THE CONSTRUCTION OF LOCOMOTIVES.

At the meeting of the Institution of Civil Engineers, held on Tuesday, March 9, Sir Frederick J. Bramwell, F. R. S., President, in the chair, the paper read was on "The Construction of Locomotive engines, and some Results of their Working on the London, Brighton, and South Coast Railway," by William Stroudley, M. Inst. C.E.

The author, on his appointment to the London, Brighton, and South Coast Railway, in 1870, had to consider what kind of locomotive engine and rolling stock would best meet the requirements of the service, as, owing to the great increase and complication of the lines and traffic, the original primitive engines and rolling stock were not able to do so. He, therefore, in the same year, designed a large goods engine, class "C," arranging the details so that they would enable him to construct the several classes illustrated, all the principal parts being interchangeable. Having had long experience with both outside and inside cylinder engines, he adopted inside cylinders, but placed the crank-pins for the outside rods on the same side of the axle as the inside crank, the outside pin, however, having a shorter stroke; and he thus obtained the advantages of both systems. He adopted the method of putting the coupled wheels in front, instead of at the back as usual, which permitted the use of small trailing wheels, lightly weighted, and a short outside coupling rod for the fast running engines, and also a much larger boiler than could be obtained when the coupled wheels were at the back. The author adopted a somewhat high centre of gravity, believing that it made the engine travel more easily upon the road, and more safely at high speeds; the slight rolling motion, caused by the irregularities of the road, having a much less disturbing influence than the violent lateral oscillation peculiar to engines with a low centre of gravity. The high centre of gravity also threw the greatest weight upon the outside or guiding wheel when passing round curves; and this relieved the inner wheels, and enabled them to slip readily. The author used six wheels in preference to a bogie for these engines, to avoid complication and unnecessary weight. The engines were very light for their power. Several springs were used for the middle axle, and these had a greater range than the end ones for the same weight. The two cylinders of the large engines were cast in one piece, with the valves placed below, giving lightness, closeness of centres, and easy exhaust and steam passages. The crank-axle was the only disadvantage left in an inside cylinder, inside-framed engine, and, when this was of good proportions, it offered but a small objection. Owing, however, to the narrow gauge of the rails in this country, the crank-axle could not be made so strong as it ought to be, or there would be no reason why a crank-axle should break. When the flanges of the driving wheels were turned down thin, so as to avoid the side-shock given by crossings and check-rails there only remained the strain of the steam upon the pistons to cause breakage; the action of this was precisely the same as the methods used by the late Sir William Fairbairn in testing to destruction the model tube for the Menai Bridge, by letting a heavy weight rest upon it suddenly at frequent intervals. The deflection, if sufficient, caused a crack at the weakest place, which gradually extended until fracture took place. This was precisely what occurred in the axle; the crack invariably commencing on the side of the axle opposite to that to which the steam was applied.

The author, after thirty years' experience, believed that the separate parts of locomotives, including tires, axles, piston rods, side rods, bolts, cotters, and carriage and waggon axles, broke from the same cause; they did not break when carefully designed, and made with proper materials and workmanship. As the crank axle could not be made of the proper strength, it was well to consider how to avoid, as far as possible, risk of accident by its failure. By making the axle-boxes and horn-blocks deep and strong giving large flat surfaces against the boss of the wheel and the outside of the crank arm, the driving wheel was kept in position after the axle was broken, if the fracture occurred in the usual place, namely, through the inside web near the crank-pin, or through the centre part where it joined the inside web. An axle, broken in this manner, would run safely over any part of the road, except at a through crossing, where the guiding rail was lost, and the flange was liable to take the wrong side of the next point; this, however, had not happened in the author's experience. The author had always hooped the larger cranks, and had for some time hooped every new crank in the same proportion as adopted on the Great Northern Railway, thus reducing the risk to a minimum. The engines had been arranged that part of the exhaust steam might be turned into the tender or tanks, so that the feed water might be heated. This was a special advantage in a tank engine, by increasing the total quantity of water; it also kept the water supply of greater purity, and it relieved the boiler of a certain amount of duty in heating the water from the ordinary temperature to that which feed water required. The feed pumps had been designed to meet the requirements of pumping hot feed water. The proportions of the valve gear gave an admission of 78 per cent. of steam in full gear, which could be reduced to 12 per cent. with excellent results; and as at high speeds the steam was never exhausted, the temperature of the cylinder was maintained, and as much steam was locked up in the cylinders as raised the pressure at the end of the stroke to near that in the steam chest. This made the engine run very smoothly at high speeds, and turned what would otherwise be an extravagant coal burner into an economical machine. And for the same reason the compounding of fast passenger or frequent stopping locomotives was not likely to show much, if any, economy over a well-designed, simple engine. The case was different, however, in heavy goods engines, working with a late cut-off most of the time, and where the conditions approximated closely to those of a land or marine engine with a constant load. The back pressure observed in the diagrams of the high-speed locomotives was not therefore a defect, but an advantage, and the author accordingly used small steam ports and short travel of slide valve. These remarks as to back pressure did not apply to the pressure in the exhaust pipes, where it should be as small as possible, but only to the back pressure in the cylinder. The latter was greatest at high speeds, when a small volume of steam was passing through the cylinders, and small power was required, and least when working full power with the smallest expansion. All the passenger engines and many of the goods engines were fitted with the Westinghouse automatic air brake, as were also the whole of the carriages. The brake gave entire satisfaction and complete control of the trains. The author took considerable pains with the fittings and details when it was first introduced, and arranged the gear for the engines, so that the brake acted upon each wheel independently, allowing the springs freedom to act; or it acted upon the front of all the wheels, as in the tank engines, the brake of which was moved by hand as well as by the air pressure. The Westinghouse air pump has been fitted with a plunger at the bottom end of the rod, 1⅞ in. in diameter, and this pumped water into the boilers of the goods engines when they were in sidings or were delayed by signals. For the express and large goods engines, the greatest possible amount of heating surface had been provided; the firebox was capacious, with small tubes of considerable length in proportion to their diameter, little or no flame being generated with the coal used, and a very small amount of soot. The fuel which was found cheapest to consume in this locality, was smokeless coal from South Wales, mixed with a small quantity of bituminous coal from Derbyshire. The boilers were made of the best Yorkshire iron, with plates having planed edges; holes were drilled after the plates had been bent; the joints were butt-joints, and they were hand rivetted. The construction of the ash-pan and its dampers, perforated plates, water supply and the arrangement of firebars, brick arch, firedoor and deflector, were shown. The indicator diagrams, taken by one of the Crosby Steam Gauge Valve Company's indicators, at various speeds, and under varying conditions of gradient, afforded a fair idea of the working capabilities of these engines, the economical value of which was best shown by quoting the consumption of fuel for the half-year ending the 30th of June, 1884, when the average of the whole of the engines on this line was 29.74 lb. per engine mile, including the coal used in raising steam. A great number of careful tests had been made of the amount of coal required to raise steam in the engines from cold water, and also from the partially heated water when the boiler had not been emptied, and this amounted on an average to about 3 lb. per mile run. Some doubt had been expressed as to the value of heating feed water by the exhaust steam. The author, therefore, had a number of tests made with the ordinary heating apparatus removed, and water fed to the boilers by the feed pumps, and in one series by a Borland's injector. The amount of power required to work the pumps was inappreciable, and the heated feed water brought about reduction in the consumption of fuel to the extent of over 2½ lb. per train-mile. It had also been found that heating the feed water by direct contact of the steam did not, on this railway, injuriously affect the boiler plates. With a view to ascertain what was