No. 1,604. "On Progress in the Application of Electrical Science to Engineering Purposes in Foreign Countries, as recorded in the Abstracts of Papers in the Proceedings, during the years 1874-78." By PAGET HIGGS, Assoc. Inst. C.E.

OF all the applications of the science of electricity to practical purposes that fall within the cognisance of the engineer, telegraphy is the most important. Since the commencement of the "Abstracts" in 1874, great advances have been made in telegraphy, and that not only in one branch; whether attention be turned to the improvements upon existing apparatus and systems, or to discoveries and inventions, progress is equally marked. It is characteristic of the improvements in telegraphy that the more important excite the interest of the world; in return for this, telegraphy has perhaps done more than any other applied science towards instructing people generally in the principles of scientific engineering. Scarcely has interest subsided in the apparently wonderful fast-speed telegraphs, before the era of multiple telegraphy is opened, to be followed by the startling discoveries of the telephone and its mechanical analogue, the phonograph. If a telegraph engineer were asked to name the most important invention in telegraphic science during the last four years, the answer would undoubtedly refer to the telephone; and it is the accounts of this instrument that appear to be naturally sought when turning to the "Abstracts" to learn about progress in the applications of electricity. The discovery of the telephone follows in sequence the strange results obtained by Mr. Elisha Gray¹ when including a portion of the human body in the secondary circuit of an induction coil as a part of an apparatus for receiving musical sounds; and the valuable and striking invention of Professor Graham Bell² is found to be followed rapidly by descriptions of other modes of transmitting speech as invented, introduced, or improved by Trouvé,³ Edison, and Breguet.⁴ The invention of the telephone is singular in that the Bell instrument, which brings into play the principles of magneto-electricity, does not represent all the principles involved in apparatus by which speech can be transmitted.

Vide Minutes of Proceedings Inst. C.E., vol. I., p. 310; ² vol. I., p. 311; vol. lii., p. 396; ⁴ vol. liii., p. 393.

In Edison's telephone two totally different and novel principles are involved, namely, the variation in current produced by variation in resistance caused by varying pressure or compression employed in the transmitting instrument, and the variation in friction caused by varying rate of electrolysis employed in the receiving instrument. But to M. Breguet's telephone the palm of novelty must be awarded; for in this instrument again is a wholly different and very little applied principle involved, that of the currents produced in mercurial surfaces in contact with acid electrolytes by movement or changes of surface, and the converse of movements or vibration produced by variation of current. Thus the telephone attains its end by either and all of four distinct scientific principles, three of which may be said to have been born into our sphere of knowledge as a result of competition with the invention of the first telephone for the transmission of speech. It may also be said of telegraphy that it stands first in the applied sciences, for the speed with which improvements are evolved when once the line of work is pointed out. Illustrating this is Dr. Siemens' Paper on telephony,¹ in which improved instruments are constructed on the consideration of the imperfections of the Bell telephone, and on acoustic principles as studied by Helmholtz.

But the effulgence attending the invention of the telephone, very like the brilliancy of the electric light, is somewhat calculated to lead to omission in the study of subjects of less *éclat*. Until the present time there are many difficulties in view with regard to the general use of the telephone except for short distances, and it does not now appear at all probable that this instrument will supersede the need of invention in fast speed and multiple telegraphs. Indeed, on long circuits, until speech shall have been made self-recording in a manner to be easily read by anyone from generally applicable apparatus, fast-speed automatic telegraphs will have the advantage in speed and accuracy of transmission. Between forty-five words and one hundred and eighty words per minute (the practical limits of present automatic writers), supposing these to be accurately transmitted by the telephone, ordinary handwriting must be replaced by shorthand, and from this transcription it is well known there is considerable risk of error. Progress in duplex signalling on land lines is well represented by Mr. Louis Schwendler's Paper² on the theory of duplex telegraphy, whose system is doing good service on the Indian Government lines, as well as in other countries. In

¹ *Vide* Minutes of Proceedings Inst. C.E., vol. liii., p. 395; ² vol. xliv., p. 328.

multiple telegraphy there are described the "successive epoch" system of M. Meyer¹ and the use of tuning forks on Lacour's system,² both of which have not yet met with extended application; while illustrations of recently introduced quadruplex systems are unfortunately wanting, owing to the fact that they have not become developed sufficiently for general use on foreign lines, except in America. The application of the duplex system to submarine lines is represented by M. Ailhaud's method,³ as employed on the Marseilles-Algiers cable, in which the "kick," arising from inequalities in the discharge from the actual and the artificial cable, is obviated in a manner somewhat similar to that adopted in Dr. Muirhead's method, by the interposition of a condenser in the instrumental circuit. The subject of increasing speed on submarine lines is sought to be aided by M. Lacoine,⁴ who lays down the best proportion that the resistance of the coils of the instruments can bear to the resistance of the cable-conductor. On land lines this subject has been studied by M. du Moncel,⁵ as well as by Mr. Brough,⁶ who both give formulæ for maximum condition of electromagnets; whilst the troubles arising with such delicate instruments as the Hughes' Printer (an automatic arrangement for which is described by M. Renoir⁷), from the induction between two or more line wires where connected with earth cables, appear to be not very successfully obviated by the leakage resistances proposed by M. Lagarde,⁸ as tried on the line between Paris and Florence, where the experimentalist assured himself that the mischief arose chiefly on the aerial lines.

