

A miniature TUBE BENDER

Detailed instructions for making a useful workshop fitting together with hints on its use are given

by C. Horace Clarke

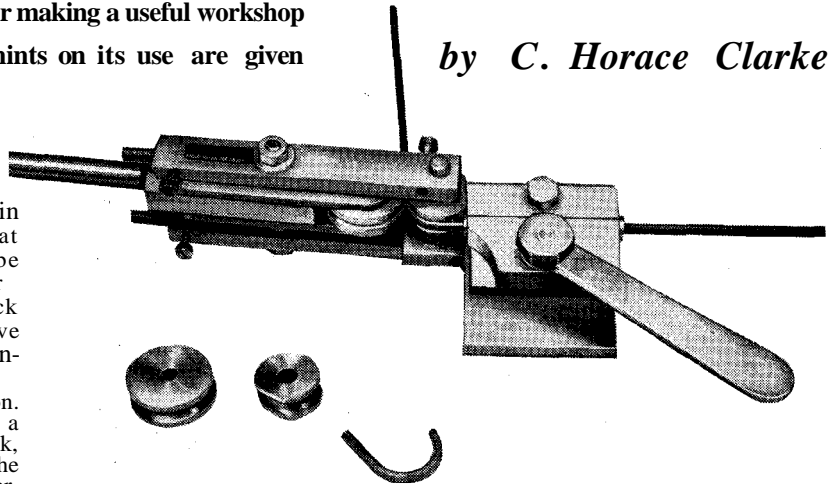
THE PRINCIPLE employed in this tube bender is that the length of material to be bent is held against a semi-circular groove round a cylindrical block while a roller with a similar groove is rolled round the block concentrically with its axis.

There are two methods of operation. The work may be pulled out of a slide and around the bending block, the latter usually rotating with the part carrying the bending roller, which could in fact be replaced by a straight groove clamping the work. Alternatively, the work may be clamped in a fixed vice while the projecting part is rolled on to the bending block. The latter is adopted in the present case.

In spite of the lack of novelty, it may be useful for readers to know how a small device can be simply made from standard sizes of material, with adjustability for different sizes of tube and different radii of bend. Any angle up to 180 deg. can be bent, i.e., a hairpin bend of the tube back on itself. The first time I made such a device was 30 years ago, when it was required to make several bends in earthed concentric electric wiring which consisted of a hard copper sheath surrounding a single rubber-insulated conductor.

Early experiments

The sheath was not a solid-drawn tube, but a thin strip wrapped nearly twice round, and bending to a small radius by hand would have resulted in kinks or breakage. A simple makeshift, for one sue and one radius of bend, was made almost entirely of wood. A hinged and hooked clamp carrying a boxwood bending block, and a boxwood roller carried between two steel strips, had a removable pin passing through the latter and the centre of the bending block. Working on a continuous length of material necessitated a



The tube bender in use with a 180 deg. bend in a pipe beside it

detachable bending arm to get the device on and off the work.

The next variation was a smaller edition in steel for bending the cores of organ chest magnets, consisting of 5/32 in. dia. solid soft iron with an internal radius of 3/8 in. at the bend. This one also had no adjustment, but when it was tried on a piece of copper tube, the result was such a satisfactory bend that the present device was evolved on identical lines, except for the provision of adjustability for both size of tube and radius of bend.

The range of adjustment in any such machine must be according to individual requirements, but if it is borne in mind that, whatever is adopted, a time will come when something outside the range will crop up, one must merely make some arbitrary decision. In this case, tubes up to 5/16 in. o.d. can be taken and bent to any radius from 1/4 in. to 1 in. on the centre-line of the tube. Anyone should be able to modify the dimensions for other ranges.

A separate bending roller will be required for each diameter of tube, but they may be all of the same diameter themselves. For the bending block, a separate diameter will be required in addition for each radius of bend. These accessories may be made at any time in the future as occasion for their use arises. They are straight-

forward turning from mild-steel rod.

