Instead of using two cranks for the purpose of apply­ing the force of two steam-engines to the same axis of revolution, two engines have been used with their cylinders laid at right angles to each other, and having their connecting∙ro∣ls applied to the same crank. For an engine of this kind, fig. 147, Mr. Brunel obtained a patent; and we have seen his machine working in a satisfactory manner. An arrangement of a similar description has also been introduced in steamboats by M. Cave of Paris.

*Of the connecting-rod and Parallel Motion.—*In considering the agency of the crank in modifying the force and velocity of steam, so as to connect its direction and distribute its force in the manner required to produce a rotative motion in the machinery, from the original reciprocating motion of the piston in the cylinder, we have hitherto avoided the introduction of another important element, by which a further variation of force and of motion is produced. The connecting-rod is a rigid bar of metal which conveys the motion of the piston from the pis ton-rod to the crank either immediately or through the interposition of the lever or beam ; and as the connecting-rod, in doing so, takes various directions different from those either of the piston-rod or of the crank, there is an obliquity of pressure produced at both extremities of the connecting-rod, which gives rise to a variation of force and of direction, which must be practically provided for, and carefully appreciated in quantity, in so far as it may affect the ultimate operation of the machine.

There are two ways in which the motion of the piston-rod is most commonly transferred to the crank ; either immediately through the connecting-rod, as in fig. 148, or through the medium of the great lever, as in

fig. 149 **;** both ends of the great lever describing circles around its middle fulcrum ns a centre, and the head of the piston-rod being connected with the one end of the lever by means of an iron strap or connecting link. From inspection of the figure, it becomes plain that the connecting rod or link, is never, except at two points, in the same straight line with the piston-rod, so as to propagate its unmodified force to the crank, but that in these oblique positions it would produce a lateral motion in the end of the piston-rod which would not only be a waste of power in producing motion in a place where it is useless, but would have the effect of continually bending the piston-rod in opposite sides so as either to break it, or materially to impair its working. In the first of these figures, P*p* being the direction of the piston-rod, *p* R that of the crank, the force in the piston-rod in the direction *p a* becomes resolved into two parts *p* R and *p c,*

*p* R being effective in the direction of the crank-rod, and *p c* tending only to give lateral motion to the piston-rod, or else to bend it, or else break it across. And so also in the second figure there is a similar separation of pressure.

To prevent these lateral pressures from wasting the power of the steam, by producing lateral, useless, or injurious motions, is the object of a series of contrivances called parallel motions, or parallel guides. The most notable of these we owe to Mr Watt.

Let it be supposed that we desire to prevent the top of the piston-rod *p*, fig. 150, from being moved by the obliquity of the connecting-rod *p* R, either towards the right or the left, then it is accomplished in the following way. A fixed support, *s,* is found on one side of the piston-rod, and another on the other *s2* at equal distances from it, and two parallel bars *g s* and *g1 s1*

are placed between the piston-rod and these points, so that it may be steadied between them. These pa rallel bars are made so as to revolve freely round the points *s* s1 as cen tres, each of the ends *g g1* describ­ing the circles *g g2 g1 g3,* from which it is evident that if these rods were directly attached to the piston-rod at *g* and *g1,* they should have the effect of keeping the point *p* in the straight line *o g g1 p.* As these bars *s* *g* and *s* *g1* must describe circles round *s* and *s1*, they would, in the positions *s g2 s1 g3,* deviate altogether from the straight line of the piston-rod ; but as the one will act nearly as much in the one direction as the other in the opposite, it occurred to Mr Watt that, by connecting their extremities with a link, *g g1,* and attaching the piston-rod, not to the ends of the guide-bars, but to the middle of this link, the point *p* might be pre vented from deviating to any appreciable extent from the straight line. This is accordingly produced in a very simple way. The following figures show the effect of these links in various positions.

This elegant and simple contrivance is not, however, absolutely perfect ; and, in accurate workmanship, and on a larger scale, great allowance requires to be made for its errors, or it will produce very many serious derangements of the machinery to which it is applied. By this arrangement the point *p* is not kept perfectly in a straight line, but is, on the contrary, compelled to deviate from it