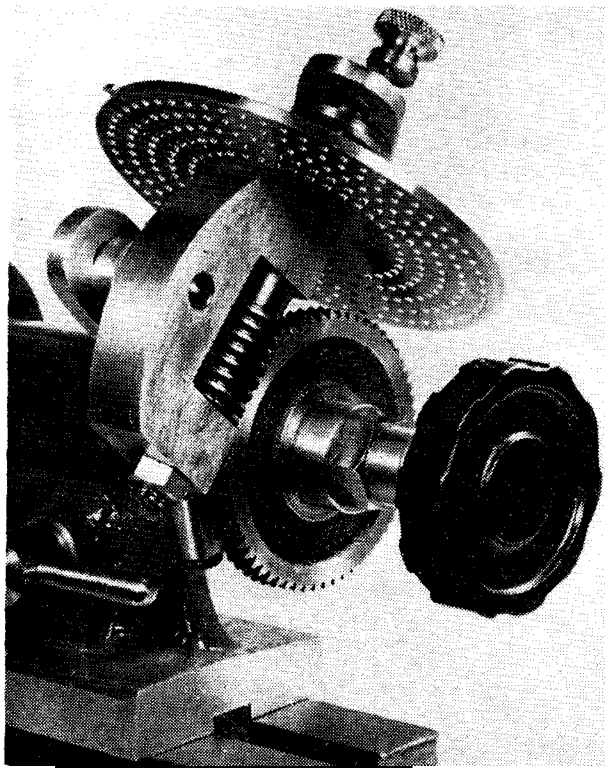
LAST STAGES : making the components of the dividing head

