others. Next came the discovery of Galvani and of Volta, and as a consequence a fresh set of proposals, in which voltaic electricity was to be used. The discovery by Nicholson and Carlisle of the decomposition of water and the subsequent researches of Davy on the decomposition of the solutions of salts by the voltaic current were turned to account in the water voltameter telegraph of Sömmering and the modification of it proposed by Schweigger, and in a similar method proposed by Coxe, in which a solution of salts was substituted for water. Then came the discovery by Romagnesi and by Oersted of the action of the galvanic current on a magnet. The application of this to tele­graphic purposes was suggested by Laplace and taken up by Ampère, and afterwards by Triboaillet and by Schilling, whose work forms the foundation of much of modern tele­graphy. Faraday’s discovery of the induced current pro­duced by passing a magnet through a helix of wire forming part of a closed circuit was laid hold of in the telegraph of Gauss and Weber, and this application was at the request of Gauss taken up by Steinheil, who brought it to consider­able perfection. Steinheil communicated to the Göttingen Academy of Sciences in September 1838 an account of his telegraph, which had been constructed about the middle of the preceding year. The currents were produced by a magneto-electric machine resembling that of Clarke. The receiving apparatus consisted of a multiplier, in the centre of which were pivoted one or two magnetic needles, which either indicated the message by the movement of an index or by striking two bells of different tone or recorded it by making ink dots on a ribbon of paper. Among other workers about this time we may mention Masson, Bréguet, Davy, Deval, Billon, Soudalot, and Vorsselman who pro­posed to use the physiological effects of electricity in work­ing an electric telegraph.@@1

Steinheil appears to have been anticipated in the matter of a recording telegraph by Morse of America, who in 1835 constructed a rude working model of an instrument ; this within a few years was so perfected that with some modi­fication in detail it has been largely used ever since (see below). In 1836 Cooke, to whom the idea appears to have been suggested by Schilling’s method, invented a telegraph in which an alphabet was worked out by the single and combined movement of three needles. Subsequently, in conjunction with Wheatstone, he introduced another form, in which five vertical index needles, each worked by a separ­ate multiplier, were made to point out the letters on a dial. Two needles were acted upon at the same time, and the letter at the point of intersection of the direction of the indexes was read. This telegraph required six wires, and was shortly afterwards displaced by the single-needle system, still to a large extent used on railway and other less im­portant circuits. The single-needle instrument is a vertical needle galvanoscope worked by a battery and reversing key, the motions to right and left of one end of the index corre­sponding to the dashes and dots of the Morse alphabet. To increase the speed of working, two single-needle instru­ments were sometimes used (double-needle telegraph). This system required two lines of wire, and, along with all multiple-wire systems, soon passed out of use. Similar instruments to the single and double needle ones of Cooke and Wheatstone were about the same time invented by the Rev. H. Highton and his brother Edward Highton, and were used for a considerable time on some of the railway lines in England. Another series of instruments, intro­duced by Cooke and Wheatstone in 1840, and generally known as “Wheatstone’s step-by-step letter-showing” or

“ABC instruments,” were worked out with great ingenuity of detail by Wheatstone in Great Britain and by Bréguet and others in France. They are still largely used for pri­vate wires, but are being rapidly displaced by the telephone.@@2 Wheatstone also described and to some extent worked out an interesting modification of his step-by-step instrument, the object of which was to produce a letter-printing tele­graph. But it never came into use ; some years later, however, an instrument embodying the same principle, although differing greatly in mechanical detail, was brought into use by Royal E. House of Vermont, U.S., and was very successfully worked on some of the American telegraph lines till 1860, after which it was gradually displaced by the Phelps combination telegraph. The House instrument is not now in use, but various modifications of it are still employed for private lines and for stock telegraphs, such as Calahan’s and the universal stock telegraphs, Phelps’s stock printer, Gray’s automatic printer for private lines, Siemens’s and Phelps’s automatic type printers, &c. (see *infra,* pp. 120-121).

II. General Description of Electric Telegraphs for Land and Sea.

The first requisite for electro-telegraphic communica­tion between two localities is an insulated conductor ex­tending from one to the other. This, with proper apparatus for originating electric currents at one end and for dis­covering the effects produced by them at the other end, constitutes an electric telegraph. Faraday’s term “elec­trode,” literally a way for electricity to travel along, might be well applied to designate the insulated conductor along which the electric messenger is despatched. It is, how­ever, more commonly and familiarly called “ the wire ” or “ the line.”

The apparatus for generating the electric action at one end is commonly called the *transmitting apparatus* or *in­strument,* or the *sending apparatus* or *instrument,* or some­times simply the *transmitter* or *sender.* The apparatus used at the other end of the line to render the effects of this action perceptible to any of the senses—eye, ear, or taste, all of which have been used in actual telegraphic signalling—is called the *receiving apparatus* or *instrument.*

In the aerial or overground system of land telegraphs the main line consists generally of a “galvanized” iron wire from one-sixth to a quarter of an inch in diameter, stretched through the air from pole to pole, at a sufficient height above the ground for security. The supports or in­sulators, as they are called, by which it is attached to the poles are of very different form and arrangement in different telegraphs, but consist essentially of a stem of glass, por­celain, coarse earthenware, or other non-conducting sub­stance, protected by an overhanging screen or roof. One end of the stem is firmly attached to the pole, and the other bears the wire. The best idea of a single telegraphic insulator may be got from a common umbrella, with its stem of insulating substance attached upright to the top of a pole and bearing the wire supported in a notch on the top outside. The umbrella may be either of the same substance as the stem—all glass or all glazed earthenware, for instance—or of a stronger material, such as iron, with an insulating stem fitted to it to support it below. Very good insulators may be made of continuous glass; but well-glazed porcelain is more generally used, or rather earthenware, which is cheaper, less brittle, and less hygro­scopic, and insulates well as long as the glazing is sufficient to prevent the porous substance within from absorbing moisture.

One of the best forms—Varley’s double cud insulator

@@@1 The reader interested in the early history of the electric telegraph may consult Edward Highton, *The Electric Telegraph,* London, 1852; Moigno, *Traité de Télégraphie Électrique,* Paris, 1849; and Sabine, *History of the Electric Telegraph,* London, 1869.

@@@2 For the different forms, see Prescott’s *Electricity and the Electria Telegraph,* pp. 562-602.