THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

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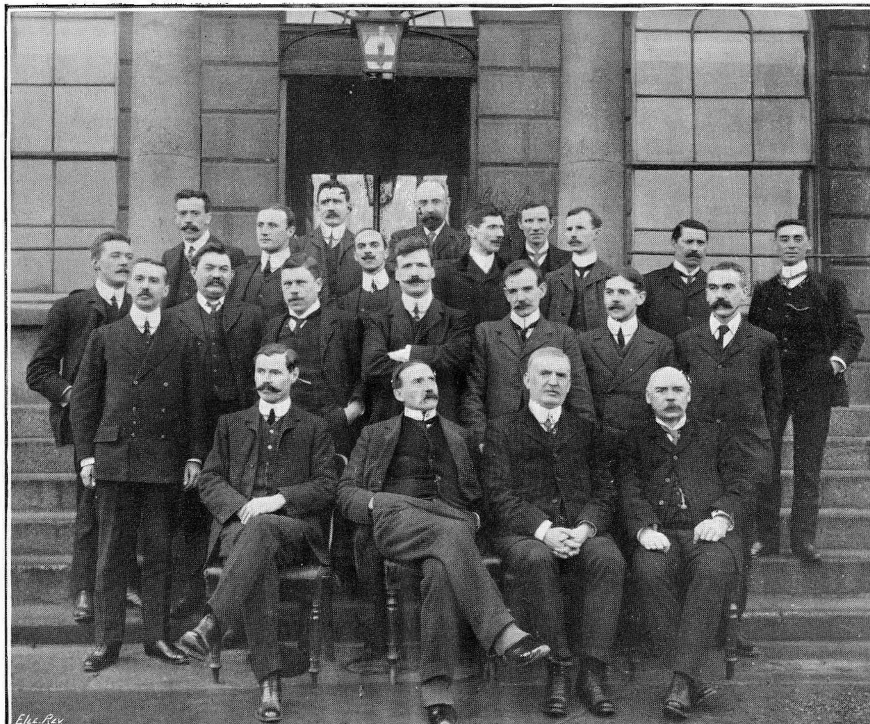


SOME OF THE ENGINEERING STAFF, IRISH DISTRICTS.

Front row: (1) W. M. Evans, (2) J. Sheridan, (3) A. Moir, (4) W. H. Cross.
Second row: (5) G. Henshilwood, (6) A. T. Kinsey, (7) E. J. Hammond, (8) W. Pennington, (9) W. F. Humphries, (10) J. McCarthy, (11) J. H. Fossett.
Third row: (12) J. H. Shaw, (13) A. E. Dawson, (14) R. A. Weaver, (15) W. Golding, (16) T. Patterson, (17) J. Davidson (18) T. McDonough, (19) J. J. Dwyer.
Fourth row: (20) G. T. Fisher, (21) H. S. Bell, (22) H. Doak.

THE

Post Office Electrical Engineers' Journal.

NOTES AND COMMENTS.

EXAMINATIONS.

IT is a good plan, when a subject comes into special prominence in connection with our life or our work, to carefully and critically examine its bearing thereon, and determine what shall be our mental attitude towards it.

We propose to do this in connection with the subject of "Examinations," because we feel sure this word has, of late, been more frequently in the minds of Post Office Engineers than any other in the dictionary.

But first we must differentiate; two kinds of examinations engage attention at present:

(*a*) Examinations within the Department for promotions to Sub-Engineerships, Engineerships, and Staff Engineerships.

(*b*) Examinations of university nominees for admission into the Service as *Engineers*.

Dealing with (*a*) let us first ask, Are such examinations necessary? and we reply that if we have to choose between a system of promotion by *seniority*, which neglects merit and stifles ambition, or a system of *selection*, which admits of grave abuses, examinations offer a third alternative, or rather, let us say, an additional aid, which every thinking man must welcome.

We can conceive no better system of promotion than one in which due weight is given to seniority (which means experience), to special fitness, as shown by past work, and to qualifications proved by examination.

We have deliberately placed examinations in the third place, below experience and special fitness, because examinations give no indication whatever as to character, which is all important, nor do they indicate with any degree of certainty a man's capacity for doing practical work, while they unduly favour the man who is fresh from study at the expense of his more experienced colleague.

In this connection, however, we rule out *competitive* examinations among established officers, for what chance would the capable engineer of ripe experience have in competition with a young man fresh from the arena of examinations?

We hope we are right in believing that the old system—under which an insignificant majority of marks obtained at an examination, overbalanced years of experience, higher rank, and proved ability—is for ever abolished.

We are strongly of opinion that all such examinations should be *qualifying*, applied, not as tests of fitness, but of unfitness. An ideal system would avoid multiplication of examinations, and would provide for another point of special importance, viz. that the final examination *qualifying* for staff rank should not be deferred till a late period in life.

Aspirants might be given the opportunity of undertaking the examination before the age of thirty, or possibly thirty-five, and gaining a certificate which would render them *eligible* for promotion to a staff appointment.

We are pleased to think that the arrival of the Selection Committee which has, during the past month, been examining second class engineers for higher appointments, is an indication that a very earnest attempt is being made to select the right men for high positions, a result which, if achieved, can only benefit all concerned.

With regard to (*b*) such outside competitive examinations may secure men with high educational qualifications, but their entrance is followed by a long period of service unremunerative to the Department, and it is open to question whether men so helped along will serve the Department better than those who, while passing through lower grades, have fully equipped themselves for higher appointments.

In this connection Major O'Meara's article, which deserves careful study on the part of our readers, is very welcome, and the phrase readily rises to the mind, "They do these things better in France." We hope the account of the French system will turn attention in this country to the possibility of founding a State school to train telegraph and telephone engineers for the Empire, a school in which students recruited from the Staff and from outside could obtain a thorough theoretical and practical training.

Sir W. H. Preece, K.C.B., F.R.S.

We are sure our readers will learn with sincere regret that Sir W. H. Preece has been very seriously ill and has not therefore been able to contribute to this number his promised article on "Pre-Post Office Telegraphs." We are pleased to know that his condition is improving, and we wish him a speedy return to good health. He has been good enough to send through Mr. Llewellyn Preece an assurance that he will proceed with the writing of the article as soon as he is sufficiently recovered.

FINANCE.

THE control of expenditure is a subject which, it is needless to say, is of the highest importance; at the same time it is one about which much diversity of opinion must exist, not only from the difference in the trains of reasoning by which deductions are arrived at, but also from the great difficulty of obtaining accurate facts upon which to base the deductions. Expenditure obviously has to be kept within limits, otherwise financial embarrassment is bound to be the ultimate outcome of such limits being overstepped. Frequently the cutting-down process is, we imagine, more a matter of chance than of anything else. Amounts are asked for for carrying out desirable works, but the controlling department, being pressed by the higher powers, has no option but to apply the pruning knife irrespective of what the result may be, *i.e.* as to whether the refusal, or the diminution, of an amount asked for may not result in a most uneconomical carrying out of the original object. Such a result is not only conceivable, but does actually take place, and until finance becomes—if such a thing is possible—an exact science, it will again and again recur.

System in keeping accounts, although it cannot ensure economy, goes far towards it, inasmuch as it indicates, or ought to indicate, in a plain manner how expenditure is being conducted, and whether a due proportion of the various items making up the whole is being arranged for.

How far elaboration of accounts is logically advisable seems to be a matter upon which no just conclusion can be arrived at; in many cases much expenditure of time, and consequently of money, takes place without any use being made of the statistics obtained; the latter are often filed away in pigeon holes, are perhaps forgotten, or if they are published they are merely looked at and the remark passed that "they are very interesting," and there the matter ends. The clerks who compiled them are paid their salaries, which enable them to keep their wives and families in more or less comfort, which doubtless is a good thing, but whether the community is the better for money so expended is rather doubtful.

In the lecture abstract on "Army Finance" by Mr. Charles Harris, which we give elsewhere, a careful analysis of general accounting is given, and while the matter is "very interesting," it is, we think, something much more than this, as it affords a close insight into the general principles of government finance put in a very plain and clear way; the criticism is at the same time outspoken, as, for instance, when the statement is made that "army accounts afford no indication whether administration is economical or not," also the phrase "financial responsibility" is often used to denote simply the power to spend public money unquestioned.

Types of Underground Cable.

Elsewhere will be found an account of the general questions to be considered in the design of lead-covered paper-insulated cables for telegraph and telephone purposes. When a cable contains conductors for both these services the insulated telegraph wires, particularly when long lengths are involved, are provided with a spiral lapping of copper tape to act as a screen against excessive induction between one wire and another.

So long as the insulation resistances of the conductors remain high and equal there is no interference between the screened telegraph circuits and the telephonic unscreened loops.

Screened telegraph wires are almost invariably arranged in layers outside the telephonic loop portion of the cable so as to be in contact with the lead sheath and make good contact with "earth."

The simplest arrangement of *loops* or *pairs* is that adopted in the formation of the *twin* type of cable, in which the individual pairs are stranded directly together. Such a type of cable is especially suitable for use where each pair of wires is wholly given up for a separate circuit. In exceptional instances—for example, the case of subscribers' circuits up to about five miles in length connected with common battery exchanges—where it is desired to arrange a loop of lower resistance than that of a pair of wires, two pairs may be given up to form one circuit by bunching two "a" and two "b" wires respectively, but this procedure, *it must be clearly noted,* is only possible with full advantage in the circumstances above mentioned for the reason that the capacity of the system is doubled by the bunching, and as the circuit is lengthened the evils of the additional capacity become noticeable. Superimposed circuit working is practically impossible with the *twin* type of cable for the reason that the limbs of any *plus* circuits would be virtually parallel with each other.