by Edgar T. Westbury

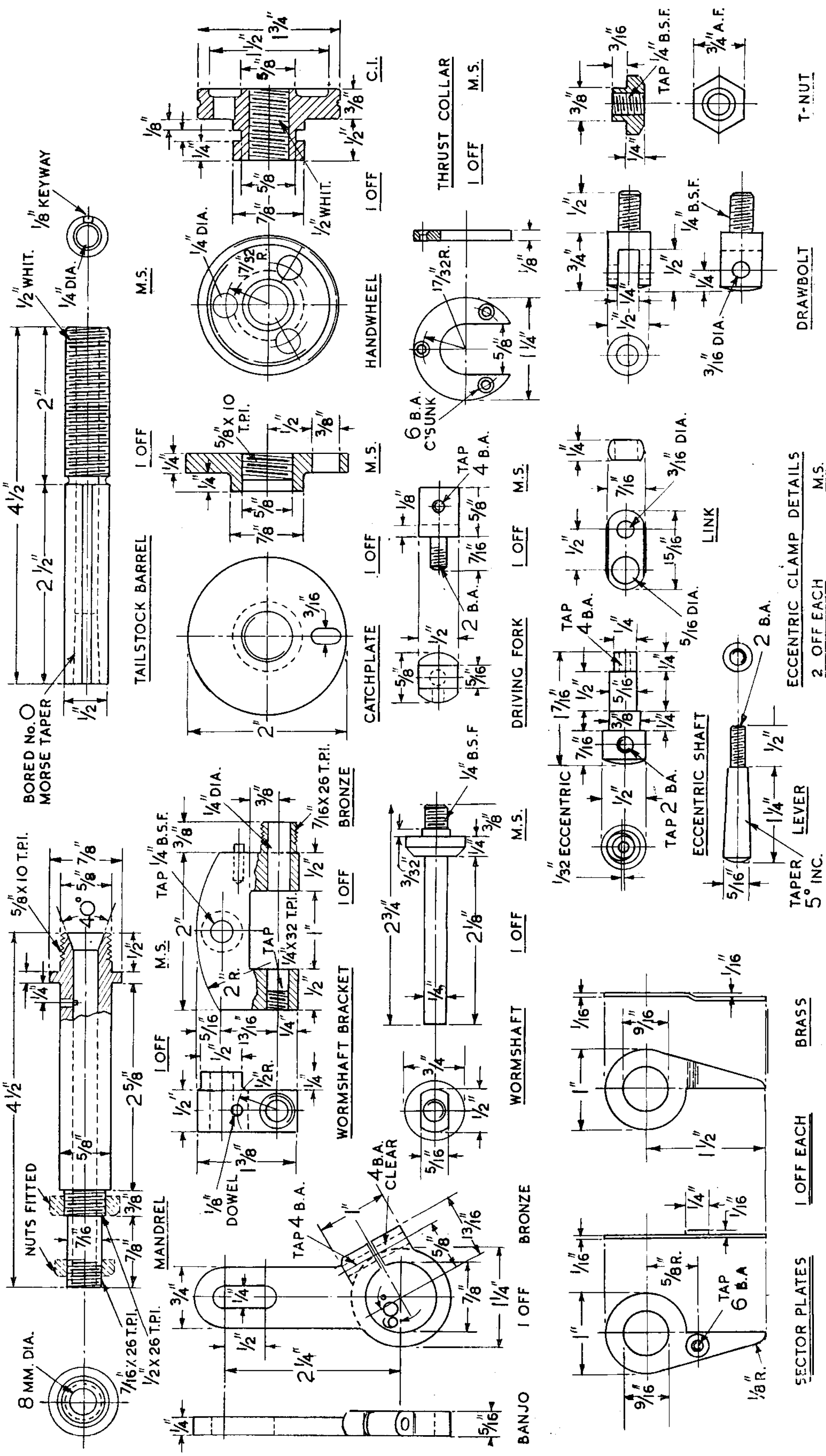
SOME may prefer to bore the mandrel to No o Morse taper to take a standard centre; they should exercise great care to preserve accuracy in the boring of the socket. Similarly, the screwed mandrel nose, to take a catchplate or even a chuck, is an optional fitting, but its usefulness is beyond question. The nose thread (and preferably the other threads as well) should be screwcut, and the register, and the front face of the collar, turned smooth and true. As the bearing of the mandrel is not provided with any means of taking up play-which should not be necessary in a fitting not subject to ***running*** wear-the mandrel must obviously be made to a close initial fit. A superfine Swiss file, or better still a ring lap, may be used to fit it to a fine clearance, but it should not be lapped into its bearing.

The fine thread immediately behind the bearing surface is given either a hexagonal or circular nut, which is adjusted to take up end-play. Adjacent to this, the mandrel is turned down to 7/16 in. to fit the bore of the worm gear, and a further fine thread is cut on the extreme end, and provided with another nut. In clamping the worm gear endwise, this nut locks the first nut after it has been adjusted. Both must be faced parallel and true with the threads. The pitch specified, 26 t.p.i. in the two diameters, conforms to British brass and copper pipe standard. If you do not have taps and dies to suit, a different pitch may be preferred, such as 24 t.p.i. which is easier for screwcutting, as it is a multiple of 8 t.p.i., now generally employed for the leadscrews of small lathes. But a fairly fine pitch thread makes for accuracy and ease of adjustment, and I do not recommend anything much coarser.

The tailstock barrel, on which the operations may follow a similar sequence, can be made from a piece of standard 1/2 in. bright mild steel rod provided that this fits the bore of the casting, and that it is set up dead true for centring, drilling and later operations. The taper boring of the socket, to an included angle of very slightly under three degrees (0.625 in. ***per*** ft), calls for the use of a long boring tool



Headstock with division plate sectors and indexing arm (top) and the rear view, with the worm gearing



of such a small diameter that its rigidity can never be all that is desired. If you are able to use a reamer for finishing the taper, it will make things easier. The barrel may be located from the bore, as for the mandrel, for cutting the external thread and carrying out any other operations.

