glued upon the original chuck. It is also advisable sometimes to run a quantity of the hot cement all round the sides of the piece or pieces as the consequences of a dislodgement are serious, often resulting in a deep score from the tool or an incurable bending up of an important part.

We now come to the more difficult portion of what may be called the fitter's province in turning—that which necessitates the employment of box-wood and clamp-chucks, &c., but it is expedient, prior to entering this department, to briefly describe the tools which will be called for.

Right-side, left-side, round-nosed, roughing, parting, and planishing tools may all be forged from cast steel, 3-8ths by 3-16ths of an inch, or from worn-out files of the right size. These are so generally known that it would be superfluous to describe them at any length, but the reader should be cautioned against any obtuse-angled side-tools, and assured that the semi-elliptical form of round-nosed tool is incorrect, the proper shape being a curved extremity, of radius equal to that of the hollow to be produced. Planishing tools are best made long and sufficiently thin to exhibit some slight amount of elasticity; the cutting-edge should be a right-angle, so that either side may be used; each surface should be rendered fine upon an oilstone, and the cutting-end not more than 1-32nd of an inch in thickness. These and the parting-tool alone require mention, a very acute angled extremity is preferred by some for these, but this is objectionable on account of the wide breach which it makes, and by the far the best shape is that similar to one of the non-cutting edges of a planisher, thinned gradually from the point to prevent wedging (Fig. 1) This is a dangerous tool in the hands of an amateur, and requires firm handling. No reference is needed to the remaining ones on cut. For economical motives, triangular files are often employed, but are extremely clumsy and difficult to use. Milling-tools should be mounted so as to work freely upon their axis, and should be firmly fixed into a large handle. They may also be used in the slide-rest in some cases.

But more generally useful, perhaps, than any of these, is the common graver, as answering most of the requirements of a right-side, left-side, and roughing-tool in one (Fig. 2, A, graver in use as a roughing-tool, B, graver in use as a right-side tool). It is maintained by some—principally engineers—that this should never be used save on iron and steel; but this dictum is ignored by the class who use the tool to its greatest advantage. A few pence will purchase one of as good a quality as can be produced, but they are often found to be improperly tempered, and require some little treatment before being used. In sharpening this, do not be tempted to grind its sides: for it is detrimental to its performance, and time thus saved in preparation is doubly lost in the sequel.

For making chucks, select straight, new, and sound boughs, and the larger number, in reason, the workman possesses, the smaller will be the necessary consumption. For making:—Place upon the mandril-nose of lathe a peg-chuck (Fig. 3, *a*), *i e*, one which has upon its surface a conical peg of steel cut with a coarse pitched screw tool, and having sawed up the boxwood into pieces of the desired length, and drilled their centres upon one side to the smallest diameter of screw mentioned, select the first one to be prepared and insert the peg into the hole, then twist it up till the boxwood face and shoulder of chuck are in close contact, to prevent further tightening through the resistance of screw-tool (Fig. 3, internal screw-tool cutting boxwood chuck).

Now ascertain the diameter of mandril-nose and drill up the boxwood chuck, leaving sufficient stuff for cutting the thread, for which directions will be given at the end of this chapter. It is now in a position to be "screwed" and carefully fitted. Some gasfitters and others, prefer to fix their boxwood into cup-chucks to prevent their splitting (a common occurrence), but the same end may be attained by tightly inclosing the circumference with a ring of metal tube.

These chucks are utilized by turning holes in their faces for the reception of the various shaped castings which are to be worked, or by decreasing their external diameter, so as to fit into pieces of shape more suitable to that method. They should always be left slightly tapering in their fittings, so as to wedge firmly in on the application of a hammer, but not sufficiently so as to run the risk of dislodgement through vibration. A little space must always remain in case the casting should require knocking more firmly upon its chuck prior to finishing, as pieces frequently become slightly loosened in the roughing process, but a piece can never be "rechucked" when once commenced upon without being thrown out of truth from its original axis, owing sometimes to the inequalities upon the casting, and often to the variable density and consequent hardness of boxwood; indeed, it is only practicable when the part which fits into the chuck has already been turned, and even then a nick should be made at the edge of casting to correspond with a similar nick in the edge of chuck, that it may be placed the second time in the same relation, and even then it is troublesome to restore truth.

There are certain parts of instruments which require not only to be well fixed upon their chucks but to be also cemented, and sometimes even packed up and supported by small blocks, but this is rarely necessary.

American scroll and iron surface chucks are scarcely ever used by professional instrument makers, their drills, countersinks, &c., being generally fixed in a simple chuck with a small clamping screw, which may be tightened by means of a hand-vice or key made for the purpose; many also use the common die-chuck.*

It is not within our range to include such turning as is effected between the centres of the lathe, but it may not be out of place to caution readers against dependence upon centre-punch marks which have not been drilled, and against using *arbors* which have not been turned true to their ends.

But ere the learner will be able to accomplish the most simple constructive task successfully, he must make himself master of the screw tool; and, though in this he may be assisted by a few directions, one hour's practice will be of more effect than a year's reading. The standard gauge in use is that of Whitworth, and its different varieties are distinguished by size; thus a ½in. tool is one which has been cut upon a ½in. "hob," and so on. This system, though, is little known to instrument makers, who, often finding it requisite to cut a fine thread upon a large diameter, ignore for the most part any standard, and keep each firm its own particular pitches It is commonly asserted that a thread should not be cut upon a diameter which is not equal to that of the hob upon which the screw tool was made. The observance of this rule might possibly possess some advantage, but as an appalling number of tools would be required, the manipulator who courts such an insignificant modicum of assistance would do better to spend his money in the purchase of a travelling mandril,† or better still, in receiving lessons.

A hob for *our* purpose may be of any reasonable diameter, the thicker the better, and the tools in use may be classed according to their number of threads to the inch They should be made at a tolerably acute-angled cutting edge. Standing, I think, first in importance for success, is that the work should be true and *smooth*; external pieces should be nicely rounded off, with a tool upon the corner, where the thread is to be commenced, and internal ones—more difficult—should be similarly treated. Considering the external first, it must be remembered that the motion required for striking the first thread is a circular one (see Fig. 4), where the dotted lines represent the motion of tool, and the black spot the central axis A screw tool, in this instance, is nothing more nor less than a lever, of which the operator's thumb forms a fulcrum; and therein should be seen the absurdity of resorting to the angular plate contrivances, which place one's work entirely at the mercy of a, perhaps, much indented hand-rest, and give no room for cutting a screw upon a very small space.

For the purpose of cutting a thread upon an internal part, many prefer to bring the T rest at right angles to the lathe-bed, with its edge a little below the centre; this may be done with advantage where the work is of any size requiring a deep and coarse screw, especially if the work be of iron or steel, but in the lighter branches most commonly required in optical instruments, it is far more workmanlike, expeditious, and safe, to use an arm rest (Fig 5). In using this tool the handle must be tucked well up under the left armpit, the left hand

* Holtzapfel "On Turning and Mechanical Manipulation," "The Lathe and its Uses," "The Amateur Mechanic's Workshop," &c An excellent contrivance is also published by a contributor to the ENGLISH MECHANIC, No. 316, Vol. XIII.

† It frequently requires as long a time to learn properly the manner of using this arrangement as to become master of doing the work by hand.