Superimposed working is so commonly resorted to that for the underground sections of trunk routes it is necessary to use a form of cable in which the pairs are arranged in groups. In these groups the pairs are so disposed that each two, or multiple of two, revolve about a common centre. This object is attained in both the *multiple twin* and *quad pair* forms of cable. In the multiple twin type each pair of insulated wires is twisted with another similar pair to form a 4-wire core, such that by using the *a* and *b* wires of each pair as a single conductor, a pair is formed of which the conductor weight per mile is twice that of the wires forming the component pairs. The process may be further continued, and one set of four wires be twisted with another similar 4-wire core, but for general purposes the simple construction of two-pair cores meets all requirements. The capacity per mile between one pair and another in this type of cable is from 25 to 50 per cent. greater than between one wire and another in a single pair, depending upon the tightness with which the wires are packed in the cable.

In the quad-pair cable four simple pairs are stranded about a centre of yarn, the presence of the latter being essential as a means of ensuring that the four pairs shall occupy positions as nearly as possible symmetrical about the centre, *i. e.* at the corners of a square. If required, four smaller pairs of wires may be stranded in the respective interstices between the larger pairs of which the quad core is made up. A number of such cores are then stranded together. In this form of cable it is diagonal pairs of wires which are used for superimposed working or for making up circuits of conductor weight double that of a component pair. The capacity between pair and pair may be equal to, or 25 per cent. greater than, that between the two wires of a simple pair, according as the conductors are loosely or tightly packed in the cable. The conductor resistance is, of course, halved by bunching.

It will be seen that for a given wire-to-wire capacity of the simple pairs in multiple-twin and quad-pair cables respectively, the latter has the advantage, in that by bunching the conductors the capacity is not increased to quite the same extent as in the multiple-twin type, where a minimum increase of 25 per cent. takes place. Considered, however, from the point of view of the number of simple pairs of given capacity which may be formed into a cable of given size, the multiple-twin type has the advantage, owing to the fact that the space taken up by four pairs in the quad-pair is at least 30 per cent. greater than in the multiple-twin form.

It is, therefore, a matter for consideration whether it is better to provide (*a*) fewer quad-pair circuits with a given capacity on both simple pairs and an equal or slightly increased capacity on superimposed circuits, or (*b*) multiple-twin cable with a *greater number of pairs*, having a capacity the same as the simple circuits in the quad-pair cable and a capacity on the superimposed circuits 25 to 50 per cent. greater than that of a simple pair. One other point in favour of multiple-twin is that, for a given number of wires in a given space (owing to the absence of yarn) the cable is slightly more flexible than the quad-pair type, and desiccation is easier.

EDUCATION AND TRAINING OF TELEGRAPH ENGINEERS IN FRANCE.

By Major W. A. J. Omeara, C.M.G.

The appearance on the scene of 'The Post Office Electrical Engineers' Journal' cannot but be regarded as a sign of the healthy activity of the members of a great public service, and it is indeed a matter for sincere congratulation that the engineers of the British Post Office now possess a publication which will enable matters of particular interest to them to be brought to notice in a readily accessible form.

Although my inaugural address at the opening of the second session of the Institution of Post Office Electrical Engineers, in October last, dealt with the training of the telegraph engineer, and Sir John Gavey has also very recently read a paper on "The Education and Training of the Engineer," there is much to indicate that the topic is one which still continues to afford considerable interest to many readers of this Journal. This, I think, was clearly shown by the discussion which followed the reading of Sir John Gavey's paper on the occasion just referred to, when I was unfortunately guilty of a breach of the rule laid down that no speaker, after the first one, was to occupy more than five minutes of the time of certainly a very patient audience.

In the time at my disposal I was able to touch only on the fringe of the points raised in the discussion, and I failed, therefore, to deal with the important question raised by one of the speakers taking part in the discussion, who stated that a great deal had been said concerning the general lines on which the education and training of a telegraph engineer should proceed, but that no indication had been given in precise terms of the subjects, and their scope, which should engage the attention of the telegraph engineer desirous of success in his profession. It is in the hope of filling up this blank that I undertake my present task.

The subject is naturally one which has engaged much of my attention, and more particularly so as the question has also been before the Civil Service Commissioners for some little time. I have had to give consideration to the subject from the two points of view of:

(1) What shall be the subjects of examination, and the standard in each subject, for entrance into the Engineering Department of the Post Office? And—

(2) What can the Civil Service Commissioners reasonably require as a proof of their abilities from officers, already in the service, before

the latter may be recommended for promotion to Staff rank by the Engineer-in-Chief?

It may serve a useful purpose if I state the manner in which the investigation of the subject was approached by me. First, then, I felt that it was possible to draw a distinction between the examinations proposed. In the one case the question for consideration was:—What is a suitable foundation in theoretical knowledge for the telegraph engineer to start with, which will not only support the structure of practical engineering knowledge which satisfies present-day practice, but which will also prove to be one capable of standing the test of time and thus provide a margin to meet any modifications which may be dictated by later-day requirements? In the second case, the question seemed to me to resolve itself into one concerning the value of the structure of engineering knowledge built by practical experience on a foundation laid many years ago.

I do not propose to touch upon the second question in this article, for the Civil Service Commissioners have recently issued the scheme of examination for promotion to Staff rank, and the Postmaster-General's decision on the subject has been promulgated in the Engineer-in-Chief's monthly circular for April last.

In examining the question of the qualifications which should be expected from new entrants into the Engineering ranks, both in the case of those officers who are already in the Post Office service as well as in the case of those who may be drawn from some other source, I felt that the subjects for examination and the standard fixed should be chosen in relation to the scope and character of the duties of the engineers engaged on executive duties. It was not difficult to decide, in the abstract, that the subjects for examination should be chosen with a view to providing new entrants with knowledge of a kind which, after a short practical training, should enable them to perform their duties intelligently and efficiently. But I recognised that it was a more difficult matter to decide on the standard in each subject which it was desirable that the embryo telegraph engineer should have acquired before appointment to engineering rank. I felt that reliance on my own personal experience alone might tend to the creation of an arbitrary standard in my mind, and, in consequence, I decided that it would be safer, before adopting a standard for my own guidance, for me to examine the curriculum adopted for the education of telegraph engineers of the Indian Service, and also the courses of instruction laid down for the engineers in the telegraph services of France and Germany.

Since I commenced the study of this subject the abolition of the Royal Indian Engineering College at Cooper's Hill has been decided upon, and I am not yet in possession of information as to the method by which the Government of India proposes to obtain its telegraph engineers in future. Under these circumstances I have felt that it would be better to postpone reference to the course of instruction at Cooper's Hill for the present. I therefore propose to deal, in the first instance, with the training provided for telegraph engineers in France.

The scheme for recruiting engineers for the Telegraph Service in France cannot fail to be of immense interest to us, and as my old friend, M. Thomas, the Director of the Ecole Professionelle Supérieure des Postes et des Télégraphes, has very kindly furnished me with some particulars regarding the programme of instruction carried out in the Institution under his charge, I propose to place the same before the readers of the JOURNAL.

The engineers for the French Telegraph Service are drawn from two sources :

(*a*) Officials of the postal and telegraph branches of the P.O. service.

(*b*) Candidates having certain qualifications who are not connected with the Postal Administration.

Officers obtained from both sources have to undergo a course of instruction of two years' duration at the École Professionelle Supérieure des Postes et des Télégraphes.

Officers of the Postal Administration desiring to become engineers have to compete at an examination for admission into the École Professionelle ; they are nominated as candidates if they hold a good service record and are well reported upon by their superior officers. They must possess at least two years' effective service, and must be under thirty years of age on January 1st of the year in which the examination takes place ; the entrance examinations are held once in every two years. The candidates have to undergo written and oral examinations in the following subjects :

Written Portion.

Mathematics	4 hours.
Mechanics	4 ,,
Physics / Chemistry	4 ,,
Drawing	3 ,,

Oral Portion.

Mathematics.
Mechanics.
Physics.
Chemistry.
Modern language (English or German).
Second modern language (other than English or German).

The details of the subjects of examination are given in Appendix I.

No candidate is allowed to take part in the oral portion of the examination unless he has first satisfied the examiners in the written portion of the examination. Bad spelling also disqualifies a candidate. The positions of the candidates on the competitive list are determined by the total number of marks obtained in the two portions of the examination. The subjects mentioned above, except the modern languages, are all compulsory. The whole of the marks obtained in each subject are counted for placing, with the exception that in the case of the modern languages marks equal to 60 per cent. allotted to these subjects are first deducted from those obtained, and the balances only are credited to the candidate.

Candidates for engineerships, who are not already serving in the Postal Administration, must have satisfied the requirements of the French law regarding military service, and must be less than twenty-six years of age on January 1st of the year in which they join the École Professionelle. Their applications for admission to the School are addressed to the Under-Secretary of State for Posts and Telegraphs, and must be accompanied by:

(1) Birth certificate, and, if necessary, letters of naturalisation.

(2) Certificate of good moral character.

(3) Extract from sheet relating to offences tried in civil courts of law.

(4) Certificate of good health from Medical Officer of the Administration. This certificate must also state that the candidate has been re-vaccinated within less than six years from date of application.

(5) Document proving that the candidate has fulfilled his military obligations.

The candidates not already serving in the Postal Administration, who are admitted to the École Professionelle, are drawn from the students of the École Polythenique who have completed the two years' course at the latter Institution; they are not required to pass the examination for admission to the École Professionelle already referred to, which only applies to officers serving in the Postal Administration.

It may be of interest to the readers of the JOURNAL to learn that although the École Polythenique is essentially a military school, and a strict military discipline is maintained there, yet nearly all the civil engineers required for the service of the State are trained at this Institution. Entrance to the École Polythenique is obtained by means of a competitive examination open to young men between seventeen and twenty-one years of age, and as this Institution holds a high reputation owing to the large number of eminent and illustrious Frenchmen who have been trained there, a large number of candidates of high attainments are attracted. Candidates for admission must possess a University-leaving certificate, and success at the entrance examination proves that the candidate has already obtained a wide range of scientific knowledge. At this examination mathematical subjects occupy a very important place, and considerable proficiency is also required in physics, chemistry, and drawing. The aim of the school is to provide a very advanced scientific education. The subjects studied are differential and integral calculus, geometry, mechanics, thermo-dynamics, electricity, optics, acoustics, and chemistry. The students after leaving the École Polythenique receive specialised teaching in a number of schools of practical engineering, such as the School of Mines, the School of Roads and Bridges, etc.

