attending the arrangement. More recently, it was found almost impracticable to compress machinery of sufficient power into the narrow space between the wheels; and the cylinders and working gear have, in some cases, been restored to their original position outside the wheels. This however, has been objected to, as giving instability to the engine when in motion; and in many cases a return has been made to the former arrangement of the machinery.

Improvement has thus advanced in the structure of the engine; and though it cannot be said yet to have attained perfection, still the contrast which is presented between the locomotive as it was in its earlier history, and as it is now, is as great as that between the poorest hack that ever tottered under a burden, and the race horse that won the last "Derby."

The £550 early engine, on four wheels and of five or six tons weight, is now snperseded by the six or eight wheel engine, of £2500, and of 20, 30, or 40 tons; and though cost and weight are not to be identified with efficiency, yet they are fairly indicative of the extent of the alterations, and, we may say, improvements which have been made. The successful competitor on the Liverpool and Manchester line was required to draw a load of only three times its own weight, or a total of less than twenty tons; an engine will now drag after it, without difficulty, thirty passenger carriages, each weighing five tons and a half, at thirty miles an hour; while the express train on the Great Western proceeds, when in motion, at from sixty-five to seventy-five miles an hour; and the goods engines are capable of propelling five hundred tons at twenty miles an hour.

The power of the engines now ordinarily employed on our railways is indeed enormous. On the broad gauge we may take the "Lord of the Isles," which was shown at the great Exhibition, as the type of the class of locomotives constructed on the Great Western line since 1847; it is capable of taking a passenger train of one hundred and twenty tons, at an average speed of sixty miles an hour, upon easy gradients. The evaporation of the boiler, when at full work, is equal to 1,000 horse power, of 33,000 lbs. per horse; the effective power, as measured by a dynamometer, is equal to 743 horse power. The weight of the engine in working order is thirty-five tons, besides the tender, which, when laden weighs nearly 18 tons.—The diameter of cylinder is eighteen inches, the length of stroke 24 inches, the diameter of the driving wheel 8 feet, and the maxmium pressure of steam 120 lbs. The actual consumption of fuel in practice, with an average load of twenty tons, and an average speed of twenty-nine miles, including stoppages, is rather more than 20 lbs. of coke per mile. For the better distribution of the enormous weight of the "Lord of the Isles," it runs on eight wheels. The cylinders are laid horizontally under the front of the boiler, and can be easily examined together with the rest of the working parts, by going down into the ash-pit, over which the engines are often made to stand in the sheds.

Nor is the narrow gauge behind in the colossall power of its engines. One of the strongest of these is the "Liverpool," built on Crampton's patent which was also exhibited in the Crystal Palace. This engine contains 2285 feet of heating surface, being 270 feet more than the largest engine on the broad gauge. The diameter of the cylinder is 18 inches, the length of stroke 24, and the diameter of the driving wheel 8 feet. The engine itself weighs thirty tons, and the evaporation of the tubes, when in full work, is equal to 1140 horse-power. The pressure of the steam is 120 lbs., on the square inch. The engine is built with a very low boiler, and the greatest weight is on the extreme wheels in order to insure steadiness. To realize the amounts thus given of the power and the speed is not easy, and in order to understand them more fully, one or two illustrative facts may be mentioned. When a speed of seventy miles an hour is obtained, a space has to be passed over of 105 feet per second, that is to say 35 yards must be traversed between the tickings of the clock. If two trains proceeding at this speed pass one another, the relative velocity will be doubled, so that if one of them be seventy yards long, it would flash past the other in a single second of time. Now, according to the experiments of Dr. Hutton, it appears that the flight of a cannon ball having a range of 6700 feet is a quarter of a minute, which is at the rate of five miles a minute, or 300 miles an hour; and hence it follows that a railway train moving at 75 miles an hour, has one-fourth of the velocity of a cannon ball,

In order to understand the processes by which one of these steam monsters is put together, a visit should be made to a locomotive factory; but as this may be difficult, the proceeding adopted in their construction may here be briefly sketched by a description of the establishment of the Great Western railway at Swindon.—

The factory here consists of two large squares, surrounded by workshops, with one or two smaller squares adjoining. In connexion with these is an engine-house, where spare locomotives are kept and a building resembling a veterinary college, where defects are remedied.

