AB ; and fig. 124 is a horizontal section through the cylinder, valve- chest, valve, stuffing-boxes, piston, and crosshead. The bedplate

is a single hollow casting, with two surfaces planed on it to serve as guides (see fig. 123). At one end the bedplate forms a pillow- block for the shaft, which has another main bearing independently supported beyond the fly-wheel. At the other end the bedplate is shaped so as to form the cylinder cover ; the cylinder is bolted to this and overhangs the bed.

The cylinder (of 10 inches diameter and 20 inches stroke) con­sists of an internal “liner” of cast-iron, exactly bored, and fitted within an external cylindrical casting, of which the ports and sides of the valve-chest form part. The space between the liner and the external cylinder serves as a steam-jacket. The use of a separate liner within the main cylinder is now general in large engines. In the front cylinder cover there is a stuffing-box through which the piston-rod passes. The stuffing-box is kept steam-tight by a soft packing which is pressed in by a gland. In some in­stances the packing consists of metallic rings. The cylinder cover and gland are lined with a brass ring in the hole through which the piston-rod passes. The valve-rod is brought out of the valve- chest in the same way. The piston is a hollow casting into which the piston-rod is screwed and riveted over. It is packed by two split rings of cast-iron, which are sprung into recesses turned in the circumference of the piston. This mode of packing is used in locomotives and small engines. For large pistons the usual plan is to employ wider split rings, called floating rings, pressed against the sides of the cylinder, not by their own elasticity, but by sepa­rate springs behind them in the body of the piston ; they are held in place by a movable flange called a junk-ring on one face of the piston. One example of the packing of a large piston is shown in fig. 134. The crosshead consists of a steel centre-piece with a round boss, in which the piston-rod is secured by a cotter, and a forked front, where the end of the connecting-rod works on a pin. A pair of pins at top and bottom carry the steel shoes or sliding- blocks, whose distance from the centre is adjustable by nuts to take up wear. There is no crank ; the connecting-rod works on a pin fixed in a disk on the end of the shaft in front of the main bear­ing. The valve-rod, which is worked by an eccentric just behind the bearing, is extended through the end of the valve-chest, and forms the plunger of a feed-pump which is bolted to the end of the chest. Frequently the feed-pump is fixed at any convenient part of the bedplate, and is driven by a separate eccentric, and in some cases its plunger is connected directly to the crosshead. In the main bearing the shaft turns in gun-metal or phosphor-bronze blocks called brasses. In heavy engines these are generally lined with Babbit’s anti-friction metal or other soft alloy, and in many modern engines the brasses are entirely dispensed with, a lining of Babbit’s metal being let into the cast-iron surface of the bear­ing. When the brasses are in two pieces, the plane of division between them is chosen to be that in which the wear is likely to be least. A more satisfactory adjustment is possible when the brasses are in three or more pieces.

196. When a condenser is used with a small horizontal engine it is usually placed behind the cylinder ; and the air-pump, which is

within the condenser, is a horizontal plunger or piston-pump worked by a “tail-rod”—that is, a continuation of the piston-rod past the piston and through the back cover of the cylinder. Figs. 125 and 126 show in section one of Messrs Tangye’s small condensers fitted with a double-acting air-pump to be driven by a tail-rod. The condenser proper is the chamber A, and into it the injection-

water streams continuously through perforations in the pipe B, which has a cock outside to regulate the supply. The pump draws condensed water down to the lower part of the vessel at either end alternately through the valves C, and forces it up thence through the valves D to a chamber E, from which the delivery-pipe leads out. The pump is a gun-metal piston working in a cylinder fitted with a gun-metal liner. The valves are flat india-rubber rings held down in the centre by a spring, which allows them to open by rising bodily, as well as by bending.

