retained by Watt, and for many years it remained a favourite with builders of engines of the larger class. The beam formed a convenient driver for pump-rods and valve- rods ; and the parallel motion invented by Watt as a means of guiding the piston-rod, which could easily be applied to a beam-engine, was, in the early days of engine- building, an easier thing to construct than the plane surfaces which are the natural guides of the piston-rod in a direct-acting engine. In modern practice the direct- acting type has to a very great extent displaced the beam type. For mill-driving and the general purposes of a rota­tive engine the beam type is now rarely chosen. In pumping engines it is more common, but even there the tendency is to use direct-acting forms.

193. The only distinctive feature of beam-engines requir­ing special notice here is the “ parallel motion,” an ordinary form of which is shown diagram­

matically in fig. 119. There MN

is the path in which the piston-

rod head, or crosshead, as it is

often called, is to be guided.

ABC is the middle line of half

the beam, C being the fixed centre

about which the beam oscillates.

A link BD connects a point in the beam with a radius link ED, which oscillates about a fixed centre at E. A point P in BD, taken so that BP : DP : : EN : CM, moves in a path which coincides very closely with the straight line MPN. Any other point F in the line CP or CP produced

below it, the guiding surfaces at Q are avoided, but the path of P is then only very nearly straight. An example of the linkage in this form, with the further modification that A is shifted out, and B is brought nearer to P, occurs in the pumping engine of fig. 130 below.

In by far the greater number of modern steam-engines the crosshead is guided by a block sliding on planed sur­faces. In many beam-engines, even, this plan of guiding the piston has taken the place of the parallel motion.

is made to copy this motion by means of the links AF and FG, parallel to BD and AC. In the ordinary application of the parallel motion a point such as F is the point of attach­ment of the piston-rod, and P is used to drive a pump-rod. Other points in the line CP produced are occasionally made use of, by adding other links parallel to AC and BD.@@1

Watt’s linkage gives no more than an approximation to straight-line motion, but in a well-designed example the amount of deviation need not exceed one four-thousandth of the length of stroke. It was for long believed that the production of an exact straight-line motion by pure linkage was impossible, until the problem was solved by the invention of the Peaucellier cell.@@2 The Peaucellier linkage has not been applied to the steam-engine, except in isolated cases.

194. Another “ parallel motion ” which has been used in steam-engines is shown in fig. 120. AB is a link pivoted on a fixed centre at A, and connected to the middle of another link PQ, which is twice

the length of AB. Q is guided

to move in a straight line in the

direction of AQ. P then moves

in an exact straight line through

A. This is not a pure linkage,

since Q slides in a fixed guide,

but the distance through which

Q has to be guided is small compared with the stroke of P. If Q is guided to move in the arc of a circle of large radius, by using a radius rod from a fixed centre above or

195. No type of steam-engine is so common as the horizontal direct-acting. A small engine of this type, made by Messrs Tangye, and rated as a 10-horse-power engine, is illustrated in figs. 121 to 124. It furnishes a good example of a very numerous class, and serves to illustrate the principal parts of a complete engine. Fig. 121 is a side elevation, fig. 122 a plan, fig. 123 a transverse section through the bedplate in front of the cylinder, on the line

@@@1 The kinematics of the parallel motion are discussed in Rankine’s *Machinery and Mill Wark,* p. 275, aud rules are given for the proportions and positions of the parts.

@@@2 See Kempe’s *How to Draw a Straight Line* (“Nature Series,"), 1877.