I strongly advise you to screwcut the Whitworth standard thread, though you may use a good die nut for finishing it. If dies are relied upon for cutting the thread, there is a risk of a pitch error which may cause it to jam when engaged with a deep thread, such as that of the tailstock handwheel. To simplify the run-out of the thread at the left-hand end, a groove may be cut in the barrel as shown; it should not be cut with a square-ended tool, as sharp internal corners tend to weaken the barrel at its point of minimum cross section. To feed the barrel forward by right-hand rotation of the handwheel you should use a left-hand thread; but in view of the added difficulty of cutting the external and internal threads, this matter will not generally be considered of any great importance.

Finally, a keyway needs to be cut along the plain part of the barrel to keep it from rotating when in use. This may be done by either side or end milling, as may be more convenient. I used a 1/8 in. Woodruff cutter, set to the centre height of the barrel, which was clamped in a pair of V-blocks on the milling machine table.

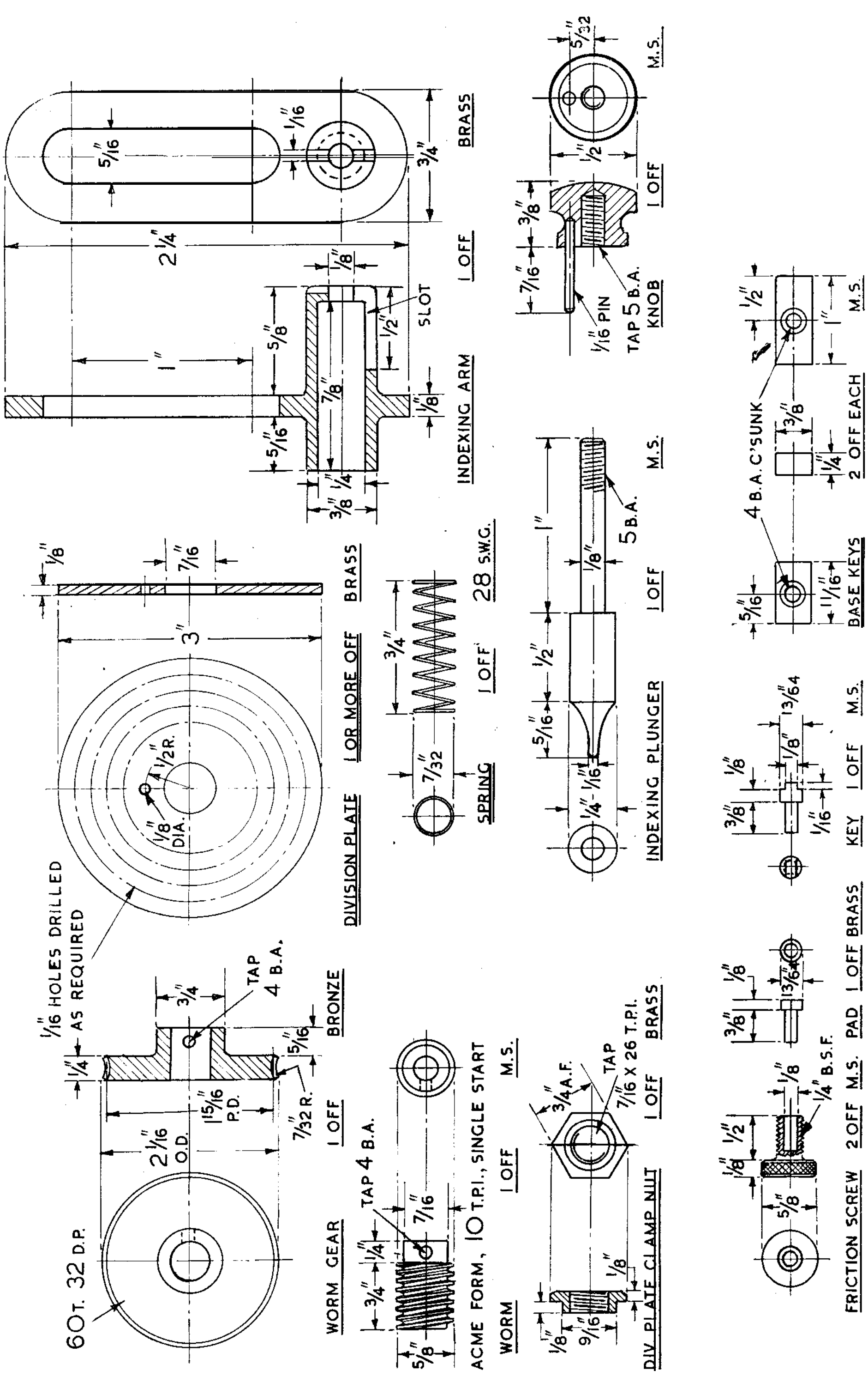
The tailstock handwheel should be made of cast iron for preference, as this has good wearing properties for both the internal thread and the thrust faces. Hold it over the rim for turning the boss and boring the centre hole. Screwcutting is recommended for producing the thread, though you may use taps if care is taken to obtain axial and concentric truth.