The working of the appliance will best be seen from Fig. 1. The bending block, A, is mounted on a general base, B, of 1/4 in. steel plate, which for use is held horizontally in the bench vice. The bending roller, C, is pivoted in a fork-ended lever, D, which in turn is carried by a pair of links, E, which can be swung round the pivot pin, F, on which block, A, is mounted. Since for good results, the grooves in A and C must press tightly against the work, insertion of the latter would be difficult.

To facilitate this, lever, D, is pivoted to the links, E, at G so that the roller can be swung clear of the work shown dotted (Fig. 1). When the lever is then turned clockwise, roller E is first forced tight on to the work when the parts reach the full-line position of Fig. 1, at which point a stop, not shown in this drawing, engages one of the links, E, when further rotation of the lever carries the roller around block A as far as required for the angle to be bent.

The dotted position (Fig. 1) shows a 90 deg. bend, but it will most likely be necessary to go a little farther to allow for spring-back in the material being used.

Two requirements must now be met. The links, E, must swing together as a rigid frame and the distance between the centres of A and C must be slightly

adjustable, both for initial setting to get *C* tight on the work, and for taking up subsequent wear. In the fixed-size device mentioned, the links were firmly secured to the pivot pin, *G*, and were free to rotate on pin, *F*.

This is the better arrangement. Adjustment for centres of *A* and *C* was provided by means of eccentric bushes in the links, *E*, for the pin, *F*; these bushes being fixed by set-screws after adjustment. In the present arrangement, the adjustment can be met by that for different sizes of the block, *A* (the radii of bend), which is of much greater range and is given by mounting the pin, *G*, in the slots, *H*, in the links, *E*. This obviates the eccentric bushes, but makes it necessary to fix the links to the vice *F*, which must then be a very close-rotating fit in the base, *B*, as the latter is off the centre line of the rollers, where the strain comes.

Use of the vice

The work is held in a vice which has facing semi-circular grooves in the jaws. The fixed jaw, *J*, is mounted on a plate, *K*, which is adjustable. Iron the base, *B*, to allow for different diameters of the block, *A*. The jaw, *J*, while being wide enough where fixed to the base, *K*, to give sufficient support to prevent tilting, is cut away to clear the work which is bent to a small radius through 180 deg. or thereabouts.

The moveable jaw, *M*, is forced towards the fixed jaw and against the work by means of a lever-operated eccentric cam, *N*. The jaw, *M*, is cut away at *MI* to clear the roller *C* while enabling the work to be gripped as close as possible to the bending point. The grooves in the faces of the jaws are made to fit the largest size of tube to be taken: smaller

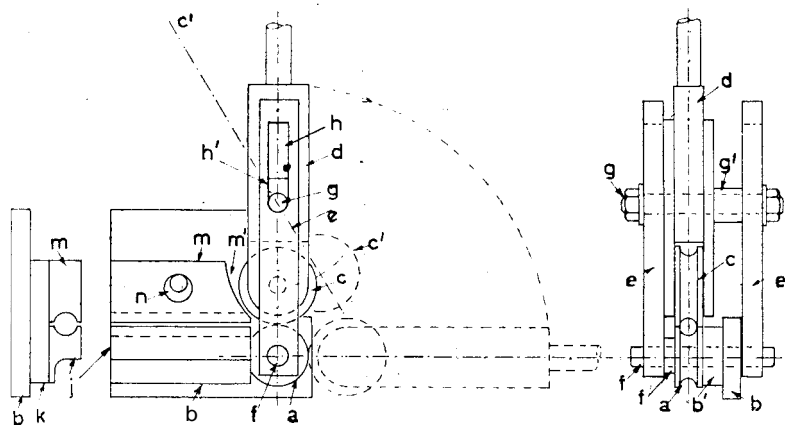


FIG. 1
 Fig. 1: Construction of the unit. The keyed parts are referred to in the text

sizes are accommodated by means of split sleeves in the vice.