All the candidates admitted to the École Professionelle Supérieure des Postes et des Télégraphes are appointed "engineer-students," and receive a salary of £72 per annum, and the allowances provided for by regulations. The officers of the Department who are admitted to the School retain the salary of the rank they hold, and they also retain, whilst at the École Professionelle, any rights regarding promotion which they may possess on their class. These officers are also granted an allowance to cover their transfer to Paris, the maximum of which is fixed at £16.

The "engineer-students" have to undergo the instruction laid down for the "Second Section" of the École Professionelle. The course consists of:

(*a*) The theoretical and practical courses in the École Supérieure d'Électricité.

Comprising: General electro-technics; lectures on the application of electricity for traction purposes, etc.; continuous and alternating current generators; construction of electrical machinery; distributing systems, aërial and subterranean; accumulators; electro-chemistry; practical laboratory work, including testing of machines; workshop practice; visits to electric works; preparation of scheme of electric lighting and power transmission; design of plant; calculations in connection with the design of continuous and alternating current generators.

(*b*) The courses and lectures special to the "Second Section."

Comprising: Application of statutory provisions incorporated in the laws affecting the P. O. services; theory of electricity, and its applications to telegraphy and telephony; propagation of electric current in conductors, during its variable period, in relation to telegraphy and telephony; steam, heat and hydraulic machines; automobiles and railways; submarine cables; pneumatic tubes; construction of aërial and subterranean lines; course of architecture; strength of materials; postal materials; laws relating to workmen; machine designs.

(*c*) The courses common to the two sections of the School.

Comprising: General principles of telegraphy and telephony; construction of aërial and underground lines; statutory powers; general principles relating to administration and accounting.

(*d*) Practical studies and visits to places in France and abroad for purposes of instruction.

Comprising: Manipulation on telegraph circuits; testing; English and German conversation and translation; visits to large telegraph and telephone offices; graphic representations; visits to district headquarters in France for study of industrial undertakings; visits to foreign countries for study of a postal, telegraphic or telephonic installation, and of an industrial undertaking; working out of a complete scheme of installation; laboratory exercises.

Further details concerning the subjects mentioned above are given in Appendix II.

During the first year the application of electricity to industrial purposes is studied at the École Supérieure d'Électricité. During the second year the students attend the professional courses of instruction at the École Supérieure des Postes et des Télégraphes. Some of the subjects require a considerable knowledge of the higher branches of mathematics, and the necessary instruction is provided for those students who are able to derive profit from the same. A great part of the course in the second year is thoroughly practical in character: the students work out practical problems, signal messages, carry out electrical tests of apparatus and lines, visit important telegraph and telephone offices, go through a laboratory course and prepare projects for telegraph and telephone installations, etc.

The students have to furnish reports in connection with each of their visits relating to the courses of instruction, and their papers carry marks which are added to those obtained at the examinations, the grand totals thus obtained determining the final classification of the students on completion of the course at the École Professionelle.

At the end of the first year an examination is held. It consists partly of written replies to papers, partly of answers to oral questions, and partly of practical tests. The marks obtained at this examination are carried forward to determine the final classification of the students.

At the end of the second year the students have to furnish a scheme relating to a telegraphic or telephonic installation, and also a paper on laboratory work (standardisation, special study of a particular apparatus, etc.). The marks obtained again count for the final classification. In addition, a second series of examinations on the subjects on which instruction has been given, are held. These are also partly in the nature of written replies to papers, partly oral, and partly practical.

For a pass, students must obtain 65 per cent. of marks. Students drawn from the Postal Administration failing to satisfy the Examiners are relegated to the positions they held when nominated for admission to the School, whilst those who were not formerly in the service of the Postal Administration are appointed to clerkships, and retain the scale of pay they may be receiving at the School.

Students who fail at an examination may be allowed to present themselves for re-examination once only. The successful students are appointed 2nd Class Engineers.

It is quite clear from the above account that not only do the French telegraph engineers enjoy the advantage of receiving a thoroughly practical and wide training to fit them for their responsibilities, but that care is also taken that only those shall participate in the course of instruction in the École Professionelle who have shown that they possess the energy to study and are likely to derive profit from the course of studies laid down for the "engineer-students."

It is further recognised that it is not possible for every young man in the P. O. Service to acquire, without assistance, the necessary knowledge to take advantage of the education provided at the École Professionelle, and in consequence, facilities are granted to officials desirous of competing for admission to the "Second Section" of the École Professionelle, for study at one of the higher State Schools at Paris, and, in some cases, at the University.

I hope at some future date to be in a position to describe the systems adopted by other f•reign administrations for training telegraph engineers.

APPENDIX I.

Examination for admission to École Professionelle (*Extracts from the programme of the École Professionelle Supérieure des Postes et des Télégraphes*).

I. Mathematics.

Differential calculus.—Formation of differential equations; functions of an imaginary variable; Taylor's theorem and extension of same; Demoivre's and Euler's theorems; maxima and minima; indeterminate forms; envelopes and surfaces; plane curves; skew surfaces.

Integral calculus.—Indefinite integrals; definite integrals; lengths of curves; areas and volumes by integration; change of the variable; Green's theorem; successive integration; linear differential equations; systems of simultaneous differential equations; integration of some of the well-known equations of the second order.

II. Mechanics.

Kinematics.—Motion of a point; parallelogram of velocities; motions of a solid; theory of relative motion; cylindrical and conical gears; worm wheels; winch; Stephenson's link motion; Watt's parallelogram.

Statics and dynamics.—Fundamental principles; theory of moments; equilibrium and movements of points under various conditions; gravity; Newton's law of attraction; Foucault's pendulum; equilibrium of forces; funicular systems; equilibrium of fluids; laws of dynamics; theory of moments of inertia; energy; theory of small displacements; d'Alembert's principle: compound pendulum; Pouisot principle; Bernouilli's theorem; Prony brake; fly-wheels; governors; principal parts of steam engine; indicator diagram.

III. Physics.

Heat.—Expansion of liquid and solid bodies; thermometers; compressibility of gases; liquefaction of gases; influence of temperature and pressure on gases; specific heat of gaseous bodies; conductibility; Senarmont's experiments; thermo-dynamics; mechanical equivalent of heat; isothermic and adiabatic curves; Carnot's cycle and principle; absolute temperature; application to perfect gases and saturated vapours.

Acoustics.—Vibratory motion; amplitude; period; phase; measurement of number of vibrations; registering apparatus; musical scale; propagation of sound; velocity of sound in gases, solids and liquids; wave-length; vibration of strings, pipes, rods and plates; compounding of vibratory motions; interference; harmonics; experimental analysis of a sound; phonograph.

Optics.—Study of heat, light and chemical radiations; spectrum analysis; phosphorescence and fluorescence; photography; velocity of light; corpuscular and undulatory theories; periodicity of luminous vibrations; interference; Newton's rings; Huyghen's and Fresnel's principles; diffraction; polarisers and analysers; rectilinear, circular and elliptic polarisation; rotatory and magnetic polarisation.

Magnetism and electricity.—Elementary principles; Coulomb's law; Faraday's experiments; conducting bodies and dielectrics; condensers; electric energy; machines utilising property of induction; electric currents; Faraday's laws; accumulators; Joule's law; Oersted's experiments; Laplace's law; Kirchoff's theorem; Solenoids; electro-magnets; Lenz's law; Foucault's experiments; vacuum tubes; units.

Chemistry.—Metalloids; general laws of chemistry. Metals—generalities and classification; alloys; salts and their properties; laws of Richter and Berthelot; general principles of thermo-chemistry; alkalies; clays, porcelain and glass; extraction, properties and compounds of potassium, barium, strontium, calcium, magnesium, aluminium, iron, nickel and cobalt, manganese, zinc, tin, antimony, lead, copper, mercury, silver, gold and platinum.

Organic chemistry—composition of organic bodies; analysis; classification of organic substances; alcohol, ether; aldehyde; organic acids; albuminoids; fermentation.

V. Foreign Languages.

German or French; any other language taught at the Universities.

VI. Drawing.

Geometric drawing; perspective; mechanical drawing.

APPENDIX II.

Extracts from the programme of instruction for the "Second Section" of the École Professionelle Supérieure des Postes et des Télégraphes.

First Year.

Statutory Provisions.

Control exercised by P. O. Engineers; *rôle* of the Electricity Committee; technical instructions relating to industrial electricity undertakings; interpretation of technical instructions; protective regulations relating to high and low tension transmission, and electric tramways; telephone net-works; provision of lines in the neighbourhood of industrial systems; administrative regulations.

Manipulation.

Plan Drawing.

Second Year (First Half-year).

Theoretical Electricity.

General study of the magnetic field in the varying state; fundamental ideas; laws of action at a distance; electric force on unit surface, and unit volume; dissipation of energy in conductors; study of magnetic field; laws of Laplace and Ampère; magnetic energy; study of electro-magnetic field in varying state; laws of induction; equation of electro-magnetic field in a medium at rest; application of same to Hertz's experiments; measurement of velocity of propagation; electro-magnetic theory of light.

Experimental study of dielectrics; polarisation of dielectrics: pyro-electricity; piezo-electricity; action of electric field on propagation of light in electric media; general ideas on apparent conductivity of dielectrics.

Study of conductors.—Study of net-works of linear conductors in cases of constant or varying currents; apparent resistance of conductors carrying alternating currents; variation of conductivity in relation to changes in physical condition.

Magnetic properties of bodies.—Classification of bodies; magnetic permeability and its measurement; magnetisation curves; conditions modifying magnetisation; dissipation of magnetic energy; effect of magnetic field on propagation of light.

Electro-chemistry.—Study of electrolysis; thermo-electricity; electro-capillary phenomena; ultra-violet light; actino-electric phenomena; cathode rays; Röntgen rays radio-active substances; electrification of gases; electric phenomena in rarefied gases.

(SECOND HALF-YEAR.)

POSTAL MATERIAL.

