To return to the cutting steels, say turning tools, the development in the efficiency of these agents of civilization is almost astounding. In 1740 the standard turning tool in iron and carbon steel contained as to-day about 1.25 per cent. of carbon. When hardened its turning efficiency was limited by the fact that its cutting hardness was thermally unstable, and the nose of the tool became soft and broke down with the heat of friction at a brown tempering heat, say 250 deg. C. This fact limited depth of cut, breadth of traverse, and speed of running within well defined limits.

Then about 1870 Robert Mushet, at the works of Messrs. Samuel Osborn and Co., put to a practical issue his discovery of tungsten steel. He found that tungsten so fortified the hardness of the plain carbon steel that the breaking-down temperature was raised perhaps 100 deg. C.; also that it was not necessary to quench such steel, but merely to cool it from, say, a yellow heat in a blast of air. Hence such steel was known as Mushet's self-hardening steel. Later, perhaps in the early eighties, Mushet still further fortified the thermal stability of the carbon hardness with relatively small quantities of chromium.

At the Paris Exhibition of 1900 Messrs. Taylor and White, of America, startled steel manufacturers by showing that a steel of the Mushet type might, under certain conditions, turn at a low red heat, say 550 deg. C. The steel makers of Sheffield were not slow to take this hint, and began that series of experiments which ultimately gave to the world modern high-speed steel, a material which has altered the whole trend of the possibilities of modern engineering output. The main features of this development from Mushet's original steel may be summarized as follows:—Much lower carbon, much higher tungsten and chromium, and the virtual abolition of silicon and manganese.

The final phase of this development has been the application as a fortifying item of the rare element vanadium. The influence of this element on steel was discovered in the manufacturing laboratories of the University of Sheffield in a series of researches extending from 1899 to 1902, and its application to high-speed steel by Sheffield makers followed a few years later. The net result of these collective Sheffield experiments between, say 1900 and 1910, was to produce a turning alloy with a thermal stability up to 650 deg. C., a distinct red heat, or in other words, an advance of 400 deg. C. over the plain carbon steel of 1740. The result, of course, is that cuts, traverses, and speeds which even in 1890 would have been dismissed as a madman's dream are now calmly accepted facts. To put this advance in another way, the 1740 turning tool would before breaking down remove 15 cubic inches of material, whilst, cœteris paribus, a second quality modern high-speed steel will remove, say, 215 cubic inches.

The latest application of science to steel making is to the melting and refining of steel by electrical heat as a substitute for the heat of external fuels, such as coke or coal gas, or the combustion of internal fuels such as carbon, silicon, manganese, and phosphorus. There are two main types of furnace—the arc and the induction. The latter must be regarded as a melting apparatus, the former as a refining furnace. There seems little doubt that electrical steel melting has come to stay, but to what extent it is not easy to predict. Its development has undoubtedly been retarded by the very able electrical engineers who have with consummate skill developed their methods, ignoring altogether the steel metallurgist's knowledge, and assuming that the problem was purely one of electrical energy converted into thermal energy. The electrical engineer has well achieved his part. The final verdict must be pronounced by the steel metallurgist. There are things in steel and iron metallurgy undreamed of in the philosophy of the electrical engineer.

It has been a common reproach that Sheffield was asleep, hide-bound, in this matter. No greater mistake was ever made. What are the facts? In Sheffield at the present moment there are (including one at the University Steel Works) three induction furnaces and four arc furnaces which are being worked on costly experimental lines, and this with electrical energy at, say, 0.6d. per unit. There is talk of making steel with 500 units per ton, but this is nonsense. That figure multiplied by two would be nearer the mark. The whole problem is still in the air, and the writer would ask electrical engineers to remember that Sheffield has a reputation for steel extending back into the centuries, and with this she cannot afford to trifle. In the writer's opinion the electrical method has a future before it, but it has yet to find its exact metallurgical level.

RAILWAY TIES OF REINFORCED CONCRETE AND ASBESTOS.

A new reinforced concrete tie is being tested on the Bavarian railways, which seems to combine the elasticity of wood with the durability of steel and concrete. This tie uses asbestos fibres soaked in water and saturated with pure cement as one of the elements. The mixture after complete saturation with water forms a soft, tenacious mass, which does not permit tamping or ramming as concrete does, but reaches two-thirds of the breaking strength of concrete. After setting, it can be drilled, nailed, and hammered like wood and retains its hold upon other materials better than wood. The concrete consists of one part cement, one part rubble, and two parts gravel sand. The asbestos is used only below the actual seat of the rails. The ties are 8 ft. 9 in. long, 8 in. wide, and 6 to 7 in. thick. Seven steel rods for the tensile zone reinforcement are imbedded below the rail seat, which is also of concrete, and the asbestos is placed on top of this. This lessens the cost of the tie, as the asbestos is rather expensive. A tie costs from six to seven shillings, and the weight is about three times that of the wooden tie (484 lb.). The setting of the cement and asbestos is much slower than that of concrete, and is accompanied by formation of heat. Hydrates of lime are formed in the process, as asbestos (calcium-magnesium silicate) has only a little silicic acid due to impurities. The excess of lime in the cement (25 per cent.) is also changed to hydrate of lime with formation of heat. Whether the ties will meet the requirements of the expected wear and tear is still a matter of doubt, as they have only been used for some nine months so far, although they have shown no defects within that time.

BACTERIA IN HOUSE DRAINS.

Dr. F. W. Andrewes, Local Government Board Medical Officer, dealing with experiments he had made in reference to the bacteria of sewer air, says: "While the experiments prove the possibility of the escape of sewage bacteria into the air of house drains, in the absence of an intercepting trap, we must not lose sight of the fact that the test organisms were present in the sewage to the number of hundreds of thousands, and in one case of at least 1,000,000 per cent. No one has ever suggested that pathogenic bacteria are pre-