to the teeth, should undue stress come upon the saw. This is usually effected by the use of weights or springs, which allow a certain freedom or latitude to the driving gears. The work is held by screw clamps, V-blocks being required in the case of circular objects. A number of pieces, such as shafts, rails or girders, can be fastened down close together in a pile and cut through in one operation.

There is a very useful class of circular saw, the flush-side (fig. 55), that is valuable for cutting close up to a surface. The disk is bolted to a flange on the end of the spindle with countersunk bolts, so that the face is quite flat. Another class of saw used for dealing with girders and bars is carried in bearings upon a pivoted arm, which is pulled downwards by a weight to give the feed. The work is bolted to a table below the saw. Ample lubrication, by oil or soapy water, is essential in cutting wrought iron and steel; it is pumped on the blade, keeping it cool and washing away the cuttings.

Band-saw machines resemble in outline the familiar types employed for sawing wood, but they are necessarily stronger and stiffer, and the saws run at a much lower speed. The tables, moreover, differ in possessing compound slides for moving the work and in the provision of a series of slots on the top table, whereby the object to be sawn is secured with bolts and clamps. The tables are moved automatic- ally or by hand. The rate of cutting must be varied according to the thickness of metal. Lubrication is effected by running the lower saw pulley in a bath of oil or soapy water, which is carried up, so keeping the blade cool and “ easing ” the cut.

The reciprocating class of saw has until recently been confined to small types for workshop use, termed hack saws, which have a small blade ranging from 12 to 18 in. long. This is strained between a couple of bearings in a frame which is reciprocated above the work clamped in a vice. An arrangement of weights feeds the saw downwards. The larger hack saws cut off bars and girders up to 12 in. across, and in some there is a provision introduced for giving intermittent rotation to the bar, thus presenting fresh faces to the saw. The hack saw is of great utility for comparatively light work, and, as the smallest blades are cheap enough to be thrown away when worn out, there is no trouble and expense connected with their sharpening, as in the circular and band saws. An adaptation of the reciprocating saw is that of the jig type, which has a small blade set vertically and passing up through a table on which the work is laid. It is handy for cutting out dies and various curved outlines, in the same manner that fret-sawing in wood is done.

VIII.—Shearing and Punching Machines

These have much in common as regards their mode of operation. They are actuated either by belt and spur gearing, by steam-engine, by electric motor, or bydraulically. The first named is only suitable where arrangements can be made for driving from a line shaft. In view of the great convenience of the other methods of driving, they are coming into greater use, especially for ship-yards and other works where shafting is undesirable or inconvenient.

For boiler makers’ and platers’ use the function of punching, and shearing are usually combined in one machine, the rams being placed at opposite ends and actuated from the same source of power. The last shaft in the train of gearing is set to bring its ends within the boxes containing the rams, and eccentrics on the shaft are moved within die blocks fitted to the rams, so that as the shaft revolves it causes the rams to move up and down and operate the shear blade and

the punch attached to the bottom end. Another class of machines is worked by means of massive levers, pivoted in the framing, and actuated by cams on the driving shaft which cause the levers to rock and move the punches or shears up and down by the opposite ends. The punch slides are constructed to “ dwell ” for a short period at the top of the stroke at each revolution, thus giving the attendant time to place and ad- just the plate accurately beneath the punch. The same effect is obtained in the eccentric types of machines mentioned above, by a disengaging motion, which is thrown in by touching a lever, thus stopping the punch until the operator is ready for its descent. The more complete machines have an angle shear situated centrally, with V-blades for severing angle iron. The largest forms of shears, for massive plates, usually have the blade reciprocated by crank or eccentrics on the driving shaft, coupled by connecting- rods to the slide.

Hydraulic punching and shearing machines are used largely on account of their convenience, since they dispense with all belts, engines or motors in the vicinity, and give a very powerful