The pillar, which supports the beam or lever, instead of being fixed in an upright position, has a joint at the bottom, as will be seen in fig. 165, on which it and the beam and the crank rod perform a joggling motion back wards and forwards during each stroke.

The motion is of the following nature. The point *s,* fig. 166, is fixed ; so is *s’ ; s g* and s' g' are moveable bars ; *p g* is ½ of *p g'.* The point *g* describes a circle round s, and *g'* round *s'* : hence *p* describes the curve *p s p',* of the sixth order. The oscillation of the mo­ving mass of the engine in alternate direc tions, with a sudden jolt at the end of the stroke, renders this a bad engine when made on a large scale ; and it is obvious that the deviation of the piston rod from the straight line is very great.

A very elegant parallel motion was invented by the Rev. Mr Cart wright, and applied by him to the steam-engine so early

as 1797. Two equal toothed wheels N N, fig. 167, work into each other, and from corresponding points of their circumference two connecting links unite at the extremity of a cross bar, to the middle of which the piston-rod is joined. These wheels and connecting-rods being always in similar positions on opposite sides of the piston rod, the obliquity of their actions balances each other, and the rod describes a straight line. But it is difficult to make and to maintain the wheels of this machine in the state of accuracy and perfection necessary to its working well.

The cycloidal parallel motion is one of high geometrical beauty. It was invented by Messrs Fenton, Murray, and Wood, and applied to the steam-engine in practice in 1802. lt. depends on this principle that an encycloidal curve, described by one-circle rolling within another,

approaches a straight line as the inner circ!e becomes more nearly equal in diameter to the radius of the outer one. For the purpose of applying this principle, a large wheel *q q,* fig. 168, with teeth on its inner circumference, is fixed on a frame concentric with the axis and circle of the crank O O. N O is a wheel with external teeth, which is fixed freely on the crankpin, and *p* is the point of attachment of the piston-rod *p l.* By this arrange ιnent the small wheel N O is compelled, by the pressure of the piston-rod upwards, to roll round the great circle, ascending on the one side, and descending on the other, so that the distance of the end of the piston-rod from the point of contact of the circles is always equal to the distance of the circle from the diameter ; (or, *n* + *r.* sin. *e — + 1/2 r.* 2 sin. *e,)* and thus the straight line is always preserved. We have seen this motion working very well.

But the principle which furnishes the most perfect parallel motion, is one which, although it be well known, we have never seen applied to practice. It is well known that the locus of the extremity of a straight line, the middle of which moves in a circle, the other end being confined to one straight line, is also another straight line at right angles to the former.

Let a straight bar

*x* *y,* fig. 169, be placed

with one end *y* confined in an horizontal

groove *a s*, and let *a* pin

in the middle *g* be allowed to slide in a

circular groove *y g .x,*

then the end .r will

always describe a

straight line *s* *x*: perpendicular to the first.