were of larger dimensions, two of them had cylinders 63in. diameter, and were capable of working with a load of 11 lb. or 12 lb. on the square inch of the piston. The first-named of these three, that at Ting-Tang, was put up with the concurrence of one of the Hornblowers, who was engineer to the mine, and the capstan and shears put up, that the pit work may be lowered into its place. The capstan is erected directly over the engine shaft, in such a position that the rope may hang just over the pump; and the capstan is usually placed in a line with the shears, as shown on the lithograph. The wood used in the construction should be red pine, but yellow pine is often substituted. The legs of the shears are square in section, with the square lower edge. The top pulley is carried in plummer block, which are secured to two pieces of red pine (one on each side of the pulley), supported on shoulders formed on the top of the legs, and filling pieces secured to the sides means of strapping plates, which are made to receive girdles, for the purpose of firmly securing the pieces which support the shears. Tie rods are also carried from one arm to the other, just placed on the inside of one of the sheer legs; the outer bearing is carried in a plummer block supported on a piece of timber firmly secured to the leg by means of staples and girdles.

The construction of the framing of the capstan will be readily understood from an inspection of the drawing. The shears are made of two radius and straight sections, and to stay the shears legs by means of iron or wood rods from the walls of the engine house. The shaft of the capstan is of wrought iron; and it is keyed a cast iron drum provided with socket pieces to receive eight wood arms each; in the top socket pieces the arms of the capstan are secured. At the top of the shaft a cast iron centre piece is keyed, from which tie rods extend to each of the arms; the tie rods are also carried from one arm to the other, just under the outer part of the wood roofing. The details of the iron work we shall give more fully in our next impression.

The object of the balance-bob is to afford a means by which the surplus weight of the pump rods may be taken up. A beam of red pine, with a kingpost, tie rods, and halspan, is fastened to the plating, the fulcrum is cast iron, and are made on the socket, which receives the foot of the kingpost; a flange is also formed around the socket, and is provided with bolt holes to receive the staples, which serve to secure the beam to the socket piece; a cast iron socket is provided to receive the top of the kingpost, which is called the bishop's head. The balance-bob is fixed with the purpose of carrying the pin for the connecting rod, and is formed with a gap which receives the head of the connecting rod. The tie rods are usually made flat. The connecting rod from the balance-bob to the pump rods is sometimes made of iron and sometimes of wood. When formed of wood it is made six or seven fathoms long, and the bottom end is secured to the pump rod by means of staples and girdles, on a set-off to bring it in a vertical line when at half-stroke. The vibration is given by the elasticity of the timber. The construction of the box will be clearly seen on inspecting the engraving.

Before we proceed further with the subject it will be well, perhaps, to give a few definitions of technical terms. Cornish mines in connection with the pumping machinery, &c.

Add, tye, or level.—An add is a tunnel or conduit, driven or cut in the side of a hill, sometimes used for the purpose of bringing out ore, but usually for the purpose of draining the mine at that level. The pumping engine lifts the water from the add to the level where it is to be pumped into the main stream or adit.

ON THE DYNAMICAL PRINCIPLES OF THE MOTION OF VELOCIPEDES.

By W. J. Macquorn Rankine, C.E., LL.D., F.R.S.

26. Promptitude in recovering the balance.—When the base-point M, Fig. 6, happens to have swerved to one side of its proper position under the centre of mass, so as to risk the overturn of the vehicle, that deviation is corrected, as already stated in Section 1, Article 7, page 79, by re-affecting the fore-wheel towards the left. This re-affecting, so as to cause the track of the base-point to incline in that direction also, and so bring that point back to its proper place. For example, in Fig. 6, representing a plan of the roadway, A is the fore-wheel, B the hind-wheel, A B the wheel-base, M the base-point, which is supposed to have swerved to the right, thus causing the centre of mass to tend to fall towards the left. The rider inclines the fore-wheel towards the left, as shown at A; the velocipede begins to move round a centre at C, where the projections A C and B C of the axes of the wheels cut each other; the tracks of the two wheels and of the base-point become concentric circular arcs, A a, B b, M m, described about C; and the lateral deviation of the base-point M from its former track brings it back to its proper position under the centre of mass, and causes the balance to be recovered.