Manufacture of postage stamps; letter-boxes; indicators, etc.; stamps; obliterating machines; inks; bags; paper; wax; seals, etc.; mail-vans; general study of questions relating to picking up and dropping mails from express trains; postmen's bags.

CONSTRUCTION OF AËRIAL AND UNDERGROUND LINES.

Instruction under this head practically covers matters dealt with in British Post Office Technical Instructions XIII and XIV.

SUPPLEMENTAL INSTRUCTION IN CONNECTION WITH AËRIAL LINES, SUBMARINE CABLES, PNEUMATIC TUBES.

A. *Aërial lines.*—The Catenary; numerical tables; curves and their application; influence of variations of temperature, wind force, and accidental loads on aerial lines; curves relating to same.

B. *Submarine cables.*—Make up of submarine cable and its electrical characteristics; Thomson's law; study of transmission and reception of signals in case of a long perfectly insulated cable; curves at receiving end of conductors, with and without condensers; comparisons between these methods of working circuits; case of a circuit with uniform leakage along its whole length; circuit with single leak: influence of line losses on form of signals; influence of apparatus on ends of line; duplex working; problem of telephonic communication by means of cables; application of Fourier's law of diffusion to various phenomena connected with apparent diffusion of electricity in cables; determination of economic size of conductors in submarine cables and numerical tables relating to same; determination of strength of armouring of cable in relation to conditions to be met; manufacture of armoured cable; cable ships and special materials for work on the sea; laying of submarine cable; theories of Thomson and Siemens; localisation of faults; repairs; lives of cables in various localities; frequency of interruptions, their causes and cost of repairs; Cable Companies.

C. *Pneumatic tubes.*—Pneumatic tube networks; construction; description of apparatus; cost of providing; maintenance; tracing defects; proposed improvements.

POWERS OF VARIOUS ADMINISTRATIVE BODIES.

General principles; *rôle* of the State; public and moral power; separation of legislative and executive power; separation of administrative and judicial authority; administrative machinery; the central, county, and local administrations and decentralisation; the central administration, the head of the State, the Cabinet, etc.; details of county administration and officials concerned; municipal administration and officials concerned; external relations and national defence; police; administration of justice; highway authorities; public works and rights of private property invaded to facilitate execution of same; expropriation; optional services undertaken by State, industrial in character, *e.g.* mines, transport, posts, telegraphs, and telephones; services, intellectual in character, *e.g.* education, public worship; public finances, national debt, taxes; bird's eye view of fiscal system.

GENERAL PRINCIPLES OF ADMINISTRATION AND ACCOUNTING.

A. *Rôle of the services.*—General organisation of administration; duties devolving on administration; transmission of postal, telegraphic and telephonic correspondence; accessory services; money orders, cash on delivery, savings bank, parcel post, etc. central administration; supervision; technical committees.

B. *Fundamental legislation.*—Monopoly—Study of actual situation and comparison between this and situation involving free trade in conveyance of postal matter; postal monopoly and contraventions; telegraph and telephone monoply and contraventions; control of telegrams; railway lines and private interests; secret correspondence and exceptions; responsibility of administration and its officers; exemptions.

C. *Ways and means.*—Budget, definition, preparation, etc.; expenditure, payment, etc.; receipts; different classes of offices; supply of funds to same; different classes of officials; recruitment and general rules relating to promotion; distribution in offices, salaries, etc.

Steam Engines: Heat Engines; Automobiles.

Production of steam.—Combustion of solids, liquids, and gases; calorimetry and practical applications; proportion and arrangement of fire-box; flues and chimneys, and determination of their dimensions; conduction of heat; feed-water heaters; super-heaters; boilers; general rules concerning dimensions of various parts; multi-tubular boilers, Belleville, Niclausse, Babcock and Wilcox; accessories and safety appliances; quality of boiler-plates, tubes, etc.; essentials of good design; administrative regulations relating to installations.

Theory of the steam engine.—General principles of thermo-dynamics; Carnot's cycle; different forms of heat engines, steam engines, gas engines; properties of steam; losses, means to be adopted to reduce same; calculations for determination of dimension of plant for given horse-power; indicators.

Construction of steam engines.—Reciprocating engines; turbines; cylinders, pistons, etc.; valves and valve gears; Zeuner's and other valve diagrams; Corliss and Sulzer gears; advantages of multi-cylinder engines; Woulf's compound engine; calculations relating to engines to develop given horse-power; reduction of losses; governors; feed-pumps; condensers; air-pumps; injectors.

Application of steam engine to compression of air.—Pneumatic pumps; project for installation of pneumatic plant.

Gas engines.—Principles of action; complete study of an Otto type of engine; different systems of ignition and regulation: utilisation of mineral substances, petrol, alcohol, and poor gases.

Automobiles.—Arrangement of chassis; driving mechanism and variable speed gear; steering gear; brakes; examination and comparison of various types of machine.

General Principles of Telegraphic and Telephonic Communication.

Object and division of course. Apparatus required for elementary form of electric communication.

Sources of energy.—Chemical and electro-dynamic generators of continuous current; alternators; telephone; production of Hertzian waves; transformers for converting continuous into alternating current.

Transmitters.—Study of the method of producing signals; keys for uni-directional currents; synchronism; mechanical and electrical governors; correction; double-current keys: automatic transmission; perforators; study of the voice; microphone; Hertzian wave transmitters.

Receivers.—General ideas on electro-magnets; electro-magnets for alternating currents; utilisation of electro-magnets for receiving continuous currents.

Telephone receivers and theory of same; Hertzian wave receivers; syntonisation; relays; Morse, Hughes, Wheatstone, and Baudot apparatus; syphon recorder; formation of signals; time-constants; interference due to induction; protective devices; telephone installations of various magnitudes; telegraph installations.

Architecture and Strength of Materials.

Materials of construction; whence obtained, composition, quality, defects, and uses.—Construction: study of site; excavations and foundations; walls; arches and floors; staircases; doors and windows; wood and iron framing.

Roofing; drainage of water; pipe-work; lightning protection; sanitary arrangements; lavatory accommodation.

Joinery; painting; warming and ventilation.

Properties of building materials.

Building of offices; all matters relating to conditions to be fulfilled; observance of building bye-laws; conditions attaching to leases, etc.

Execution and Control of the Service.

Transmission of postal correspondence—conveyance by road, rail and water; distribution; parcel post; transmission of telegraphic correspondence, circulation; general organisation of net-work; distribution and transmission of telephonic correspondence. Rates for services; general organisation of net-work.

Money-order and cash-on-delivery systems.—General ideas on subject; postal orders; telegraphic remittances, etc.

Social and economic value of savings bank; savings bank transactions, etc.

Control of expenditure; general organisation to effect same; accounting and general rules relating to same, etc.

International relations.—Relations with foreign countries—Postal union; exchange of correspondence with foreign countries; international accounts, etc.

Principle of telegraph and telephone conventions with foreign countries and agreements with cable companies; clearing-house arrangements relating to fees received, etc.

Lectures on Legislation Relating to Workmen Acts.

Lectures on the General Subjects of Instruction.

Lectures on Electrification of Railways.

Lectures on Hydraulics.

Lectures on Special Subjects of Technical Nature.

PROFESSIONAL PAPERS.

The attention of readers is called to the announcement on page ii of our cover as to the supply of copies of the Professional Papers which have been read before meetings of the Institution. In each case the latest available information on the given subject is presented, and the illustrations are clear and arranged for easy reference.

The variation in price is due to the fact that the Council—animated solely by the desire to propagate knowledge—regulates the price by the *cost of printing.* The intrinsic value of the papers is many times greater.

THE MOTOR-DRIVEN WHEATSTONE TRANSMITTER.

By C. C. VYLE and E. V. SMART.

WHEATSTONE'S automatic system is the best system in the world where the economy of line wire is concerned. Four hundred words a minute can be passed over the wire as against about one hundred by the next best system. This means that three wires at least between the two stations are saved. When great pressure exists on a circuit Wheatstone working is resorted to. When a special event of any importance takes place it is the Wheatstone system that is used to dispose of the work. It is the Wheatstone system that transfers the news of the world from London to all parts of the United Kingdom. When a general breakdown occurs it is by means of the Wheatstone system that the work is disposed of over the few wires remaining. The Wheatstone system is to any key-worked system what our fastest express trains are to the old stage coaches. The staffs at both ends, one lot punching and feeding the transmitter, the other receiving the news and writing it up, soon dispose of the work. One drawback is the writing up of the slip, especially by artificial light; the constant transfer of the eyes from the moving slip to the writing, and *vice-versâ*, is a strain. This might be remedied by producing a slip, which, by being passed through another instrument, could be read by sound.

When required for re-transmission purposes the slip might be gummed on a form. It would be as easy to send from the slip so gummed as from the written words. Much time might be saved by adopting the latter method.

Again, instead of the present form of Wheatstone perforator a key-board perforator would greatly increase the speed of punching.

Enough has been said to show the great utility and supremacy of the Wheatstone system in circumstances when speedy transmission over the line wire is of the utmost importance.

Although many years have elapsed since Sir Charles Wheatstone introduced his automatic system, very little has been done to improve the transmitter, and it remains to-day practically as it was when first invented.

The driving of the transmitter is a matter which has received a great deal of attention with a view to abolishing the use of the heavy weights at present used, and it is in connection with this subject that the present article deals.

It is now more than twenty years since the need for a motor-driven transmitter was first felt. When it was necessary to obtain high speeds, the practice was, and still is, to tie extra weights to the driving weight; this frequently ended in disaster and the suspension of work until a fresh transmitter had been obtained.

The difficulty in obtaining high speeds was the prime cause of a motor-driven transmitter being sought, but many other reasons can be advanced for the demand. Some of these are:

(1) To obviate the need for weights (45 lb. each) and weight guards.

(2) To avoid transmitters "running down" during the transmission of messages, and the consequent confusion, loss of time, and repetition of work.

(3) To relieve the telegraphist of the labour of frequent winding, leaving him free to attend to slips, etc.

(4) To minimise the liability to shocks. Shocks have occasionally been experienced by telegraphists while winding transmitters. In this connection it may be mentioned that an extra terminal was recently provided on the transmitter for the purpose of connecting the frame-work of the transmitter to earth.

