objection has arisen a new design, the *side planer* (fig. 43), in which the tool-box is carried by an arm. movable along a fixed bed or base, and overhanging the work, which is fastened to the side of the base, or on angle brackets, or in a deep pit alongside. Here the important difference is that the work is not traversed under the tool as in the ordinary planer, but the tool moves over the work. But an evil results, due to the overhang of the tool arm, which being a cantilever supported at one end only is not so rigid when cutting as the cross-rail of the ordinary machine, supported at both ends on housings. The same idea is embodied in machines built in other respects on the reciprocating table model. Sometimes, one housing is omitted, and the tool arm is carried on the other, being therefore unsupported at one end. Sometimes a housing is made to be removable at pleasure, to be temporarily taken away only when a piece of work of unusual dimensions has to be fixed on the table.

Another objection to the common planer is this. It seems unmechanical in this machine, to reciprocate a heavy table and piece of work which often weighs several tons, and let the tool and its holder of a few hundredweights only remain stationary. The mere reversal of the table absorbs much greater horse-power than the actual work of cutting. Hence a strong case is often stated for the abandonment of the common practice. But, on the other hand, the centre of gravity of the moving table and work lies low down, while when the cross-rail and housings with the cut- ting tool are travelled and reversed, their centre of gravity is high, and great precautions have to be taken to ensure steadiness of movement. Several planers are made thus, but they are nearly all of extremely massive type—the *pit planers.* the device is seldom applied to those of small and medium dimensions.

But there is a great group of planers in which the work is always fixed, the tools travelling. These are the *wall planers, vertical planers* or *wall creepers,* used chiefly by marine engine builders. They are necessary, because many of the castings and forgings are too massive to be put on the tables of the largest standard machines. They are therefore laid on the base-plate of the wall planer, and the tool-box travels up and down a tall pillar bolted to the wall or standing independently, and so makes vertical cutting strokes. In some designs horizontal strokes are provided forf or either vertical or horizontal as required. Here, as in the side planer,

there is no limitation whatever to the length of the work, since it may extend to any distance beyond the base-plate.

*Shaping Machines.—*The shaping machine (fig. 44) does for com­paratively small pieces that which the planer does for long ones. It came later in time than the planer, being one of James Nasmyth’s inventions, and beyond the fact that it has a reciprocating non-cutting return stroke it bears no resemblance to the older machine. Its design is briefly as follows: The piece of work to be shaped is attached to the top, or one of the vertical side faces, of a right- angled bracket or brackets. These are carried upon the face of a main standard and are adjustable thereon in horizontal and vertical directions. In small machines the ram or reciprocating arm (see fig. 44, G) slides in fixed guides on the top of the pillar, and the necessary side traverse is imparted to the work table *B.* To the top of the main standard, in one design, a carriage is fitted with hori­zontal traverse to cover the whole breadth, within the capacity of the machine, of any work to be operated on. In the largest machines two standards support a long bed, on which the carriage, with its ram, traverses past the work. These machines are frequently made double-headed, that is carriages, rams and work tables are duplicated,

and the operator can set one piece of work while the other is being shaped. In all cases the movement of the reciprocating arm, to the outer end of which the tool is attached, takes place in a direction transversely to the direction of movement of the carriage, and the tool receives no support beyond that which it receives from the arm which overhangs the work.. Hence the shaper labours under the same disadvantages as the side planer—it cannot operate over a great breadth. A shaper with a 24-in. stroke is one of large capacity, 16 in. being an average limit. Although the non-cutting stroke exists, as in the planer, the objection due to the mass of a reciprocating table does not exist, so that the problem does not assume the same magnitude as in the planer. The weak point in the shaper is the overhang of the arm, which renders it liable to spring, and renders heavy cutting difficult. Recently a novel design has been introduced to avoid this, the *draw-cut shaper,* in which the cutting is done on the inward or return stroke, instead of on the outward one.

*Slotting Machines.—*In the slotting machine (fig. 45) the cutting takes place vertically and there is a lost return stroke. All the