The promptitude with which the balance is recovered, after a given extent of deviation of the base-point to one side of its proper position, depends on the transverse component of the speed with which that point moves in the curved track M m; and that transverse component is less than the speed of advance of the velocipede in the proportion in which the radius of the base-point from the point of support of the hind-wheel, is larger than C M, the radius of curvature of the track of the base-point. Let v denote the speed of advance; then the promptitude of recovery may be represented as a quantity by the following expression:

\[ \frac{v}{C M} \]

Hence it appears that promptitude in balancing is favoured not only by a high speed, as already stated in Article 7, but by placing the base-point (and, therefore, the centre of mass) well forward, so that M B may be as great as possible consistently with having a load on the hind-wheel sufficient to prevent it from slipping sideways.

27. Difficulty of balancing with the steering-wheel behind.—It has sometimes been proposed to make the hind-wheel the steering-wheel, as shown in Fig. 7, in order that the rider's legs may not be liable to be grazed by the rim of the wheel when in an inclined position. It is true that for the purpose of steering, or describing curves, as distinguished from balancing, the hind-wheel is quite as suitable as the fore-wheel; but a fatal objection to the proposed alteration arises from the fact that with the steering-wheel behind, it becomes extremely difficult for the rider to keep the balance of the vehicle.

To show why such is the case, let it be supposed that the base-point M in Fig. 7 has swerved to the right of its proper position, thus causing the centre of mass to tend to fall over towards the left. In order that the base-point
Difficulty of balancing the steering-wheel behind.—It has sometimes been proposed to make the hind-wheel the steering-wheel, as shown in Fig. 7, in order that the rider's leg may not be liable to be grazed by the rim of the wheel when in an inclined position. It is true that for the purpose of steering, or describing curves, as distinguished from balancing, the hind-wheel is quite as suitable as the fore-wheel; but a fatal objection to the proposed alteration arises from the fact that with the steering-wheel behind, it becomes extremely difficult for the rider to keep the balance of the vehicle.

To show why such is the case, let it be supposed that the base-point M in Fig. 7 has swerved to the right of its proper position, thus causing the centre of mass to tend to fall over towards the left. In order that the base-point may move sideways towards the left, so as to restore the balance, the hind-wheel B is to be inclined towards the left, when the velocipede will begin to move round the centre C, situated at the intersection of the projections B'C and A'C of the axes of the wheels. The tracks of the wheels and of the base-point will become concentric circular arcs, B'B' and A'A', described as the base-point moves.

The base-point begins, as required, to deviate sideways towards the left, with the transverse velocity v, or MA; and this motion may possibly, with extremely delicate management of the steering-bar, serve to restore the balance. But by the time the vehicle has advanced through the distance MA, between the base-point and the fore-wheel, the base-point has reached its extreme deviation towards the left; and if its insufficient to restore the balance the velocipede must upset; and should the deviation be sufficient to restore the balance, the rider must instantly bring back the steering-wheel to the steady position; otherwise, the base-point, moving in the circular track MM, will come back to a point in its original straight track, cross this track, and rapidly swerve towards the right of it, thus renewing the loss of balance in the same direction as before, and making an overturn almost certain.

A bicycle, then, with the steering-wheel behind, may possibly be balanced by a very skilful rider as a feat of dexterity; but it is not suited for ordinary use in practice.

Glasgow, University, 1870. W. J. M. R.

DOCKS AND HARBOURS IN FRANCE.—Authority is granted by imperial decree to carry out the following harbour works:—A harbour at Berre, on the lagoon of that name, at the mouth of the Rhone river, near Bouches-du-Rhone; a new harbour at Sete, near Boulogne; and a new harbour at La Ciotat, conceded to the Messageries Impériales Company, and a new harbour in the bay of Port-en-Bessin (Finisterre); estimate, 23,520,000f. = £230,000.