As allied to progress in telegraphic construction may be considered the substitution, where possible, of underground for aerial lines, and the laying down of long subterranean lines, such as the seven-core cable connecting the city of Berlin with the town of Halle.⁹ In Germany, however, there seems to exist a peculiar method of judging of the value of a cable by the smallness of its percentage of loss of current, the plan adopted for estimating this being described by Dr. Brix.¹⁰

Related to the construction of land lines is M. Bourseul's inquiry into the causes of destruction of wooden poles,¹¹ from "dry," "wet," and "black" rot, and the remedies; and the report upon the durability of the insulation of Brooks' insulators¹² as compared with

¹ *Vide* Minutes of Proceedings Inst. C.E., vol. xxxix., p. 429; ² vol. xliii., p. 434; ³ vol. i., p. 308; ⁴ vol. xlix., p. 388; ⁵ vol. li., p. 395; ⁶ vol. lii., p. 397; ⁷ vol. xlv., p. 337; ⁸ vol. xlii., p. 386; ⁹ vol. lii., p. 395; ¹⁰ vol. i., p. 313; ¹¹ vol. xli. p. 261; ¹² vol. xliii., p. 433.

the porcelain insulator, the experiments in M. Gaugain's hands indicating equality, if not superiority, for the Brooks' insulator.

The laying and testing of submarine cables is represented by Dr. W. Siemens' Paper¹ on these subjects, which raised considerable discussion when translated and contributed to the Society of Telegraph Engineers, particularly with regard to the strains occurring on a cable during submersion.

Amongst the numerous applications of the electric current, as an aid in the arts and manufactures, is to be mentioned the coating of cast-iron cylinders with copper in a galvanoplastic bath, described by M. Schlumberger², for the purpose of printing upon calico and other stuffs, a process in which the difficulties have been unsurmounted for thirty years, but appear about to yield to a cheaper production of the electric current. As a means of reducing or precipitating copper from mother liquors too impure to yield merchantable sulphate, electricity has been proposed by Mr. Keith,³ and it appears that the process could be conducted at a low cost. More nearly related to engineering pursuits is the application of electricity to blasting. Amongst the Papers on this subject is that by MM. Champion, Pellet, and Grenier,⁴ relative to fuses and their construction; and Mr. Striedinger⁵ describes the circuit closer for the simultaneous ignition of many mines as used at the great blast for the removal of the Hell-Gate rock,⁶ where more than three thousand six hundred separate charges were simultaneously exploded.

At the present time electricity is asserting a claim upon public attention other than that presented by the telephone. According to the statements of some engineers of high standing, the days of gas-lighting are numbered; according to others electric lighting is a thousandfold too costly to come into common use. Probably these statements are the extremes between which the true mean is to be found, and containing some elements of both. As the Author has pointed out, in a Paper presented to the Institution,⁷ the field for electric lighting is in the illumination of large open spaces, leaving to gas the lighting of small and of subdivided areas. It has also been pointed out, that with the means of subdividing the electric current, so that it can be made available for several small centres of light instead of one of abnormal power, the present advancement of gas lighting must cease, because there cannot be a doubt that

¹ *Vide* Minutes of Proceedings Inst. C.E., vol. xlii., p. 380; ² vol. xxxix., p. 425; ³ vol. lii., p. 404; ⁴ vol. xli., p. 267; ⁵ vol. I., p. 292; ⁶ vol. liii., p. 396; ⁷ vol. lii., p. 36.

the electric light can be produced more cheaply, is attended with less danger of fire, and is less detrimental to health, than gas. M. Tresca¹ shows that, with the Gramme machine, the cost of the electric light is, as far as regards the mere cost of coal to work the engines, only one-fifteenth of that of gas consumed at Paris prices, or one-hundredth part of the cost of oil; while M. Fontaine² points out that, under certain common conditions, the relative costs of electric and gas lighting are in the ratio of 1 to 14, and even using gas in an Otto and Langen gas-engine as a motor, the ratio is 1 to 3 in favour of electric lighting. These views are borne out by the evidence of M. Heilmann Ducommun,³ M. Dieu,⁴ and M. Delahaye;⁵ and M. Jamin states that the Compagnie Lontin are willing to supply the electric light at a cost of 50 centimes per one hundred Carcel burners (nearly eight hundred candles), and that the Denayrouze-Jablochkoff system is maintained at a cost 30 per cent. less than the cost of gas. Much was expected from the introduction of the Jablochkoff "candle,"⁶ but neither in light effect nor economy has this invention superseded the Serrin lamp when used for a single light, although if it were to be applied in conjunction with the system of dividing the electric light, by the same inventor,⁷ its advantages would, doubtless, be great. Much has been said about the divisibility of the electric light for the purposes of domestic illumination. Such a well-regulated system as the present gas system can be scarcely expected to spring full-grown into existence, and it must be remembered that the present gas system had its period of development. There is, however, a method which seems to have been overlooked, by which, when electric lights of sufficient power are employed to illuminate streets, houses might also be lighted, and that is by admitting the rays of the artificial source as the sun's rays are now admitted, by the window. The present objection would be, that the electric light is not sufficiently diffused, a difficulty that might easily be overcome, if the out-door use were general. There is, however, a field in which the advantages to be derived from the use of electric light machines are incontestable, and that is on board ship, whether in navigating the open seas or in entering or leaving ports and roadsteads. That these advantages, as well as those arising from the use of the light as an aid in the detection of torpedo vessels,⁸ are appreciated is fully evinced by