(5) To ensure constant speed of the transmitter when used in connection with apparatus where "slowing down" or "racing," due to overwinding, results in malformation of the signals, rendering the slip unsuitable for re-transmission or printing purposes.

(6) To prevent the cutting of instrument tables to provide for the movement of the chain attached to the weight.

When the need was first felt, an electrically-driven transmitter was designed, but this, in common with others since designed, did not give constant speed, and on this account the signals were unreliable. Other electrically-driven transmitters have been unsuitable, because, in arranging for varying the speeds of the motor by shunting some of the current, considerable overheating took place; they, too, were subject to the troubles of momentary racing and irregular running.

Air-driven transmitters were also tried, but were unreliable, on account of the difficulty in maintaining constant pressure. The air actuated a fan that was attached to the driving axle.

The Hughes instrument is one to which motor-driving has been successfully applied, but in this case the instrument is driven at a constant speed and the work done is kept constant by means of a governor.

The requirements for a motor-driven Wheatstone transmitter are:

(1) It shall be capable of running at any speed required for Wheatstone circuits.

(2) It shall give constant speed when run at any given rate.

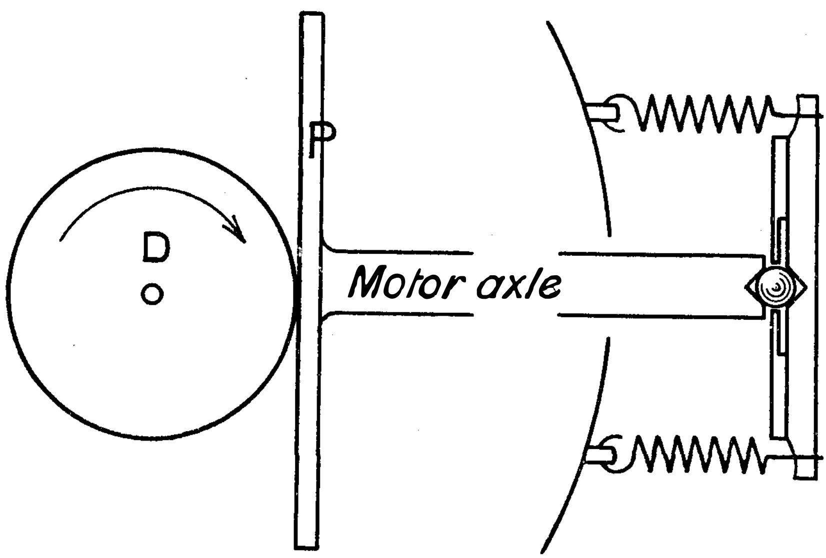
(3) The motor and controlling apparatus shall not overheat.

(4) The speed must be easily controlled.

Small motors with electrical governing, such as are required for Wheatstone transmitters, are not easy to design when all the requirements mentioned have to be met, and all attempts hitherto have failed. Mechanical means have been attempted, but have not, until the present instrument was designed, proved satisfactory.

Small motors to be efficient should have their armatures to revolve at constant high speeds. If the efficient speed of the motor be too high for the purpose required, it should be reduced by *gearing.* This is the fundamental principle of the motor-driven transmitter designed by the writers.

Choose a motor of sufficient horse-power to do the work easily



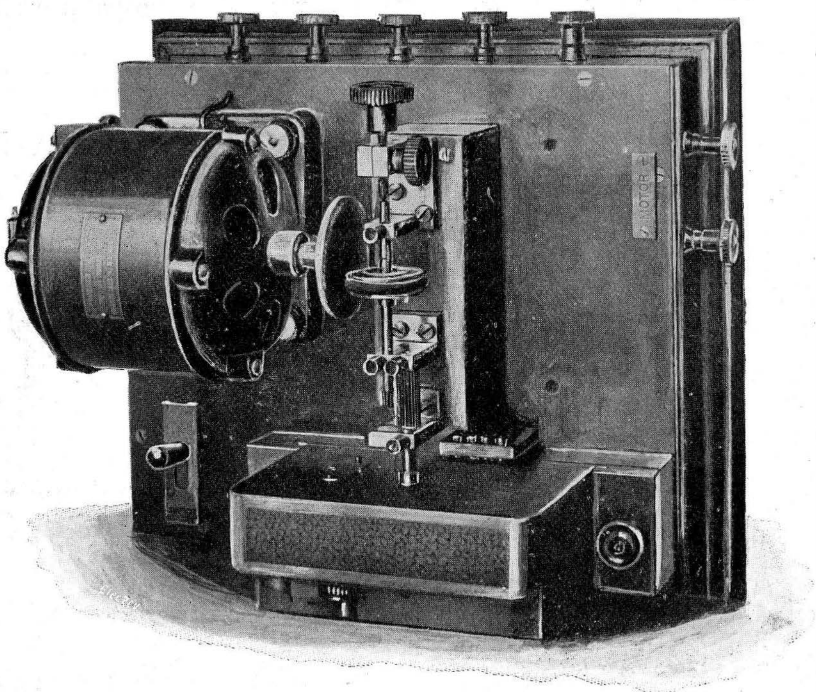
I.—Motor-driven Transmitter.

and keep its speed invariable and high. With this explanation the description of the instrument should be easily followed :

A motor, 110 v. $\frac{1}{16}$ h.p. (series wound, for a reason to be explained later) has a thick German-silver plate fitted at one end of the axle; this, backed up and made rigid, is used as a friction-plate. On the front of the friction-plate rests the edge of a friction-disc, consisting of two thicknesses of compressed hide held tightly between two metal plates. The metal plates are slightly less in size than the hide discs, to prevent the metal touching the friction-plate.

The contrivance sketched in Fig. 1 shows how the friction-plate and disc are kept in firm contact. A ball is held to the end of the armature axle remote from the friction-plate. A short piece of steel, each end of which is connected to the shell of the motor by a spiral spring, presses on the axle by way of the ball bearing. The friction-plate might be kept to its work by the motor being so placed that the armature, in striving to get to its normal position when running, keeps the friction-plate forced towards the disc. (When a motor is running, the armature, if free to do so, places itself in a certain definite position, and considerable force is necessary to move it from that position. If, now, the motor be so set, with respect to the friction-disc, that the friction-plate just touches the disc and the armature is to the left of the position referred to, the force tending to bring the armature to the right will keep the friction-plate up to its work.)

The friction-disc is fitted on an axle, at one end of which is a

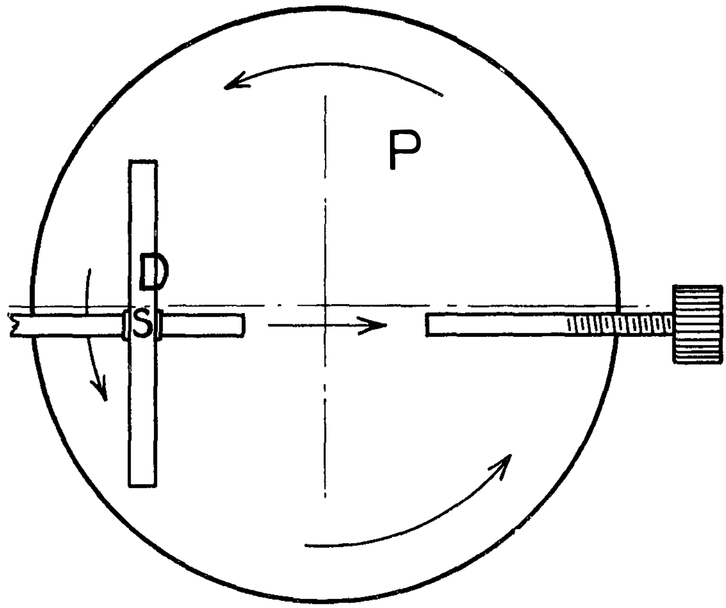


2.—Motor-driven Transmitter.

pinion gear to which the driving axle of the transmitter is connected by means of a clutch; at the other end is a cup-like end into which fits a pointed termination of the adjusting screw, this latter being in alignment with the friction-disc axle. The general arrangement will be seen from the photograph (Fig. 2), in which the observer is looking down on the instrument.

The method of varying the speed is on the well-known principle that the various parts of a revolving wheel have different speeds through space; *e.g.* any part of the periphery of a wheel travels much faster than a part near the centre. The adjusting screw pushing the friction-disc axle inwards, causes the friction-disc to be carried from the centre to the periphery of the friction-plate, varying the speed *from slow to fast* in so doing. To vary *from fast to slow*, another property of a revolving wheel has been utilised. The upper half of a revolving wheel has a motion contrary to that of the lower half, and anything rubbing against the side of a revolving wheel, if free to do so, takes up the motion of translation of that part of the wheel on which it rubs. Assume the friction-disc to be placed in the left lower half of the friction-plate near the periphery. On causing the friction-plate to revolve in a non-clockwise direction, the friction-disc will travel towards the centre. A sketch will make matters clear (Fig. 3).

The friction-plate P is revolving in a non-clockwise direction, the



3.—Motor-driven Transmitter.

friction-disc D is placed at position S, this being to the left of the vertical diameter and below the horizontal diameter of P. By virtue of D's position to the left of the vertical diameter, there is a tendency for it to take a downward motion, but, as it is not free to move bodily downwards, and, as the part touching the plate is the periphery of a wheel, that sustained downward force on every part successively produces a circular motion of D. By virtue of D's position below the horizontal diameter it has a tendency to move to the right. If the adjusting screw is not pressing against the friction-disc axle, the disc will move to the right. From these considerations it will be seen that it is only necessary to take the adjusting screw outwards for a reduction of speed; the force on the disc, due to its position below the horizontal diameter of the plate, causing the disc-axle to follow in the same direction. Screwing inwards to increase speed is against that force.

All speed variations for the transmitter are thus brought about without interfering with the speed of the motor.