The main base, *B*, is shown in Fig. 2. It has a projection, *B1*, of the same thickness as the vice base, *K*, to bring the cylindrical block, *A*, into line with the vice. First drill the holes in *B* and *B1* for the pin, *F*, undersize. If a 7/32 in. parallel reamer is available, drill them Morse 3; if not, leave them 5/32 in.

With an aluminium plug to align the holes, set the straight edge of *B1* square with the edge of base and solder the block in place with a blowpipe. Then drill and countersink the two small holes for 1/16 in. rivets a tight driving fit for the latter, hammer up both sides, and file flush. Then enlarge the hole for the pin, *E*, to size with a reamer or drill, taking great care that it is square with the face of base. It should be made a tight push fit for the pin, *F*, and the

same fit for this pin should be observed in due course for the links, *E*, and the block, *A*.

As the pin is a plain piece of rod, it is not separately illustrated; it is preferably a piece of silver steel. The slots in the base are to allow adjustment of the vice into alignment with the block, *A*, in accordance with the radius of the bend. The easiest way to do this is to clamp a piece of work in the vice and bring it into contact with the groove in *A* and then tighten the nuts on the studs under the vice base.

Details of the vice

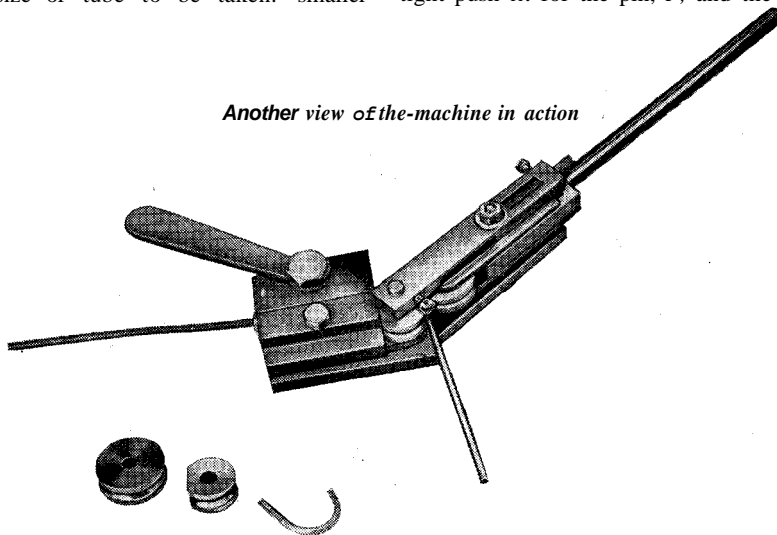
Fig. 3 shows details of the vice, which are sufficiently apparent without description except for the method of producing the two semi-circular grooves. It should be noted that these are about 1/64 in. less in depth than a full semi-circle in order that a gap between the jaws shall allow them to be fully tightened on to the work.

After drilling and tapping the two 2B.A. holes on the centre-line of the base, *K*, cut two pieces for the jaws out of 3/4 in. x 3/8 in. stock and clamp one (*J*) into position 1/64 in. from the centre line. A good way to do this is to set the outer edge by feel in line with a piece of 28 s.w.g. strip held against the edge of base. Then drill and countersink the holes for 9/64 in. headless rivets a tight fit and file them flush both sides after riveting.

Clamp the moving jaw, *M*, against the fixed jaw, *J*, with a piece of 20 or 21 s.w.g. soft brass interposed. Set up some packing on the cross-slide of the lathe to be 7/16 in. below the line of centres. On to this, clamp the vice assembly with the brass division parallel to the line of centres and feed across until it is centrally in line with them.

Put a short stump drill in the head-

Another view of the machine in action



A MINIATURE' TUBE BENDER

stock chuck and feed the saddle slowly against it. This should start a hole correctly without a centre punch mark. The latter should not be made; it will be almost impossible to ensure that it is set exactly opposite the drill and if it is not, the drill will follow it, start on the slant, and run still farther out of truth.

