

energies were being devoted to arms and their capital to armaments, the fertile brains of inventors were busy. Great discoveries were being made, or, what is more important for our purpose, were being turned to useful ends.

Two centuries earlier men had become aware that a great instrument stood ready for those who knew how to use it, but the common opinion which gives to James Watt (1736-1819) the credit of the steam engine, and forgets Giovanni Branca (1601), Solomon de Caus (1615), the Marquis of Worcester (1663), Denis Papin (1690), and even Thomas Savery (1698), is doing that rough substantial justice which the popular view rarely fails to distribute. Though the great Scotchman was unquestionably aware of the importance of his improvements, which, in fact, made steam the powerful agent we know, even he would be surprised could he see how far his successors have surpassed him in its economical use, and what purposes they have made it serve. For Watt died in 1819, when the steamboat was in its earliest infancy and steam traction on land was hardly begun.

The propulsion of ships by steam dates from the end of the eighteenth century, but John Fitch's invention brought him nothing but misery, and led to his suicide in 1798. The Iron and Steel Institute is of so cosmopolitan a character that it would be unseemly to assert for Great Britain claims which may be contested. I will, therefore, not seek to award the merit of the practical employment of steam in ships as between my namesake Henry Bell (1767-1830) and Robert Fulton (1765-1815), though I might claim the credit for "Britain" in either case, since the American was born at "Little Britain," in Pennsylvania, while Bell hailed from Torphichen Mill, in Great Britain. The two purposes to which I have referred give us the reason why the nineteenth century should have witnessed the great industrial developments, to a rapid sketch of which my address is devoted.

While men were dependent on such puny instruments as those which had served their purposes since civilization dawned on the world, we may rather be surprised at the wonderful ingenuity which enabled them to accomplish so much than at the slow progress which had been made. I have within the last few months visited the Valley of the Nile and seen with amazement the great works accomplished by a people who, as far as we know, possessed no other contrivances than the lever, the wheel, and the inclined plane, and those primitive instruments which our remote ancestors devised when they emerged from the rest of the animal creation and stood forth as men. The magnificent monuments of that wonderful land bear comparison for stupendousness with the great works which the engineers of the nineteenth century have constructed for the benefit of the country and the world at large, while in beauty they vastly surpass them. But without such assistance as we can now call to our aid, it is impossible to conceive the industry of the world on its present scale conducted under the conditions which produced the marvels we admire in Egypt.

Now, of all the aids we have at our disposal to-day, none is more important than the facility of transport. It has been said that no real improvement in this respect was made from the time when the Romans began to build roads till steam took the place of vital power as a propelling force, and that the Emperors Caracalla and Geta, hurrying from York to claim the Imperial purple in the third century, were no longer in reaching Rome than was Sir Robert Peel in returning from Rome to London to become the Prime Minister of Great Bri-

tain in the nineteenth. Yet till the power of bringing together in great masses the mineral resources of the world was attained the output of iron was limited to those districts where the ore and the fuel chanced to lie in juxtaposition. The great developments of recent times depend entirely on the improvements in transport. What would the founder of the ironworks at Dowlais have said had he been told that their prosperity would come to depend not so much on the fact that the iron ore and the coal could be extracted from the same pit as on the accessibility of Cardiff to the Basque Provinces of Spain? And the two things react on one another—without steam transport a highly developed iron trade is impossible; without abundant and cheap iron steam traction is inconceivable. It is for these reasons that the history of railways is so intimately connected with that of the iron trade.

As is well known, the idea of a fixed and rigid path along which the wheels of a wagon should travel is a very old one, but until the end of the eighteenth century it had been but little utilized. It remained for George Stephenson (1781-1848) to show that it was essential to the construction of a road on which the means of traction should be that new power which the genius of Watt and his collaborators had placed at man's disposal. Here, again, the common opinion which connects the name of Stephenson with this great invention and disregards, or at least places in subordinate positions, Murdock, or Trevithick, or Blenkinsopp, or Hedley, does no more than substantial justice. The first quarter of the nineteenth century witnessed the trials and failures which were to end in revolutionizing carriage by land. In 1822 the first railway, in the modern sense of the word, was opened for mineral traffic, while three years later (in September, 1825) the first passenger line, the forerunner of the vast network which now overspreads the civilized world, began operations between Darlington and Stockton.

But to render this possible much more was needed than to invent the locomotive engine or the fixed path. Here, again, we find many names claiming to be inscribed on the roll of fame as entitled to the honor of inventor of the process which was destined to bear its part in the coming revolution. To Henry Cort (1740-1800) we must, in any case, assign a prominent place on the roll, for though we may deny him the title of "father of the iron trade," or even that of the "inventor of puddling," there can be no question that to his ingenuity the industry owes a deep debt—a debt only indifferently discharged by grants from the Government of the day, the last of which was made, at the instance of Dr. Percy, one of my predecessors in the chair, by Lord Palmerston, to Cort's only surviving son, in 1856. If to him we add John Wilkinson (1728-1808), and the veritable dynasty of Abraham Darbys, of whom the grandfather was born in 1677 and the grandson died in 1791, we have noted the chief of those whose endeavors towards the improvement of processes connected with the iron trade rendered it possible for the inventors of the railroad to make the fixed path of malleable iron produced in great quantities and at reasonable cost. It is not unnatural that the bulk of the names mentioned have been citizens of Great Britain. This country, from its physical configuration, its geological peculiarities and its limited size, presented the most favorable laboratory in which to try experiments. To these circumstances is due the fact that, at the beginning of the last century, one-third of the world's production of pig iron came from these islands, though the total production of the world did not exceed three-quarters of a million tons.