When an ordinary transmitter is started on a quadruplex circuit, we find, owing to the comparatively slow arrival at its proper speed and the line being disconnected for comparatively long periods during the time taken, that the signals on the B-side are interfered with. With a series-wound motor-driven transmitter, the speed desired is obtained almost instantaneously on account of its great starting powers. The work for the motor-driven transmitter is practically constant, so that variation in speed due to variable work has not to be allowed for; the friction introduced by the paper is negligible on account of the friction already present.

A dust-proof switch is used to start the instrument. This switch operating a bell crank lever connects the power leads to the motor, the batteries to the transmitter contacts, and also makes the connections through the transmitter as in weight-driven instruments.

The clockwork or front portion of the transmitter is attached to the driving portion by means of a clutch so shaped that the need for a given position to grip is obviated: it fits in any position. The connections are provided by means of buffer contacts. When the front portion is pushed into position, the contacts are securely made and a raised edge keeps the front pressed back. It is clamped by two plates and thumb-screws. The clock-work or train has been reduced to a minimum, the frame containing this portion being about one half the size of that used for weight-driven transmitters. A change of transmitter can now be made very quickly. It has been demonstrated that the change can be made in ten seconds.

The instrument which has been described cannot be said to be a *new* instrument. A great deal of the valuable part of the weight-driven transmitter has simply been transferred to the motor-driven instrument. The instrument has been used recently in connection with some trials of the Wheatstone system between Edinburgh and London and has proved a boon to the telegraphists, who speak highly of the relief afforded them.

THE DESIGN OF TELEPHONE AND TELEGRAPH CABLES.

By A. G. LEE, B.Sc.

THE fundamental point in the design of cables for telephone or telegraph work is the combining together of a number of pairs or wires of the required efficiency in a symmetrical manner.

Before commencing the design of a cable the following particulars should be known:

(1) The number of pairs or wires required.

(2) The efficiency required in terms of 20 lb. standard cable (or, in the case of telegraph circuits, the K.R. per mile). This is determined by the length and type of transmission required, and the rules for finding it are well known.

It will be seen below that the efficiency may be obtained in two different ways:

(*a*) By large gauge conductors.

(*b*) By smaller gauge conductors and increasing the size of the cable to give low capacity.

The mere provision of a certain gauge of conductor does not necessarily mean that the efficiency required will be obtained if the pairs are tightly packed into the cable in order to obtain a large number of circuits.

The rules for finding the number of wires that will go into a cable will first be given, and afterwards a few examples worked out.

SIZE AND NUMBER OF WIRES IN A CABLE.

The diameter of any cable, D, with n round wires in the outside layer, each of diameter d, is:

$$D = d \times \left(1 + \text{cosec.} \frac{180^\circ}{n}\right)$$

From this formula the number of wires that will go into a layer may be found when the diameters d and D are known.

The following values obtained from the formula are very useful, and should be committed to memory.

When n = 3 D = 2·155 d
,, n = 4 D = 2·414 d
,, n = 5 D = 2·7 d
,, n = 6 D = 3 d

In paper cables, however, a pair of wires is not perfectly circular in section, and adjacent pairs fit into one another to a certain extent, so that a larger number of pairs can be placed in a layer than is indicated by the above formula. On the other hand, no allowance is made for the section of the wires, in an orthogonal section of the cable, being elliptical, due to the wires passing in a spiral round the cable.

Taking into account these two considerations, the following simpler formula will be found to meet the case of paper cables more nearly.

The number of pairs that will go into a layer is—

$$n = \frac{(D-d) \times 3}{d}$$

where $D-d$ is the pitch circle diameter and d=diameter of wire or pair.

It should be explained that the pitch circle diameter is the diameter of the circle passing through the centres of all the pairs in the layer.

Telephone Cables.

The following table, No. 1, shows how the ordinary twin cables, with all the conductors of the same gauge, are made up.

It will be observed that the simpler formula given, which has been used in compiling this table, causes the number of pairs in succeeding layers to increase by 6. Where the number of pairs in a layer is large a few extra pairs may be put in. For instance, in the 1600 wire cable, the pairs in the layers increase by 7 towards the outside of the cable.

The diameter of any of these cables is the sum of the diameter of the centre core, plus the diameter of a pair multiplied by twice the number of layers.

Example.—To find the diameter of a 1200 wire cable.

There are 12 layers and the diameter of the centre core of 3 pairs is 2·15 d.

Then diameter of cable

$$\text{is } 2{\cdot}15\,d + 24\,d$$
$$= 26{\cdot}15\,d$$

where d=diameter of pair.

To find the external diameter of the cable two thicknesses of lead sheathing should be added to the figure previously found.

Relation of Diameter of Pair to Efficiency.

It is found that considerable variation in the wire-to-wire capacity occurs between cables made at different times and by different manufacturers.

When the average of the results obtained over a period is long worked out, it is found that the wire-to-wire capacity per mile in

TABLE No. 1.—*Order of Stranding.*

Number of Conductors in Cable.	Number of *Pairs* of Wires in Central and succeeding Layers.																
	Centre.	1st.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.	12th.	13th.	14th.	15th.
6	3																
8	4																
14	1	6															
24	3	9															
30	4	11															
38	1	6	12														
50	3	8	14														
52	3	9	14														
54	3	9	15														
74	1	6	12	18													
96	3	9	15	21													
100	3	9	16	22													
104	4	10	16	22													
122	1	6	12	18	24												
150	3	9	15	21	27												
154	3	9	15	22	28												
182	1	6	12	18	24	30											
200	2	7	13	19	26	33											
204	2	8	14	20	26	32											
216	3	9	15	21	27	33											
254	1	6	12	18	24	30	36										
294	3	9	15	21	27	33	39										
300	3	9	15	21	27	34	41										
306	4	10	16	22	28	34	39										
338	1	6	12	18	24	30	36	42									
358	1	6	12	18	25	32	39	46									
384	3	9	15	21	27	33	39	45									
400	4	10	16	22	28	34	40	46									
408	4	10	16	22	28	34	41	49									
434	1	6	12	18	24	30	36	42	48								
486	3	9	15	21	27	33	39	45	51								
500	3	9	15	21	27	34	40	47	54								
510	4	10	16	22	28	34	40	47	54								
542	1	6	12	18	24	30	36	42	48	54							
600	3	9	15	21	27	33	39	45	51	57							
612	3	9	15	21	28	34	40	46	52	58							
700	1	7	14	20	26	32	38	44	50	56	62						
800	1	6	12	18	24	30	36	42	48	54	61	68					
806	1	6	12	18	24	30	36	42	48	55	62	69					
900	4	10	16	22	28	34	40	46	52	59	66	73					
1000	2	8	14	20	26	32	38	44	50	56	67	70	77				
1100	1	6	12	18	24	30	36	42	48	54	60	66	73	80			
1200	3	9	16	22	28	34	40	46	52	58	64	70	76	82			
1600	4	10	16	22	28	34	40	46	52	58	64	71	78	85	92	100	

general varies directly with the gauge of the wire and inversely as the overall diameter of the pair.

The following expression represents an average value so obtained:

$$K\ (\text{mfs}) = 0{\cdot}2 \times \frac{d_1}{d}$$

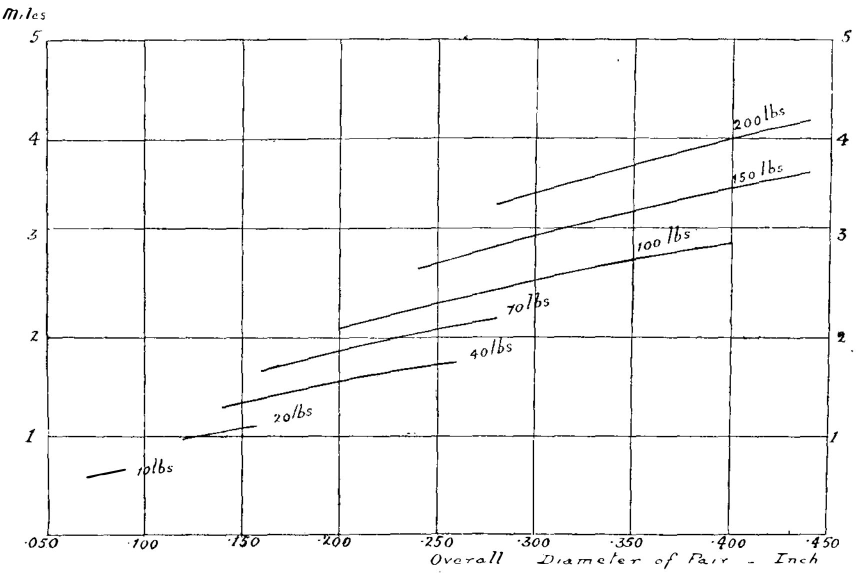
where d_1 is the diameter of the wire, and d is the diameter of the pair, and is fairly true for 20 lb. and larger conductors.

The loop resistance per mile of the wires varies inversely as the square of the diameter, or—

$$R \text{ (ohms)} = \frac{107{,}200}{d_1^2}$$

where d_1 = diameter of wire in mils.

Using these two expressions in Pupin's attenuation formula, the



I.—Variatien of efficiency with overall diameter of pair.
Miles of cable equivalent te 1 mile of Zoll's standard cable.

efficiency in terms of the number of miles of cable equivalent in speech transmission to one mile of 20 lb. standard cable is given by—

10 lb.	pair	0·0687	$\times \sqrt{d}$	miles
20 lb.	,,	0·087	$\times \sqrt{d}$	,,
40 lb.	,,	0·108	$\times \sqrt{d}$	,,
70 lb.	,,	0·131	$\times \sqrt{d}$	,,
100 lb.	,,	0·148	$\times \sqrt{d}$	,,
150 lb.	,,	0·174	$\times \sqrt{d}$	,,
200 lb.	,,	0·2	$\times \sqrt{d}$	,,

where d is the diameter of the pair in mils.

The change of inductance with the diameter of the pair has been neglected in these calculations, as the wires do not usually occupy central positions in their insulating envelopes, but are pulled close together by the twinning operation.

The possible error due to neglect of the change in this factor is of the order of 5 per cent. on the 200 lb. size and less on the other sizes.

Fig. 1 shows the variation of efficiency with diameter of pair of different gauges of wire.