You can carry out the remaining operations by mounting the casting on a screwed stub mandrel. These operations include grooving the boss, facing and recessing the back, and turning the outer rim, which should be knurled or serrated to provide a hand grip. One hole at least must be drilled through the disc, to provide access to the screws in the thrust collar. Three holes are better, allowing all three screws to be manipulated at one handwheel position.

The collar is simply a steel disc faced parallel on the two sides to fit neatly in the handwheel groove, and cut out as shown so that it can be assembled. After the screw holes have been drilled and countersunk, it may with advantage be case-hardened. In marking or spotting the holes in the tailstock casting for attaching the thrust collar, make certain that it is correctly aligned, so that the handwheel works freely on both the thread and the thrust bearing.

Either cast iron or mild steel may be used for the catchplate, the machining of which follows much the same sequence as with the handwheel. Although the accuracy of this part is not so critical as that of a lathe faceplate, care in screwcutting and boring the register is well worth while. As the work must be coupled positively to the catchplate, without backlash, the ordinary driving pin is replaced by a fork with a side screw to grip the carrier; or a special forked carrier, which provides the same facility, can be employed. These fittings are, of course, used only for work which is mounted between centres; for many jobs, you will find it more convenient and efficient to hold the shank or arbor in a split collet, and remove the catchplate to provide more room for the run of the cutter.

The fittings for the headstock include the banjo and the wormshaft bracket, both of which can be made from bronze or gunmetal castings. Machining is simple for both parts; the banjo should be bored and faced on the boss to fit on the seating of the headstock. After drilling and tapping for the clamp screw, split it through the centre of the lug, and clean up and slot the front end by filing or milling. You may set up the bracket in the four-jaw chuck for drilling, tapping and facing the mounting boss; then you can mount it on an angle plate for drilling the bearing, facing one end, and turning and threading the seating for the division plate. At the other end, the hole is reduced to tapping size, and threaded to take an end play adjusting screw, with lock nut. The inner end of the main bearing must be spot faced or otherwise machined, to form a thrust seating for the boss of the worm.



To avoid the need for turning the wormshaft down from 3/4 in. dia., you may use a piece of 1/4 in. ground steel rod, with the flange screwed on tightly and machined in place. Flats on the front of the flange form a key to locate the slotted indexing arm, which is clamped to it by a nut and washer.

After the worm has been fitted to the shaft, it may be fixed either by a taper pin or by a socketed screw sunk well into the shaft surface.

To prevent inadvertent movement of the headstock mandrel and the tailstock barrel, simple friction screws with knurled heads are used. They are drilled centrally 1/8 in. dia. to form sockets which receive the shank of a brass pad and a flat key. The pad eliminates any risk that the mandrel surface will be bruised, and the key prevents the barrel from rotating, besides serving to clamp it endwise when required.