Any circumferential marks left by the drill are an advantage, as they help to grip the work endways—the direction of pull on it. Do not finish the hole with a reamer.

Next feed the saddle across to a position for drilling a hole to form the radius in corner of the cutaway, and proceed with drilling as before. Make two sawcuts to meet the hole and trim the space with a file, also filing flush with the edge of the base—the 1/64in. projecting part of the jaw, now reduced to 1/16in. thickness.

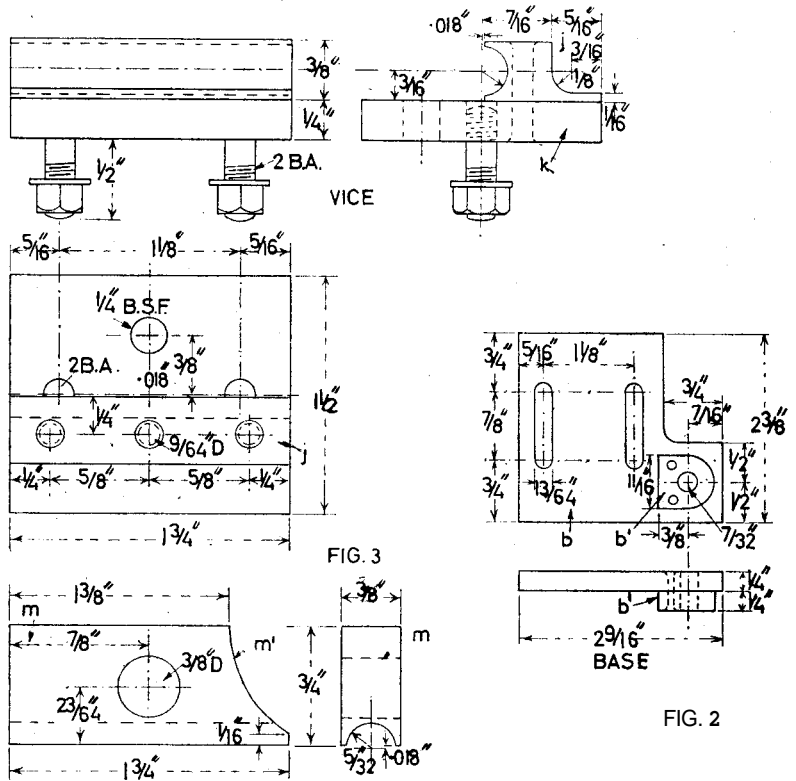
Cam and handle

The hole in the moving jaw, *M*, for the cam, *N*, is preferably finished with a reamer to leave the smoothest working surface, because the cam, *N*, must be a tight working fit, just moveable by the handle, otherwise, the jaw might have a tendency to slip loose. The cam pivot is turned out of a 5/16in. or 3/8in. bolt so as to have a head large enough to cover the end of the handle.

The screwed end is filed flush with underside of the base, *K*. The handle is of 3/4in. X 1/8in. stock, and the attitudes of the square hole in this and the square on the cam are such that the handle will be outwards parallel with the lever in the position of Fig. 1 when the vice jaws are closed up.

The tight position on the work should be a little before this. The eccentricity is so small in order to give sufficient closing force that there is a very small margin of movement to compensate for errors in workmanship, hence some experiment may be necessary and this is best applied to the positioning of the tapped hole in the vice base to receive the cam pm.

The bending roller lever, *D*; is shown in Fig. 4. The fork end is built up from 3/4in. x 1/8in. flats riveted to a piece of 3/4in. x 3/8in. stock. First drill and tap the holes in the latter for the 5/16in. round handle extension. Drill the holes for the roller pivot and, with a piece of rod through these for alignment, clamp the flats to the central block with the aligning rod square both ways. Drill and counter-



Figs. 2 and 3: Dimensions of the main base and vice

sink for rivets as before, then after riveting up, drill a hole for the pin, *G*, finally rounding the fork ends. The pin, *G*, should be a close working fit in the hole.

