

and afterwards to all the principal canals being constructed at that time in England. The King of Sweden consulted him on the construction of the Gotha Canal, and Telford superintended the work on it. Telford's fame, however, rests on his magnificent roads. He built 920 miles of roads in the Highlands of Scotland and also a system of roads through the Welsh Mountains, which included the beautiful Menai Suspension Bridge. His continental work also included the road from Brest to Warsaw, constructed for the Austrian Government.

Mention has been made of the revolution caused in the profession of engineering by the introduction of steam, and we must now take a glance at Watt and his many discoveries in steam engineering.

In 1757 Watt, then only twenty-one years old, was established in the University of Glasgow as scientific instrument maker. With Black, the Professor of Chemistry, and famous as the discoverer of latent heat, he often discussed the possibility of improving the steam engine as it then existed. Newcomen's engine, the forerunner of Watt's, was merely used as a pumping engine. In this engine the top of the cylinder was uncovered, the steam was admitted below the piston only, and was condensed in the cylinder by a jet of cold water. After nine years of thought and study on the nature of steam, Watt at last conceived the idea of the condenser, and this with many other improvements, such as packing for the piston, cover and stuffing-box for cylinder, admitting steam to both sides of the piston, and the steam jacket he patented in 1769. Other inventions of Watt with regard to the steam engine are methods for converting the reciprocating motion to a motion of rotation, expansive working, parallel motion for the piston rod, throttle valve, centrifugal governor, and indicator. In fact, the only im-

portant changes since Watt's time are three, namely: (1) The great beam has been abandoned; (2) adoption of high pressure; (3) compound expansion. In 1780 Watt took out a patent for a simple process now used over the whole civilized world—the method of copying letters by using damp paper and slightly glutinous ink.

The inventions of Watt thus paved the way for George Stevenson and the first steam railroad in 1825, and with the railroad the present era of engineering began.

Though engineering is an eminently practical profession, still it differs in a marked way from the other scientific profession, that of medicine, in depending most closely on mathematics and mathematical physics, and we shall see that a thorough theoretical knowledge is absolutely necessary for its successful practice. An engineer must be a scientist as well as a practical man, and, although in the foregoing sketch we find names of men who have attained to great eminence as engineers without having had a sound theoretical training, still it was owing to great natural ability that they were so successful, and in many of their great works practice which then was worthy of praise would now be rather worthy of blame. In a recent lecture delivered by Dr. Anderson he said that, "having seen the great advantages that have accrued from the employment of men of the highest scientific culture in carrying out the engineering works in continental Europe and in the United States of America, we must recognize the fact that the days are past when an engineer can acquit himself respectably by the aid of mother wit alone, or of certain constructive instincts which have been almost the only guide of engineers and manufacturers down to quite recent times." A practical man is one who is guided by his own experience, and so is one who in narrow limits is not likely to make serious