Make the keys to fit the base of each casting from short pieces of 3/8 in. X 1/4 in. rectangular mild steel. They must be a good fit both in the machined grooves of the base and the T-slots of the machine table. After drilling the holes for the fixing screws, put the keys in place to spot the tapping holes in the base.

The components for the clamps of both the headstock and tailstock are identical. For the eccentric shaft, a piece of 1/2 in. mild steel rod may be used. It is held in the chuck with a little over 1 in. projecting. The end is turned down to 1/4 in. for a length of 1/4 in., and drilled and tapped for the retaining screw, and then a further length of 3/4 in. is turned to 3/8 in. dia. You may repeat this procedure on the other end of the rod, *or* on a second piece, before you set it over about 1/32 in. in the four-jaw chuck to turn the eccentric part to 5/16 in. dia. Before parting off and rounding the head, drill and tap the cross hole, at right angles to the plane of the eccentric throw. The lever, turned to the shape shown, is permanently screwed into this hole in the most convenient position.

Drawbolt and link

Steel rod of the same size can be used to make the drawbolt. Instead of turning the screwed end first, you will find it easier to face and round off the other end, from a piece of substantial length, and hold it in the lathe toolpost for milling the slot. A 1/4 in. hole may be drilled in the centre to reduce the amount of metal which has to be milled away. You may drill the crosshole as well, so that its squareness in relation to the slot can be checked by a piece of 3/16 in. rod when it is set up for milling. The piece may then be cut off to a total length of 1 1/4 in., and chucked for turning down and screwing.

The link is made from rectangular steel bar, 7/16 in. X 1/4 in., rounded off on the sides to give clearance in the vertical hole in the casting, and drilled as shown. A piece of 3/16 in. steel rod, inserted through the link and drawbolt and filed flush at the ends, forms the pivot. You may think that the T-nut should be made square; but hexagonal nuts have been used, to give six positions of adjustment instead of only four. When the clamps have been assembled in their castings, the eccentric shafts are kept in place by a large washer and an end screw in each.

I give the details of the worm and worm wheel in case you decide to make them yourself though, as I have explained, they can be obtained ready-made from Bonds o' Euston Road. The blank dimensions of the worm wheel are only approximate, as the final form and diameter of the throat are produced in the hobbing operation. Methods of generating worm gears accurately have been described in ME. The worm gear may be keyed or secured by a sunk grub screw to the mandrel after the nuts on both sides of it have been properly adjusted.

One or more plain circular brass blanks may be used for the division plates, or they may be trepanned from 1/8 in. brass sheet. If the metal is reasonably flat, they require no more than to be drilled truly through the centre to fit the bracket seating closely, and to be trimmed on the outer edge. A 1/8 in. hole is drilled at a radius of 1/2 in. to fit a dowel in the face of the wormshaft bracket. There is room for up to five rows of holes in the 3 in. plate, and the number of holes in each circle should be determined according to requirements. Methods of drilling division plates of sufficient accuracy for most purposes are fully described in the PM handbook ***Milling in the Lathe.***

The division plate on the appliance illustrated has five rows of holes, copied from lathe change wheels, and having 65, 60, 55, so, 45 and 40 holes. I used a high-speed drilling spindle, with a 1/16 in. centre drill, and fitted an end stop to limit the depth of each hole so that it was slightly countersunk for easy engagement of the index plunger. It was not a tedious operation to drill the 315 holes in the plate: the drilling time was only five seconds a hole, and indexing the mandrel between holes occupied about the same time. This range of holes will cover most ordinary requirements, with multiples of prime numbers 'up to 13, with the exception of 7 Special divisions not covered can be dealt with when they arise.

