Or it may he thus

modified. If the arc

of a semicircle have

one of its extremities

placed in a given

straight line, while it

moves along a given

fixed point, the other

extremity of the arc

will describe another

straight line at right

angles to the former.

Let a semicircular

round bar *ybs,* fig.

170, be allowed to

slide through a fixed centre at *s,* the one end *y* sliding in a groove, or along a bar *s y,* then the point *x* will describe the perpendicular s *x4,* a perfect straight line.

To put this in practice in a form which shall not deviate widely from received forms of construction, is not difficult. The semicircular grove, and the semicircular bar, are not good construc­tive expedients. But if we take a radius bar *s* *g,* figs. 171, 172, 173, fixed at a centre *s,* so that its end *g* de scribes a circle freely round it ; and if we take a rigid bar *p y,* of double the length of *s g,* and united to it at *g,* then the middle of *p y* being thus constrained to move in the circle round *s,* we have only to permit *y* to slide freely in an horizontal groove, and the point *p* being carried up and down, will describe the straight line *p s p.* Fig. 174 shows the application of this motion to the simple engine, and fig. 175 to the beam en gine.

Mr Oldham of the Bank of England has shown us an application of this principle, of which he has made a model : he adds a refinement which diminishes the friction at *y,* while it introduces an infinitesimal error of the second degree. To the end *y* he has attached Watt's parallel motion, as represented in fig. 177; *s g g* ***s*** being the radius bars, and *g y g* the connecting link on a small scale, the point *y* is by this parallel motion guided in the horizontal direction. Instead of this refinement, which only produces infinitesimal error, we propose, if it were re

quired, to preserve the principle without error, and to introduce only infinitesimal friction. This we accomplish by placing a secondary geometrical motion like the primary one upon the point *y,* fig. 176, so that its motion may take place in a perfectly straight line. The effect of the friction will thus become an infinitesimal of the third order. These last refinements are, however, of a higher order than the degree of practical precision in the steam-engine usually requires.

Such is the mechanism which the obliquity of the direction between the connecting-rod, or link, renders necessary to prevent any of the motion, propagated through them, from being expended in producing oblique trans verse motion in the top of the piston-rod. Still, however, the motion of the piston-rod is modified by transference in an oblique direction, and we have now to consider the nature of that modification. Suppose the crank O R to be

in the position in the diagram fig. 178, where the connecting-rod *p* R is at right angles to it, then the connecting-rod *p* R makes with the piston-rod *Pp* an angle Op Ror θ*.* The force F therefore, acting along the piston-rod *Pp,* being represented by the length of *p x,* and *x y* and *p y* being drawn parallel to R *p* and R *x, we* see that the line *x y* or *p* R = F1/cos.θ represents the force in the piston-rod along the crank-rod, tending to make it revolve, while

*p y =* R*x =* R*p*sin.θ = F.sin.θ/cos.θ represents the amount

of pressure sustained by the parallel motion.

Thus we have a true representation of what takes place when the connecting-rod, instead of being in a line with the piston, or parallel to it, is at right angles to the crank ; and in this case the whole force communicated in this oblique position to the crank·rod, acts immediately and entirely in turning round the crank. But at other points, such as are given in the two succeeding figures, the motion is again modified by the obliquity of the direction of the connecting-rod *p* II to the trank O R. If Ο R be prolonged to S, and from *ρ* a perpendicular