Locking the links to the pin

One of the two links, *E*, of fin. X gin. stock, is shown in Fig. 5, with its accessory screwed parts. The links are locked to the pin, *F*, by taper-pointed screws and the radius adjusting screws are locked by brass set-screws to avoid damaging the thread. It is intended that the adjusting screws should be made from 3 B.A. studding, but if they have to be screwed, rod can be used since a head is not necessary and would only waste time turning down.

On the other hand, long cheese-head screws can be used if available, but their heads must be reduced in diameter to the thickness of the links or less, or they will foul the lever, *D*. The same applies to the heads of the other screws. One of the links (left-hand link in the end view at right of Fig. 1) has a milled recess to receive the tip of the roller pivot and this acts as the aforementioned stop to hold the lever, *D*, against further movement after being brought into line with the links at the position shown in Fig. 1.

As has been explained, adjustment for different radii of bend, and for bringing the roller, *C*, firmly against the block *A*, is provided by mounting the pin, *G*, in the slots, *H*, in the links, *E*. Bearing blocks, *H1*, sliding in the slots are provided and, as the thrust is only in one direction, they need be only on one side of the pin, *G*, otherwise a wider and much longer slot would be necessary to accommodate them.

They are shown in the group of details (Fig. 6) and can both be made together out of 1/4in. sq. stock, drilled through for the pin, and afterwards filed on both sides to fit the slots—they are then separated. The tips of the adjusting screws should bear on the bottoms of the recesses, in which they should be a slack fit.

A spacing bush, *G1*, is required between the lever, *D*, and the right-hand link, *E*, in Fig. 1, having a clearance hole for the pin, *G*. The length over the shoulders of the pin, *G*, also shown in Fig. 6, should be such that, with links, lever, and spacing bush threaded on the pin and the washers clamped tight against the shoulders, the lever, *D*, is just free to turn without shake.

As the bearing blocks, *H1*, fit the spaces between the washers and lever, there is no possibility of their falling

out sideways and no grooves are needed to keep them within the slots.

The bending roller, C, cylindrical bending block, A, and the roller pivot are shown in Fig. 7. Where the bending radius on centre line of tube is greater than 3/8in., the block, A, must have a flat formed to clear the vice as shown. A spacer, FI, with a clearance hole is necessary between the block, A, and the link, E.

By making the roller, E, 0.005in. less in width than the internal width of the fork-end of the lever, D, the small amount of play allows the roller to settle itself correctly on the work. The grooves should be a good fit on the work, but one cannot rely on tubes being perfectly circular. It is best to make them an exact fit to a rod, say, silver-steel. The final fitting should be done in the lathe with a round-nosed scraper until, with a good light behind and a short piece of rod held in the groove without shake, an even crack of light shows.

The roller pin

The depth of the grooves should be such that when the two are on the rod, the peripheries of the rolls remain about 0.005in. apart, not more.

The roller pin can be adapted from a standard article of the kind but, if preferred, it can be a piece of silver-steel without a head. It should be a tight push fit in the holes in the lever, D, and the roller, C, should be a running fit on it without shake. If a plain rod, it should not be longer than the length given under the head, or it will be possible to push it through far enough for the tip to foul the side of the recess in the link, E.

Finally, the sleeves for holding the smaller sizes of work in the vice can be taken in hand. While a sleeve for each size, of 5/16in. external diameter, would be the easiest to manipulate

