in a very rare degree by a combination of scientific comprehension with practical instinct. In both fields he played a part which would have been great in either alone; and, in addition to this, he produced from time to time miscellaneous inventions and scientific papers sufficient in themselves to have established a reputation. His position was recognized by his election in 1862 to the Royal Society, and later to the presidency of the Institu­tion of Mechanical Engineers, the Society of Telegraph Engineers, the Iron and Steel Institute, and the British Association; by honorary degrees from the universities of Oxford, Glasgow, Dublin and Würzburg; and by knighthood (in 1883). He died in London on the 19th of November 1883.

In the application of heat Siemens’s work began just after J. P. Joule’s experiments had placed the doctrine of the conservation of energy on a sure basis. While Rankine, Clausius and Lord Kelvin were developing the dynamical theory of heat as a matter of physical and engineering theory, Siemens, in the light of the new ideas, made a bold attempt to improve the efficiency of the steam engine as a converter of heat into mechanical work. Taking up the regenerator —a device invented by Robert Stirling twenty years before, the im­portance of which had meanwhile been ignored—he applied it to the steam engine in the form of a regenerative condenser with some success in 1847, and in 1855 engines constructed on Siemens’s plan were worked at the Paris exhibition. Later he also attempted to apply the regenerator to internal combustion or gas engines. In 1856 he introduced the regenerative furnace, the idea of his brother Friedrich (1826-1904), with whom he associated himself in directing its applications. In an ordinary furnace a very large part of the heat of combustion is lost by being carried off in the hot gases which pass up the chimney. In the regenerative furnace the hot gases pass through a regenerator, or chamber stacked with loose bricks, which absorb the heat. When the bricks are well heated the hot gases are diverted so to pass through another similar chamber, while the air necessary for combustion, before it enters the furnace, is made to traverse the heated chamber, taking up as it goes the heat which has been stored in the bricks. After a suitable interval the air currents are again reversed. The process is repeated periodically, with the result that the products of combustion escape only after being cooled, the heat which they take from the furnace being in great part carried back in the heated air. But another invention was required before the regenerative furnace could be thoroughly successful. This was the use of gaseous fuel, produced by the crude distillation and incomplete combustion of coal in a distinct furnace or gas-producer. From this the gaseous fuel passes by a flue to the regenerative furnace, and it, as well as the entering air, is heated by the regenerative method, four brick-stacked chambers being used instead of two. The complete invention was applied at Chance’s glass-works in Birmingham in 1861, and furnished the subject of Faraday’s farewell lecture to the Royal Institution. It was soon applied to many industrial processes, but it found its greatest development a few years later at the hands of Siemens himself in the manufacture of steel. To produce steel directly from the ore, or by melting together wrought-iron scrap with cast-iron upon the open hearth, had been in his mind from the first, but it was not till 1867, after two years of experiment in “ sample steel works ” erected by himself for the purpose, that he achieved success. The product is a mild steel of exceptionally trustworthy quality, the use of which for boiler-plates has done much to make possible the high steam-pressures that are now common, and has consequently contributed, indirectly, to that improvement in the thermodynamic efficiency of heat engines which Siemens had so much at heart. Just before his death he was again at work upon the same subject, his plan being to use gaseous fuel from a Siemens producer in place of solid fuel beneath the boiler, and to apply the regenerative principle to boiler furnaces. His faith in gaseous fuel led him to anticipate that it would in time supersede solid coal for domestic and industrial purposes, cheap gas being supplied either from special works or direct from the pit ; and among his last inventions was a house grate to burn gas along with coke, which he regarded as a possible cure for city smoke.

