## THE NEW TAY BRIDGE.

The report by the directors of the North British Railway Company just issued has the following in reference to the new Tay Bridge:—The question of the reconstruction of the Tay Bridge has continued to engage the anxious attention of our directors and they believe that the bridge finally decided upon is the best possible under all the circumstances. It provides for the navigation of the river with spans of a width of 245 feet, the greatest height being, from high water to the under side of the girders, 62 feet as against 88 feet in the old bridge. The line of the bridge will be a uniform gradient, varied considerably, being in one part as severe as one in 74 north of the four navigable spans. There were in the old bridge nine other large spans. In the new bridge these will be replaced by eighteen spans of half the old dimensions, the girders being placed below instead of above the rails as before. Each of the piers will be of brickwork and concrete up to eight and a half feet above high water, and of plated wrought iron from that level to the under side of the girders. The termination of the bridge at each end will be by brick arching, and a substantial parapet will be erected throughout its entire length. Many suggestions have been made for the utilising of the old foundations which in themselves are quite capable of sustaining the weight of the superstructure; but the insuperable objections to their use lies in the fact that they were liable to scour, and this, in the new bridge, would be prevented by making the foundations, except those in rock, 20 feet below the bottom of the river, where they will be beyond the reach of any possibility to scour. The report adds—It will be satisfactory to the shareholders to know that all the claims for compensation arising out of the deplorable loss of life in connection with the accident have been disposed of, and that without litigation.

## THE MONOLITHIC SYSTEM OF BREAKWATER.

Mr. Kiniple, harbour engineer, of Westminster and Greenock, has patented his monolithic system of forming sea breakwaters and harbour walls. This invention, enables harbour works to be constructed in jointless masses of concrete *in situ* without the aid of divers, stagings, or overhead travellers; in fact, without the use of the ordinary costly plant. The system has been experimentally tried with success at New York, Quebec, and Greenock, and last year it was also experimentally used by the patentee at Wick in the reconstruction of the south pier-head upon its old, or rubble foundations. The Government Loan Commissioners granted a sum of from £10,000 to £12,000 for these repairs, and for the extension of the head this year for forty feet, so as to render last year's repairs safe against any seas which may enter the bay of Wick. The extension will be of the same monolithic construction, and founded deep into the hard clay of which the bottom of the bay is composed. At Wick any breakwater which is not of monolithic construction from foundation to parapet cannot be relied upon as safe against all contingencies of sudden and severe storms. There are numerous places, it is believed, where, had this system been used instead of the ordinary blocks or bags, the breakwaters would have been in existence at the present time, and at 40 per cent. less cost. One of its chief merits is its simplicity and reliability, for any breakwater in the most exposed localities can, it is asserted, now be constructed at about one-half the usual cost, and certainly within one-third of the time formerly occupied in executing these works, for there is nothing whatever to prevent a breakwater being commenced at its head, centre, or root, or being carried on simultaneously from end to end. No skilled workmen beyond ordinary labourers or fishermen are required, and, indeed, a present of a patch of Portland cement to some of the poorer fishermen is all that is necessary to enable them to repair or construct small breakwaters along the coast. The system is well adapted for founding on rocky or irregular bottoms, but in many cases trenches would have to be dredged by dipper or other dredges for the reception of the concrete. The concrete is mixed either in bulk or in blocks, and allowed to set or harden out of water, so that when thrown overboard into the foundations or works it is hard enough to prevent the cement from separating from the sand and shingle while passing through the water, and soft enough when in the work to fall together and to become one compact mass, equal in strength after a short time to the natural rocks. Where the walls are required to be vertical or battered, a few iron rods are used with sliding planks to retain the concrete in form for a few days until it is set. At Wick recently, masses of concrete cast in this manner resisted a heavy storm within twenty-four hours after they were put in, while stones of several tons weight were hurled in every direction by the same gale.—*Engineer & Building.*

# Mechanics.

## BURSTING OF FLY-WHEELS.

BY GEO. M. HOPKINS.

The theory of the bursting of fly-wheels, which has been accepted in the majority of cases, is that the centrifugal force due to a high velocity overcomes the cohesive force of the particles of the material of which the wheel is composed.

Of course this explanation is entirely inadequate when applied to a wheel whose strength is sufficient to resist any tendency to fly to pieces from purely centrifugal action under the conditions of its use; but of the fact that such wheels burst no evidence is needed, and some cause other than centrifugal force must be assigned for the bursting.

Supposing the fly-wheel to be perfectly balanced and without defects in material or design, it may be driven without danger at any velocity usually considered within the limit of safety, so long as it continues to rotate in a plane at right angles to its geometrical axis. And it may be moved in the plane of its rotation or at right angles to it, that is, in the direction of the length of the shaft, without creating any more internal disturbance than would result from moving it in the same way while at rest. But when a force tending to produce rotation at right angles to the plane of the wheel's rotation is applied, the effect will be vastly different, and the result will be a tendency to rotate about a new axis between the other two, and the centrifugal strain upon the wheel is supplemented by a twisting strain, which is an important and generally unnoticed factor in the destructive action.

To bring this idea to a practical application, the shaft and fly-wheel of a high speed engine may be taken as an example. Let the wheel be correctly designed, well made, and well balanced, and if its shaft is properly lined and supported in rigid journal boxes, the wheel will perform its office without danger of bursting; but support the same wheel and shaft upon weak plummer blocks, and allow one or both of its journals to move laterally at every stroke of the engine, or even less frequently, and a disturbing element will have been introduced which will strain the wheel laterally, and which, together with centrifugal force, will effect molecular changes in the structure of the iron, and the result will be that if the wheel is not immediately broken it finally becomes weakened, so that it will yield to the forces that tend to destroy it.

Any wheel whose axis is swung in a plane at right angles to its plane of rotation, either occasionally and irregularly or frequently and regularly, tends to turn laterally on an axis between that of the normal rotation and that of the extraneous disturbing force. This tendency exists in ordinary wheels, although not visible. The engraving shows a flexible wheel, which clearly exhibits the effects of the disturbing forces. The rim is of rubber, the spokes of spring wire, and when the wheel is revolved very rapidly and moved in a plane parallel with its plane of rotation, no disturbance results, and no effect is produced by moving it at right angles to its plane of rotation; but when the wheel is turned even slightly on an axis at right angles to its geometrical axis by swinging the shaft laterally, the rim, while preserving its circular form, inclines to the plane of the rotation of its shaft, bending the spokes into a concave form on one side of the hub and convex on the other, showing the effects of the disturbing force on the figure of the wheel, as in Fig. 2.

When the disturbing force is rhythmical the wheel sets up lateral vibrations and wave motions in the rim, which are out of all proportion to the extraneous force applied.

From the experiment it is evident that the lateral swinging of the shaft of a fly-wheel (for instance when its journal boxes are loose, or when the frame of the machine of which the fly-wheel forms a part is yielding) tends to weaken the wheel even when the lateral movement is slight; and where it is great, as when the shaft is broken, the twisting effect is correspondingly great, and the wheel or its support must yield.

No rotating machines are more subject to bursting than grindstones, and generally no rotating bodies of equal weight are mounted upon such small shafts or on such weak supports. The suspended ones are especially liable to the destructive action above described, as their frames are generally far too weak.

Fig. 3 illustrates the effect of a lateral blow on the rim of a fly-wheel. Of course the effect is much exaggerated in the flexible wheel, but it shows the form taken by the rim under a blow, the blow producing a much greater effect on the wheel while in motion than when at rest.