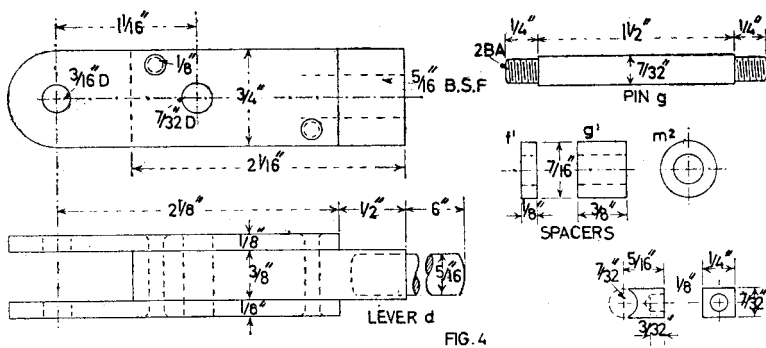


FIG. 4

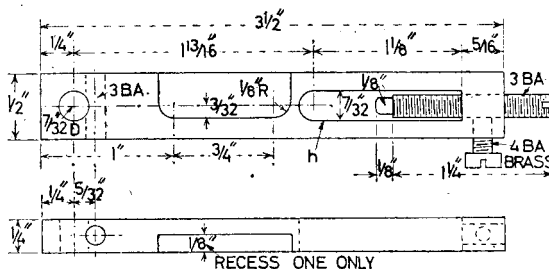


FIG. 5

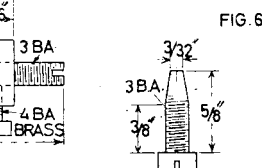


FIG. 6

Figs. 4, 5 and 6: The bending roller lever, links and bearing

in the vice, it would be difficult to make the thicker sleeves flexible enough and it also involves drilling a length of rod with a small hole concentrically throughout its length. It is better to use two or three thin concentric sleeves made from telescoping pieces of tube.

The following table gives the sizes of tube to employ in this manner for standard diameters of work below the largest size taken by the vice. Where the next thinner s.w.g. size would be too thin to clamp the work tightly, the next thicker must be used and reduced as indicated.

It is the inside of the tube which

requires to be made larger to take the work or next size smaller sleeve, but it will be noted that the thickness is reduced by taking off the outside.

The sleeves are sawn lengthways at two diametrically opposite points, one cut not running the full length so as to leave the two halves joined. They should be longer than the vice so as to be easily manipulated when in position, and it is better if telescopic sleeves are progressively longer as they get smaller. Fig. 8 shows the detail and also shows how, in the case of a thick sleeve, the sawcut which does not run the full length must be continued on the surface as a groove in order to reduce the thickness at the attached part to a flexible amount.

Figs. 7 and 8: Details of the bending roller, cylindrical bending block, roller pivot and how the sleeves are sawn

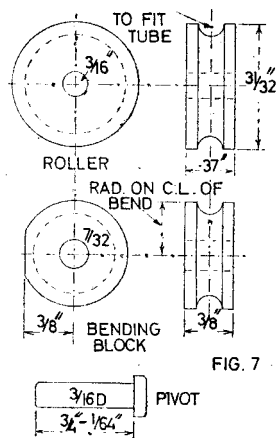


FIG. 7

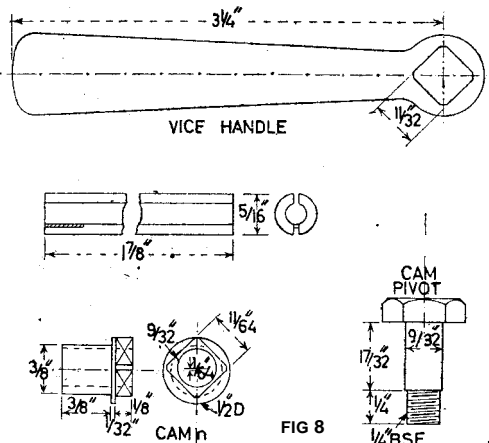


FIG. 8

Size of work in inches	Size of brass tube dia.	s.w.g.	Correction on o/s dia.
9/32 0.281	5/16	28	
1/4 0.25	5/16	20 (size a)	-.008
7/32 0.218	5/16	18 (size b)	-.002
3/16 0.187		28 (size c)	
11/64 0.172	a		
5/32 0.156	19		
9/64 0.141	28		
1/8 0.125	24		
7/64 0.109	21		
3/32 0.094	20		
5/64 0.078	18		
1/16 0.162	18 (sized)		
	28		
	1/8		
	20		