The indexing arm, with its associated parts, is shown in an enlarged scale to clarify details; the arm may be fabricated from brass, by silver-soldering the boss into a flat strip after partial machining of both parts. A D-bit should be used to finish the bore of the boss smooth and parallel, as an ordinary reamer produces a tapered hole. The plunger should be a close fit but quite free, and its location endwise should be checked so that it engages the holes in the plate when the knob is screwed on, but can be retracted at least 1/8 in. clear of the plate when the spring is in position.

For the plunger to be held out of action when required, the knob has a 1/16 in. pin screwed or pressed into its front face. A slot in the boss of the indexing arm allows the pin to travel far enough for engagement of the plunger, but when the knob is turned 180 degrees, it fits a shallow groove-a mere notch, in fact-which holds the plunger back. Both the slot and the groove can be milled at one setting by a 1/16 in. Woodruff cutter, with the flat part of the arm clamped to a vertical fixture, or in the machine vice of the milling machine.

The sector plates for the counting of holes in the division plate are cut from 1/16 in. brass sheet and are identical except that one is cranked so that its arm lies flush with that of the other when laid on top of it. A 1/4 in. boss is riveted or silver-soldered into the second plate, and drilled and tapped 6 BA to take a screw and washer. The clamp nut which holds the division plate is turned at the back to fit the bore of the sector plate, which are both free to rotate on it, but can be clamped together by the edge of the washer when the 6 BA ***screw*** is tightened. If necessary, the thickness of the tapped boss may be adjusted, or the washer slightly dished, so that it locks the plates together firmly. In use, the sectors are set so as to allow the required angular movement of the index pin for each shift of the arm (the number of holes in the plate, plus one).

Accessories as required

This dividing head is the most elaborate accessory that I have fitted to the vertical milling machine, or that I am likely to fit so far as can be foreseen. Not every constructor of the machine will need a dividing head, as so many useful operations besides dividing can be carried out on it. But for my purposes the dividing head has been well worth the making, and the ability to adapt it to other machines is a further advantage. Some may prefer to make a simplified form of the appliance, with plain indexing, and a less elaborate tailstock or none at all. I am not a believer in making gadgets for gadgets' sake, but I never grudge the time taken to make them if they are likely to save time, or improve ease or accuracy of the work.

I could suggest several other fixtures and accessories which

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adjusting screw itself D passes through the tapped bearing C, and through the pivot ***E,*** with washers on each side, and a nut which is soldered to the screw after assembly. It ***can*** be made to raise ***or*** lower the main shaft as required.

As the main shaft is moved up or down, it does not travel exactly in a vertical plane, but has a radial motion. The slots cut in the sides of the tank must therefore be slightly radiused to match.

A further point arises. If the tank were filled with oil above the level of the bottom of these curved slots, the oil would of course leak out and would make rather a mess on the footplate. An overflow pipe is therefore fitted, so that if the driver is over-enthusiastic with the oilcan the excess will pass harmlessly down between the wheels.

Plunger and cylinder are conventional, except that the spring which bears on the first non-return valve ball is contained in a cup-shaped component so that the spring itself does not touch the ball. The ball seats on a separate turning, to ensure a true seat. We must make the turning a tight fit in ***its*** passage; if it worked loose, we should be in real trouble, as the pressure of the oil would force it away from the cylinder, with the ball, spring and so forth, and no oil would be fed to the engine. Those who doubt their ability to get it in tightly enough without distorting it would be well advised to leave it out. The lubricator will work quite well without it if the normal seating for the ball is done with care.

The lubricator shown in my pictures was made for me by Severn-Lamb Ltd, of Stratford-upon-Avon, the well-known professional modellers. They have made an excellent job of it. It will pump with ease oil at up to 600 lb. per sq. in.–enough for most small engines *!*

A full-size drawing of the new mechanical lubricator is now obtainable. (Ref. No LO. 44. Price 2s. 6d.)

