an advantage gained is that a supporting pillar or standard is not required, its place being taken by the wall.

*Self-contained Pillar Machines* include a large number having the above-named feature in common. In the older and less valuable types the framework is rigid, and the driving and feeding are by belt cones. But the machines being mostly of larger capacities than those just noted, back-gears similar to those of lathes are generally in­troduced. The spindles also are usually counterbalanced. The machine framing is bolted to a bed-plate. A circular work-table may or may not be included. When it is, provision is made for elevating the table by gears, and also for swinging it aside when deep work has to be put on the base-plate.

*Radial Arm Machines.—*ln these (fig. 46) the drilling mechanism is carried on a radial arm which is pivoted to the pillar with the object of moving the drill over the work, when the latter is too massive to permit of convenient adjustment under the drill. The driving takes place through shafts at right angles, from a horizontal shaft carrying the cones and back-geared to a vertical one, thence to a horizontal one along the radial arm, whence the vertical drilling spindle is driven. The latter has its bearings in a carriage which can be traversed along the arm for adjustment of radius. The spindle is counterbalanced. Hand as well as power adjustments are included. In the work-tables of radial and rigid machines there is a great diversity, so that work can be set on top, or at the sides, or at an angle, or on compound tables, so covering all the requirements of practice.

*Sensitive Machines* have developed greatly and have superseded many of the older, slower designs. The occasion for their use lies in the drilling of small holes, ranging up to about an inch in diameter. They are belt-driven, without back-gears, and usually without bevel-gears to change the direction of motion. The feed is by lever moving a rack sleeve. A slender pillar with a foot supports the entire mechanism, and the work-table, with a range of vertical adjustment.

*Multiple Spindle Machines.—*Many of the sensitive machines are fitted with two, three or more spindles operated in unison with a belt common to all. In other machines the multiple spindles are capable of adjustment for centres, as in the machines used by boiler

makers and platers. In others the spindles are adjustable in circles of varying radii, as in those employed for drilling the bolt holes in pipe flanges. In many of these the spindles are horizontal. Some very special multiple-spindle machines have the spindles at different angles, horizontal and vertical, or at angles.

*Universal Machines* are a particular form of the pillar type in which the spindle is horizontal, moving with its carriage on a pillar capable of traversing horizontally along a bed; the carriage has ver- tical adjustment on its pillar and so commands the whole of the face of a large piece of work bolted to a low bed-plate adjacent to the machine. The term “ universal ” signifies that the machine combines provision for drilling, boring, tapping screws and inserting screw studs, facing and in some cases milling. The power required for boring is obtained by double and treble gears. These machines are used largely in marine engine works, where very massive castings and forgings must be operated on with their faces set vertically.

*Boring Machines.—*Many machines are classified as suitable for drilling and boring. That simply means that provision is made on

a drilling machine for boring holes of moderate size, say up to 8 or 10 in., by double and treble back-gears. But the real boring machine is of a different type. In the horizontal machines a splined bar actuated by suitable gears carries a boring head which holds the cutters, which head is both rotated with, and traversed or fed along the bar. The work to be bored is fixed on a table which has pro- vision for vertical adjustment to suit work of different dimensions. The boring-bar is supported at both ends. In the case of the largest work the boring-bar is preferably set with its axis vertically, and the framing of the machine is arch-like. The bar is carried in a bearing at the crown of the arch and driven and fed there by suitable gears, while the other end of the bar rotates in the table which forms the base of the machine. Some boring machines for small engine cylinders and pump barrels have no bar proper, but a long boring spindle carrying cutters at the further end is supported along its entire length in a long stiff boss projecting from the headstock of the machine—the *snout* machine. The work is bolted on a carriage which slides along a bed similar to a lathe bed. Many of these machines have two bars for boring two cylinders simultaneously.