197. The engine of figs. 121-4 makes 85 revolutions per minute, and its mean piston speed is consequently about 280 feet per minute. In some special forms of small horizontal engine the design is adapted to a much more rapid reciprocation of the moving masses, and the piston speed is raised to a value seldom exceeded in the largest land engines, although still higher values are now common in marine practice. Experience shows that the weight of engines of any one type varies roughly as the piston area. Their power depends on the product of piston area, piston speed, and pressure ; and hence, so long as the pressures are similar, the ratio of power to weight is nearly proportional to piston speed. Cases present themselves in which it is desirable to make this ratio as great as possible; and, apart from this, an engine making a large number of re­volutions per minute is a convenient motor for certain high-speed machines.

A good example of a small horizontal engine, specially designed by the symmetry and balance of its parts, by largeness of the bearing surfaces, and by very perfect lubrication, to stand the strains which are caused by high speed, is the Armington & Sims engine, made in America by the patentees and in England by Messrs Greenwood & Batley. The bedplate is symmetrical about the line of motion of the crosshead ; it supplies two very long main bearings for the shaft, at each end of which there is an overhung fly-wheel. The bearings have an adjustable side-block to take up wear. They are formed entirely of white-metal, cast on to the cast-iron pillow-blocks. In the middle are two disks, forming crank-cheeks, which are weighted opposite the crank-pin, so that they balance the pin and that part of the connecting-rod which may be treated as having its mass applied there. The crank-pin and the crosshead-pin are wide enough to give a large bearing area. The crosshead-block is a hollow bronze casting, giving an excep­tionally large surface of contact with the guides. The valve is a piston-valve of the Trick type, which works sufficiently tight without packing. The valve-rod and eccentric-rod are connected through a block which slides on a fixed guide. The governor, which has been already illustrated in fig. 100, is contained within one of the fly-wheels. An engine of this type, with a cylinder 12 inches in diameter and a stroke of 12 inches, makes 275 revo­lutions per minute, has a piston speed of 550 feet per minute, and indicates about 80 horse-power. Other good examples of high speed combined with double action are furnished by the Porter- Allen engine@@1 and by the very light engines which Mr Thorneycroft and others have introduced for driving fans to supply air to the closed stokeholes of torpedo-boats. In these a speed of 1000 revolutions per minute is made possible by the use of light recipro­cating parts and large bearing surfaces.

198. Fig. 127 shows a large non-compound horizontal Corliss engine for mill-driving, by Messrs Hick, Hargreaves, & Co. The cylinder is 34 inches in diameter, the stroke 8 feet, and the speed 45 revolutions per minute, giving a mean piston speed of 720 feet per minute. The cylinder is steam-jacketed round the barrel in the space between the liner and the outer cylinder, and also at the ends, which are cast hollow for this purpose. In large horizontal engines the weight of the piston tends to cause excessive wear on the lower side of the cylinder. In the example shown a part of the weight is borne by a tail-rod, ending in a block, which slides on a fixed guide behind the cylinder. To further diminish wear the piston is sometimes made much wider from front to back than the one shown here ; and the device is sometimes resorted to of giving the piston- rod “ camber”—that is to say, an upward curvature in the middle portion, which the weight of the piston reduces to straightness. Fig. 127 illustrates a common method of attaching the air-pump and condenser in large horizontal engines. The condenser is placed in a well in front of the cylinder, anti the air-pump, which is a vertical bucket-pump, is worked by a bell-crank lever, connected with the crosshead by a link. The fly-wheel of this engine is grooved for rope-gearing; it is cast in segments, which are bolted to one another and to the spokes, and the spokes are secured by cotters in tapered sockets in the nave. It is large and heavy, to suit the inequality of driving effort which is caused by the use of a single cylinder and a very early cut-off in engines of this class. To facili­tate starting and valve-setting, mill engines are often provided with an auxiliary called a “barring” engine. The barring engine turns a toothed pinion, which gears into a toothed rim in the fly-wheel, and is contrived to fall automatically out of gear as soon as the main engine starts.

@@@1 *Proc. Inst. Mech. Eng.,* 1868.