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could be fitted to the machine, but they are refinements rather than essentials. It has been suggested that self-acting feed might be provided for the table and possibly the cross slide as well. But this would involve complications which are of limited value on a jobbing machine. Positive locking devices for both slide movements could be simply added, and are worth while; and so are longitudinal traverse stops. I shall probably fit them as soon as I can find time. Some positive mechanical means of elevating the complete spindle head with the motor, which is rather heavy to manhandle, would be a great advantage. It is not difficult to fit either a mechanical or hydraulic jack inside the main column, but it must not interfere with the sliding and swivelling movement of the ***cross member.***

Some readers have asked what limits of accuracy can be expected in work carried out on the machine. The answer is simple; like any other job in the workshop, this machine is as accurate as you make it, and I have no doubt that individually built machines will vary widely in their quality. But it should be possible to build the machine so that it is at least as accurate as other machine tools in the range normally open to model engineers. I know that many readers, not only in Britain but also in remote corners of the earth, have been sufficiently impressed by the design to make the machine, and I am sure that they will not be disappointed with it. ❑

The First Savannah

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more heartily as she flies the American flag." But there were, as always, some Britons whose envy of American achievement made their response less than warm. While the Admiralty graciously waived all port charges at Liverpool, a young idiot of a lieutenant ordered Captain Rogers to haul down the coachwhip pennant flying at his mainmast head. After exchanging the pennant for the larger one flown by squadron commanders in the United States Navy, the captain called out an order to his crew: "Get the hot water engine ready!" This secret weapon, though it did not in fact exist, proved the ultimate deterrent: the lieutenant and his party were soon pulling away in terror of being scalded to death.

There were also responsible people who wondered if the voyage itself had a secret purpose. Some believed that the ***Savannah*** was on her way to Russia as a present from the United States; others suspected that Moses Rogers hoped to rescue Napoleon from St Helena, They were still wondering when the Elegant Steamship put out again for the Baltic.

Of her visits to Stockholm, Kronstadt and St. Petersburg, of her trip to Copenhagen and Arendal and the long voyage home, I will leave you to read in Mr. Braynard's book. She had been hailed everywhere as a triumph: the Czar had even invited Moses Rogers and his steamer to remain in Russian waters. Yet the end was failure: the steamship which Europe had coveted lay unwanted in the Navy Yard at Washington. The unkindest cut of all was the removal of her machinery: she became the kind of vessel that Fickett had built, before Moses Rogers came along with his talk of steam.

At three o'clock in the morning on 5 November 1821 the sailing packet ***Savannah*** drove on to a sand bank opposite Fire Place on Fire Island, about fifty miles east of Sandy Hook; what the seas have left of her is still there. ***Some*** day, perhaps through the efforts of Mr. Braynard, her wreckage may be salvaged. The engine, of course, will not be among it. After the machinery had been removed, the cylinder was used in the Atlantic Iron Works until 1853 and later was shown at the New York Exhibition of the Industry of All Nations (the Crystal Palace Exhibition which burned down).

Like the ***Constitution,*** the ***Sawannah*** passed through a period of neglect. In time of peril ***a*** nation ***remembers*** its past, and in particular its history at sea; and so it was that in 1944 the United States issued a stamp commemorating the Elegant Steamship. Honour was again done to her when the United States named the first commercial nuclear vessel after the ship which had introduced steam to the sea-ways of the world.

There is more continuity here than we may at first realise. We cannot read much about the nuclear ***Savannah*** without encountering an old familiar name, long honoured in the world of steam: Babcock and Wilcox. The American Babcock and Wilcox Company designed and built the pressurised water reactor for the ***Savannah:*** its Consolidated Nuclear Steam Generator can be manufactured by the British Company at any time.

In short, the new ***Savannah,*** like the old, is really a steamship. All the nuclear wonders, all the amazing complexities of controlled chain-reaction, brings us in the end to a form of power that was understood by Hero of Alexandria in the first century. Mankind has found a new way of heating James Watt's legendary kettle. ❑