Composite Cables.

The straightforward type of cable shown in Table I is usually only required near large exchanges. For trunk and junction working it is necessary to combine pairs of different efficiencies into one cable.

The procedure in this case is as follows:

The number of circuits required and their efficiency should first be ascertained.

Three examples of the design of such cables will be given.

Example 1.—It is required to combine 200 20 lb. wires and 600 10 lb. wires into one cable. Reference to the curves in Fig. 1 will give the diameters of these pairs necessary for the desired efficiency.

Table 1 shows that a 200 wire 20 lb. cable can be made up as follows:

	Centre.	1st layer.	2nd layer.	3rd layer.	4th layer.	5th layer.
Number of pairs	2	7	13	19	26	33

The diameter over this portion of the cable must now be found.

The diameter of two pairs twinned together is 1·4 times the diameter of one pair. The diameter over the 20 lb. cable will therefore be 11·4 d. Taking 140 mils as the diameter of the 20 lb. pair to give the desired efficiency we have —

$$D = 1{\cdot}6 \text{ inches.}$$

A trial calculation, taking the diameter of a 10 lb. pair as 80 mils, gives the number of pairs in the first layer of 10 lb. as 63. As there are 300 pairs required there will be 4 layers with an average of $\frac{300}{4} = 75$ pairs per layer.

This would be the number of pairs in a layer equidistant from the inner and outer layers, therefore the layers on each side of this mean layer, in this case, have 3 pairs more and less respectively, that is, the second and third layers have 72 and 78 pairs respectively. The first layer of 10 lb. will therefore have $72 - 6 = 66$ pairs, and the fourth layer $78 + 6 = 84$ pairs. If there is a layer equidistant from the inner and outer layers (in the case where the number of layers is odd) then the number of pairs in the layers on either side of it differ by 6 from the number in the mean layer.

The arrangement of the cable will therefore be:

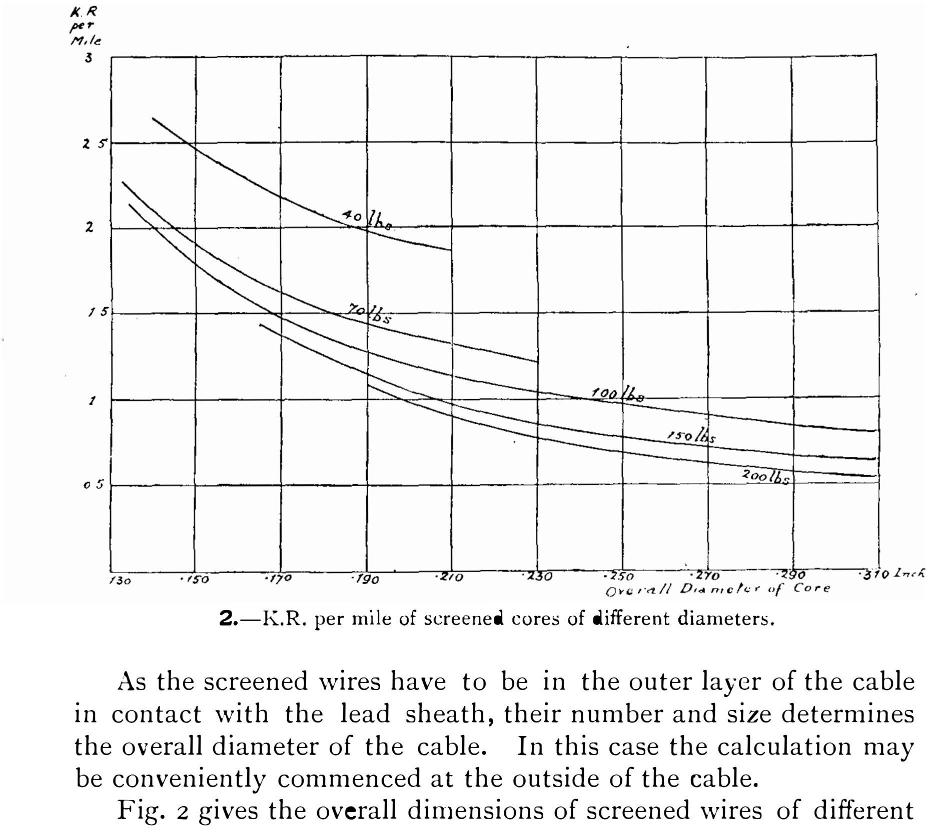
	Layers.								
Centre	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
2	7	13	19	26	33	66	72	78	84
100 20 lb. pairs.						300 10 lb. pairs.			

It is now necessary to calculate the diameter of the 10 lb. pair afresh to see that the necessary efficiency will be obtained.

It is $\frac{1 \cdot 6 \times 3}{63} = 76 \cdot 2$ mils.

It will be observed that 1·6″ has been taken instead of the pitch circle diameter (1·6 + d); 1·6″ is a mean between the pitch circles above and below it, so that the number of pairs that will go into it is 3 less than in the layer above. Hence 63 is used as divisor instead of 66.

Example 2.—It is found that the following wires will be necessary to supply a given route with circuits of a certain efficiency: 24/100 lb. wires + 6/150 lb. wires for telephones and 6/70 lb. + 18/200 lb. screened wires for telegraphs.



2.—K.R. per mile of screened cores of different diameters.

As the screened wires have to be in the outer layer of the cable in contact with the lead sheath, their number and size determines the overall diameter of the cable. In this case the calculation may be conveniently commenced at the outside of the cable.

Fig. 2 gives the overall dimensions of screened wires of different efficiencies.

As the number of screened wires is small we will take a large diameter, 315 mils, for the 200 lb. cores, so as to allow plenty of room for the telephone pairs inside the cable.

The diameter under the lead sheath is—

$$D = \frac{18 \times \cdot 315}{3} + \cdot 315 = 2 \cdot 205.''$$

This leaves $2 \cdot 205 - \cdot 630 = 1 \cdot 575''$ for the telephone pairs.

The 100 lb. pairs may be made up in quad-pair formation, with three cores of four pairs each.

The diameter of the quad core will be—

$$\frac{1{\cdot}575''}{2{\cdot}15} = {\cdot}733''.$$

As each core consists of four pairs, the diameter of each 100 lb. pair will be—

$$\frac{{\cdot}733''}{2{\cdot}4} = {\cdot}305''.$$

The 150 lb. pairs may now be placed as worming between the quad cores, the diameter which may be allowed to them being about 0·48 of the diameter of the quad core,

or 350 mils.

The 6/70 lb. screened wires will now go in on either side of the 150 lb. pairs, the diameter which may be allowed to them being 0·6 of the diameter of the larger worming pair,

or 210 mils.

Reference to the curves will now show whether the efficiences of the various types of wires are in accordance with the requirements.

Fig. 3 shows the diagrammatic arrangement of the cable.

Example 3.—Required about 120 100 lb. wires plus 29 70 lb. screened wires.

In this case we again start the calculations from the outside layer.

Taking ·215″ as the diameter of the 70 lb. screened wires to give the required efficiency, the diameter under the lead sheath is—

$$\frac{29 \times {\cdot}215}{3} + {\cdot}215 = 2{\cdot}3''.$$

This allows $2{\cdot}3 - {\cdot}430 = 1{\cdot}87''$ for the telephone pairs.

In this case we will make up the cable with 4-wire cores of the multiple twin type, a good arrangement being:

Centre.	1st layer.	2nd layer.	
4 . .	10 . .	16	= 30 4-wire cores.

The use of 8-wire multiple twin cores is not recommended, owing to the loss of space between the large cores. The same argument applies to the 8-wire quad pair cores, unless the space is filled in with worming pairs.

The diameter of the 4-wire cores will be—

$$\frac{1{\cdot}87''}{4{\cdot}6} = {\cdot}292'',$$

and the diameter of the 100 lb. pairs—

$$\frac{{\cdot}292''}{1{\cdot}4} = 210 \text{ mils}.$$

Reference to Fig. 1 shows that this gives rather a low efficiency, and the diameter of the cable should be increased if possible. If the cable is going into a $3\frac{1}{4}''$ pipe the diameter under the lead sheath may be 2·62 inches.

If all the diameters be increased in the ratio $\frac{2·62}{2·3}$ (where 2·3 was the diameter first found), the same relative dimensions will be obtained.

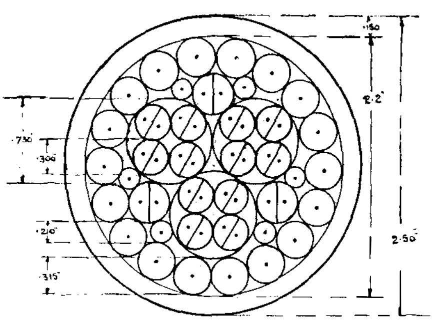
The diameter of the 100 lb. pair will now be—

$$210 \times \frac{2·62}{2·3} = 240 \text{ mils.}$$

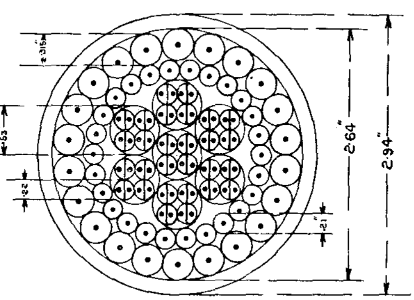
The efficiency is still rather low. If it is not desired to lay a larger pipe or another cable, the efficiency may be improved by putting in 150 lb. or 200 lb. conductors in place of 100 lb.

A few remarks on the efficiency curves in Figs. 1 and 2 may here be of interest.

Fig. 1.—It will be seen that the same efficiency may be obtained



3.



4.

with two adjacent gauges of wires over a short range on each curve. Where the efficiency required comes within this range the smaller gauge wire, in general, makes the cheaper cable.

The more usual problem, however, is that a very large number of circuits are required, and the size of the cable is limited by the size of the pipe. In this case the larger conductors may give the required efficiency without the expense of laying down a second pipe line, and cable.

