other side presses up the piston, so as to bring the plug s2, in contact with the lever, pressing it up, and the valve D down into its first position, and so on alternately.

This first plan of moving the valves by means of a plug frame, rising and falling with the alternate strokes of the piston, has been principally adopted for pumping engines that have no revolving motion. We have, how ever, seen it adopted with ndvantage even in marine engines. It

is noisy, as the sudden strokes of the prime mover produce an instant jerk, but it is effective, in so far as it at once opens the ports to their fullest extent, and so allows full effect to the entering steam, and full clearance to that escaping. The form in which we have seen it adopted in marine engines is as follows. The piston was kept in its true position by moving along two guide bars G G, on which it rested, through a cross bar H H ; O P and O P are the cranks of the revolving axis; R R is a rod connecting the piston-rod with the ends of the cranks which it turns round. The valve-rod *r r* is extended upwards as far as the piston-rod works, and two plugs r *τ* are so placed by adjusting screws, as to admit of the rod being raised and depressed at the proper moment by a projecting part of the crossbar H, at the end of each upward and downward stroke.

A very beautiful method of working the valves of the steam-engine has been recently invented by Mr. Melling, the superintendent of locomotive engines on the Liver pool and Manchester railway, and applied with perfect success. It consists in deriving the motion of the valves neither from the rectilineal nor the circular motions of the machine, but from the connecting-rod, one end of which rod moves round in the circle of the crank, while the other end performs a rectilineal, or a circular reciprocating motion. Before entering on the consideration of this motion, it may he well to attend to the curve which a point in the connecting-rod describes.

The curve, Fig. 97, is manifestly a curve resembling the ellipse, although by no means a correct ellipse. It is an oval, one end of which is more oblate, and the other more elongated, depending on the length of the connecting rod, and deviating more and more from a true ellipse, as the connecting-rod becomes shorter. In the centre of this oval, Mr. Melling places an axis, having a projecting arm, and in the connecting-rod there is placed a round projecting pin, which carries with it a radius arm from a fixed axis in the centre of the oval. This axis again carries another arm, or small crank, which is turned round with the axis, and is attached to the valve-rod, which it moves just as in the case of the eccentric. This motion has several good qualitics. It is said to continue longer in perfectly good order than the common eccentric motion, and it is said to save steam. This last fact we are disposed to question. The motion

exaggerates the properties of the eccentric.

One of the commonest of the many applications of the

steam-engine is to produce the revolving motion of an

axle and wheel, and in the second system of valve appa ratus, by which the steam-engine is rendered automatic, the reciprocating motion of the steam valves is derived from the continuous revolving motion of one of the shafts or wheels. Of the various methods in which this has been done, the following are some examples.

On the axis O, fig. 98, which is turned round by the rod LR so as to make one complete revolution during each alternate ascent and descent of the piston, and at the centre O, is placed a smaller axis, carrying round a cam or projection with it. A square frame s1 s2 s3 *s4* encloses this cam. As the axis turns round, the cam comes into such positions as to bear upon the bars s1 *s2* and *s3 s4* successively, and so pushes the frame towards the right and left alternately, *s e v* is a small crank, to which the motion of the frame is applied so as to make it move round its centre *e*, and so to raise the point *v,* and the valve rod *v v* up and down, giving the valve to which it is attached a reciprocating motion. The different positions into which the frame is forced by the cam are sketched in figs. 99, 100, 101.

Another form in which this motion has been given, is by connecting the large axle of the crank with a smaller one by toothed wheels, thus :—

The principal or crank axis carries round a wheel *a b c* whose teeth give motion to the equal wheel *d e f.* The point E is out of the centre, and carries a small axis E, to which the crank is connected by the rod E *s,* so as to raise and depress the valve-rod. It is manifest, that during the revolution of the wheels *a b c* and *d e f* the point E will be carried round a circle, and communicate alternate motion to the rod E *s,* equal in extent to the diameter