The smithy may be first noticed.—This is a long range of buildings, containing 176 forges, with all the "appliances and means to boot" for their effective working. Here all the parts of a locomotive which are of wrought iron,—as axles, piston rods, connecting rods, and other pieces too numerous to mention—are produced. Three furnaces are provided in this department, in one of which the scraps of iron which come from the lathes and fitting shops are melted. Near the furnaces are two of Nasmyth's steam-hammers, which are as potent in their work as they are easy to be directed. Before these hammers were introduced the forging of huge masses of metal was both a tedious and a doubtful process; now the requisite power can be obtained to insure security in the work. Yet this mighty engine may be directed by a boy, and is so fully under command that it can be made to crack a nut without injuring the kernel, or to drive a tin tack into a piece of wood by successive raps. One of the most important parts of the work which the steam hammers have to perform, is the forging of the crank axles of locomotives, and by its aid the huge masses of metal are welded and moulded without difficulty.

The wheel-working is a process of interest, and on the necessity of good workmanship here, it would be superfluous to dilate. The whole of the wheels are formed of wrought iron, the several parts being forged in pieces and then welded together. In the large eight feet driving wheels, there are twenty-four spokes. A wheel consists altogether of more than a hundred pieces. The scenes which are presented in the various operations around the forges, are characterized by a wild magnificence, which must be witnessed to be appreciated.

The next part of the establishment is the boiler house. The materials of which the boiler is chiefly made consist of sheet iron, prepared for the purpose, the plates of which, when brought to their proper size and shape, are drilled round the edges so that they may be firmly held together by means of rivets. The noise which fills the building is most deafening. To speak so as to be heard is impossible, and if it be attempted, the motion of the lips of the speaker is the only evidence that he is talking. The impression produced upon the minds of almost all who enter a boiler house for the first time is, that the workmen commence a most tremendous clattering of hammers and plates for his special annoyance, as it seems almost impossible that any useful undertaking can be progressing as the result of such a din.

In the foundry which may next be visited, the cast iron works are carried on, and a variety of operations may be witnessed, while in an adjoining building the wood-work of the buffers and the models in wood for the castings are prepared.

The fitting-shops form one of the most interesting departments of the establishment. In order to supply the power necessary to put in motion the numerous machines in the factory, there are two powerful engines: one with twenty-one-inch cylinders, and another with thirty-inch-cylinders. In the lower turning-shops, the axles, crank-axles and other large parts of locomotives are finished. Here is a slotting machine, which is so complete in its operation, that all the manual attention it requires is to have the supply of soft- soap and water kept up to preserve the tool from becoming unduly heated. The value of the great machines employed in this establishment may be gathered from the fact, that the resources of manual labor would be quite insufficient to secure the accuracy of adjustment, and security of workmanship, which are essential. And when the recent demands of advancing mechanical science arose, the necessity for more powerful means became imperative; and a sudden call for machinery of superior accuracy was made. The steam-engine itself, which supplies us with such unbounded power, owes its present perfection to the admirable means thus obtained, of giving to metallic objects the most precise and perfect geometrical forms; and it is this alone which has provided the means of carrying into practice the accumulated results of scientific investigation in mechanical subjects.

The last department is the erecting-shed, in which all the parts of a locomotive numbering no fewer than 5416, are put together; and it will be readily conceived that nothing short of the utmost completeness and accuracy, in the finish of these parts, could enable the workmen to combine them in one harmonious and efficient unity. Yet the failure of one screw or bolt, or the bending of one rod, may hereafter involve, not only the costly fabric itself in ruin, but occasion the destruction of property and life to a terrible extent. So complete must be the details, so accurate the adjustment, that Mr. Robert Stephenson well remarked that a locomotive "must be put together