In electricity Siemens’s name is closely associated with the growth of land and submarine telegraphs, the invention and development of the dynamo, and the application of electricity to lighting and to locomotion. In i860, with his brother Werner, he invented the earliest form of what is now known as the Siemens armature ; and in 1867 he communicated a paper to the Royal Society “ On the Con­version of Dynamical into Electrical Force without the aid of Per­manent Magnetism,” in which he announced the invention by Werner Siemens of the dynamo-electric machine, an invention which was also reached independently and almost simultaneously by Sir Charles Wheatstone and by S. A. Varley. The Siemens-Alteneck or multiple-coil armature followed in 1873. While engaged in con­structing a trans-Atlantic cable for the Direct United States Tele­graph Company, Siemens designed the very original and successful ship “ Faraday,” by which that and other cables were laid. One of the last of his works was the Portrush and Bushmills electric tram­way, in the north of Ireland, opened in 1883, where the water-power of the river Bush drives a Siemens dynamo, from which the electric energy is conducted to another dynamo serving as a motor on the car. In the Siemens electric furnace the intensely hot atmosphere of the electric arc between carbon points is employed to melt re­fractory metals. Another of the uses to which he turned electricity was to employ light from arc lamps as a substitute for sunlight in hastening the growth and fructification of plants. Among his miscellaneous inventions were the differential governor already alluded to, and a highly scientific modification of it, described to the Royal Society in 1866; a water-meter which acts on the principle of counting the number of turns made by a small reaction turbine through which the supply of water flows; an electric thermometer and pyrometer, in which temperature is determined by its effect on the electrical conductivity of metals; an attraction meter for de­termining very slight variations in the intensity of a gravity; and the bathometer, by which he applied this idea to the problem of finding the depth of the sea without a sounding line. In a paper read before the Royal Society in 1882, “ On the Conservation of Solar Energy,” he suggested a bold but unsatisfactory theory of the sun’s heat, in which he sought to trace on a cosmic scale an action similar to that of the regenerative furnace. His fame, however, does not rest on his contributions to pure science, valuable as some of these were. His strength lay in his grasp of scientific principles, in his skill to perceive where and how they could be applied to practical affairs, in his zealous and instant pursuit of thought with action, and in the indomitable persistence with which he clung to any basis of effort that seemed to him theoretically sound.

Siemens’s writings consist for the most part of lectures and papers scattered through the scientific journals and the publications of the Royal Society, the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Iron and Steel Institute, the British Association, &c. A biography by Dr William Pole was published in 1888. (J. A. E.)

**SIENA,** a city and archiepiscopal see of Tuscany, Italy, capital of the province of Siena, 59 m. by rail S. of Florence and 31 m. direct. Pop. (1901) 25,539 (town); 40,423 (commune). The area of the city within the walls is about 2½ sq. m., and the height above sea-level 1115 ft. The plan, spreading from the centre over three hills, closely resembles that of Perugia. The city possesses a university, founded in 1203 and limited to the faculties of law and medicine. Among the other public institu­tions the following are the more important: the town library, first opened to students in the 17th century; the Archivio, a record office, instituted in 1858, containing a valuable and splendidly arranged collection of documents; the Fine Arts Institution, founded in 1816; and the natural history museum of the Royal Academy of the Physiocritics, inaugurated in the same year. There are also many flourishing charities, including an excellent hospital and a school for the deaf and dumb. The chief industries are weaving and agriculture.

The public festivals of Siena known as the “Palio delle Con- trade ” have a European celebrity. They are held in the public square, the curious and historic Piazza del Campo (now Piazza di Vittorio Emanuele) in shape resembling an ancient theatre, on the 2nd of July and the 16th of August of each year; they date from the middle ages and were instituted in commemoration of victories and in honour of the Virgin Mary (the old title of Siena, as shown by seals and medals, having been “ Sena vetus civitas Virginis”). In the 15th and 16th centuries the celebrations consisted of bull-fights. At the close of the 16th century these were replaced by races with mounted buffaloes, and since 1650 by (ridden) horses. Siena is divided into seventeen *contrade* (wards), each with a distinct appellation and a chapel and flag of its own; and every year ten of these *contrade,* chosen by lot, send each one horse to compete for the prize *palio* or banner. The aspect of Siena during these meetings is very characteristic, and the whole festivity bears a medieval stamp in harmony with the architecture and history of the town.

Among the noblest fruits of Sienese art are the public buildings adorning the city. The cathedral, one of the finest examples of Italian Gothic architecture, obviously influenced in plan by the abbey of S. Galgano *(infra),* built in black and white marble, was begun in the early years of the 13th century, but interrupted by the plague of 1248 and wars at home and abroad, and in 1317 its walls were extended to the baptistery of San Giovanni; a further enlargement was begun in 1339 but never carried out, and a few ruined walls and arches alone remain to show the