¹ *Vide* Minutes of Proceedings Inst. C.E., vol. xlv., p. 338; ² vol. xlv., p. 339; ³ vol. xlvii., p. 418; ⁴ vol. xlix., p. 396; ⁵ vol. lii., p. 405; ⁶ vol. xlvi., p. 417; ⁷ vol. l., p. 312; vol. lii., p. 405.

the applications of the light on board vessels of the French navy.¹

Improvements in sources of the electric current are chiefly to be found in developments of magneto- and of dynamo-magneto-electric machines, with two notable exceptions, the Leclanché battery and the Clamond thermo-pile. M. Leclanché² not only tells what the improvements in his justly-celebrated battery are, but also gives interesting particulars as to how the cells are manufactured, and what the effect is of slightly increasing the chemical action—a result that might probably be worked out as a proof of the chemical theory of voltaic action. By substituting for galena an alloy of zinc and antimony, retaining iron for the electro-positive element, M. Clamond³ has constructed a thermo-pile capable of depositing 20 grammes of copper per hour with a consumption of 170 litres (5·95 cubic feet) of gas as shown by Count du Moncel.

The sources of electricity, as derivable from the expenditure of mechanical power, best known in the English market, are the Gramme and the Siemens machines. These machines have received descriptions⁴ at considerable length. From M. Tresca there is a full report of the lighting power of the Gramme machine before referred to, and Dr. E. Zetzsche⁵ describes the machine invented or perfected by Herr von Hefner Alteneck, but better known as the Siemens machine. The Lontin machine,⁶ which differs from the Gramme and the Siemens machines as being a radial machine—that is, a machine with independent magnets in the revolving portion, set radially—has been employed for obtaining a series of light centres from one common machine and motor. The result appears to be increased consumption of motive power expended, which may however be reduced in improved forms of this machine.

The principles relating to the work done and power expended in all magneto-electric and electro-magnetic engines have been but little developed, and this fact renders the labours of M. Mascart,⁷ who has both mathematically and experimentally investigated this relation, doubly valuable, as affording to the electrical engineer a scheme for his calculation based on the most reliable data.

In the yet unapplied principles that have been deemed of sufficiently great and general interest to obtain a place in the

¹ *Vide* Minutes of Proceedings Inst. C.E., vol. xli., p. 372; ² vol. xlvii., p. 412;

³ vol. xli., p. 338; ⁴ vol. xlv., p. 338; ⁵ vol. xliii., p. 435; ⁶ vol. li., p. 397;

⁷ vol. l., p. 310.

Abstracts, the most noticeable is the confirmation of the theory of the relation existing between light and electricity as laid down by Professor Clerk Maxwell, and supported by the independent experimental researches of Boltzmann¹ and of Silow² for gases and for fluids. Professor Maxwell, it may be said, prophesied that it would be found that the square root of the dielectric constant equalled the index of refraction; and this has been declared the case by these two experimentalists and by others. The relation between the motion of the conductor and the resistance it opposes to the passage of the current, has received investigation from the hands of Herr Edlund,³ who found that when the electric current and a conducting current of water flowed in the same direction, the resistance was diminished, whilst it was increased when the currents flowed in opposite directions. From Professor Clausius⁴ the electrician obtains an enunciation of a law of reciprocity in reference to mutual induction between two electrical conducting bodies; and Professor Mascart⁵ has given some startling facts to the effect that evaporation under the electric influence is greatly increased, it being sometimes double in vessels submitted to this influence; between the influence of positive and negative electricity, there appears to be no difference in this effect.

Generally, it may be stated that the most important applications of electrical science are at the present time in a condition of active development, which may at any moment produce results that will leave the advanced post of present knowledge far behind.

¹ *Vide* Minutes of Proceedings Inst. C.E., vol. xlii., p. 374; ² vol. xliv., p. 336; ³ vol. xliii., p. 432; ⁴ vol. li., p. 397; ⁵ vol. liii., p. 390.