Fig. 2.—The same remarks apply to a large extent in the case of screened wires. The necessity for having the screened cores against the lead, as already pointed out, usually determines their size. It will be seen that the efficiencies of the different gauges overlap to a large extent so that a wide choice of type is possible.

The difference in cost between, say, a 70 lb. and a 40 lb. screened core of the same efficiency is very small, owing to the cost per lb. of the screening tape being about 40 per cent. higher than that of copper wire, and as the 70 lb. core is smaller for the same efficiency, more wires may be put into the cable. The *cost per wire* would in such a case probably work out cheaper with the larger gauge conductor when the cost of the lead sheath is taken into account.

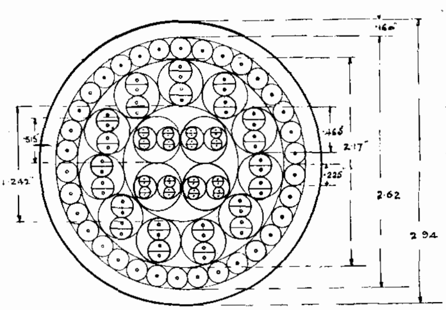
LEAD SHEATH.

The thickness of lead sheath necessary is determined by several considerations:

(1) A minimum thickness is necessary to prevent blowholes and flaws, and to provide against corrosion, etc.

(2) The lead must be sufficiently strong to withstand the air-pressure test.

(3) The lead may have to take part of the pull of the cable grip if the cable end is not properly prepared.



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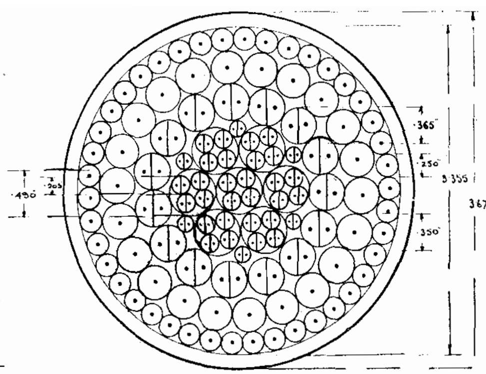


6.

The following formula is fairly in accordance with the thickness found necessary by the Post Office:

Thickness = ·055″ + ·04 d″ where d″ is the diameter of the cable under the lead sheath.

It provides a large factor of safety for cases (2) and (3), but with regards to (1) accidents will sometimes happen against which it is impossible to reasonably provide.

For aërial lead-covered paper cables and exchange cables not subject to the mechanical stresses incidental to pipe work, which tend to open any defects in the lead sheath, much thinner lead may be used.

The following expression is applicable in these cases:

Thickness = ·030″ × ·04 d″.

In all cables we allow the manufacturer 2 per cent. variation above and below the mean external diameter of the cable. Allowance must be made for this in calculating the size of the cable to go in a given pipe.

The number of possible combinations of conductors in a cable is very large, but there is no space to give them here. Figs. 4, 5, and 6, with those already given, however, illustrate the most usual arrangements of wires in a cable, the majority of other cables being variations of these types.

RECENT CABLING WORKS.

THE following particulars of the work in connection with the Birmingham - Bromsgrove cable speak well for the energy and efficiency of the officers concerned.

Length of route	13 miles.
Diameter of pipe	$3\frac{1}{4}$ inches.
Type of cable	32/100 Q.P. + 2/100 twin + 4/200 S.S. + 29/70 S.S.
Diameter of cable	2·75 inches.

	Commenced.	Completed.	No. of working days.
Pipe-laying	Feb. 12	March 23	35
Cabling	March 5	,, 31	23
Jointing	,, 6	April 8	29

The cable sections were 176 yards in length. The joints were buried.

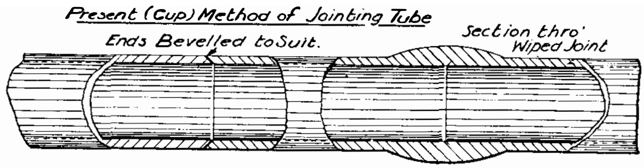
Extensive works in connection with the main underground telegraph system have recently been carried out in the same speedy manner in the Southern and Scotland (West) Districts.

PNEUMATIC TUBE JOINTS.

THE usual method of connecting the lead tube after a fault in a pneumatic tube has been removed has hitherto been by means of a cup joint, as shown in **1**.

In order to make this joint it is necessary to open ground to the first joint in the protective iron pipe, usually a distance of nine feet, to enable the tube to be raised to an angle sufficient to allow the bevelled end of the tube to enter the convex end before being lowered to the horizontal position.

The joint, as shown in **2**, is designed to avoid the necessity of



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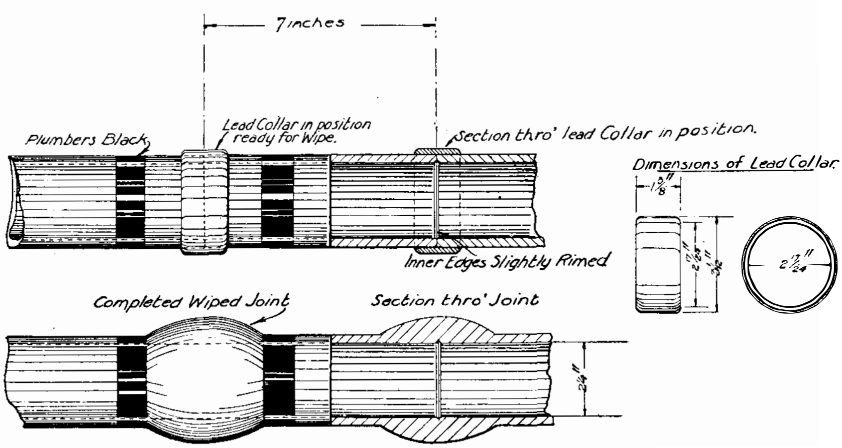


2

opening the extra length of ground. The faulty part of the tube is cut out and a gap of about 7 inches is left, into which a piece of tube is inserted, on which two bevelled lead collars $1\frac{1}{4}$ inches wide fitting tightly on the tube have previously been fitted. The short length of tube is fitted in its position, the collars are brought over the centre of the joints, and the bevelled edges closed around the tube, and ordinary wipe joints are then made over them.

A tool consisting of a circular milling cutter mounted on a mandril has been made to turn the ends of the tube in order to ensure a close joint.

Besides being more economical, the joint is more satisfactory than the cup joint.

The new joint, as well as the design of the necessary tools, is the work of Foreman G. J. Burrett, Central Metropolitan District.

W. N.

REMINISCENCES OF OVERHEAD AND UNDERGROUND TELEGRAPH WORKS.

By G. W. Hook,
Superintending Engineer, South Midland District.

Before touching on underground matters I would like to record my recollection of the early days of the Post Office Telegraphs, just after the transfer in 1870. I was attached to the London Division under the late Mr. F. Isherwood, who was Divisional Engineer, and to the best of my recollection our work was direct with the Secretary without the intervention of Mr. Culley, who was at that time the Engineer-in-Chief.

The Staff comprised the Divisional Engineer, two senior inspectors, three Inspectors (of whom I was one), and two clerks, supplemented by writers. The London Division was divided into three sections, comprising the N. & N.W., the W. & S.W., and the E. & S.E. I had charge of the N. & N.W., Mr. J. Trott the E. & S.E., and Mr. H. D. Hasdell the W. & S.W. Of the Established Staff, as it was constituted at the time of the transfer, I believe I am the only surviving officer.

Of these early days there is much which, in the light of our present organisation and methods, seems strange. The Divisional Engineer dealt with construction work at first, and personally paid the men. Afterwards the Inspectors took over the construction as well as maintenance.

It was a glorious time for wayleaves. Very little difficulty was experienced in obtaining free consents for the fixing of wires to chimney stacks, or even roof standards, and the public seemed to feel honoured by the asking. Think of it, some of you young sectional engineers. I remember one case in one of the principal streets of North London. There were two adjoining shops belonging to one owner (it was a first class drapery establishment), and the parti-wall was an excellent position for a roof standard. I obtained the owner's consent, and, as I was rather doubtful whether the consenter would like the look of the standard and wires when erected, I had them put up quickly on a Saturday afternoon after the establishment had closed. Some days after, the foreman told me that the proprietor had visited the works, and that he would like to see the gentleman who had obtained his consent for the erection of the telegraph pole on the roof of his premises. I, of course, expected that he had altered his mind and wanted it removed, so I thought I would give him time to cool down. At last I faced it, and called, when, to my relief, he said he wished to say that "he was much obliged to me for selecting his premises for the pole as he thought it *made the shop look more imposing*."

On another occasion I had to construct a very large number of fire-alarm circuits for the old Metropolitan Fire Brigade (now London County Council Brigade) and I applied to headquarters for assistance in connection with wayleaves. An officer was sent to me and I explained to him clearly, as I thought, the particulars of the duty required of him. I took him to a street containing about twenty houses on each side of the road, and told him a consent for a fixing on any house there would suit. Some days elapsed and I asked him how he was getting on in —— Street, and he replied, "Oh I have got all except one, and he won't have it at any price." He thought I had said *every* house instead of *any* house.

In connection with the same work (fire-alarms) I called on a shop-keeper in the East End of London and tried to persuade him to let me fix the wires to his chimney-stack, but when I told him for what purpose they were intended, and that the alarm would be at the corner a few doors up, he absolutely declined. I pointed out the advantage it would be to him to be able to call up the firemen in case his place was on fire; but it was like waving a red flag to a bull, for he said, "When he had a fire, he hoped it would be a good one, and he should not want any firemen to be anywhere near." Way-leave-getting is truly very uncertain.

I think one of the most exciting of my experiences was the following: My section included the maintenance of the wires on the North London Railway, including the signal wires and double-needle instruments in the booking offices. The block instruments in the signal cabins were maintained by a firm of instrument makers. This divided maintenance was very confusing and led to much friction. One day I received an urgent message from the company's officials informing me that the lineman was causing much confusion at Dalston Junction, where he was renewing some wires. I immediately went to Dalston and found that trains signalled on No. 1 were coming in on No. 2, and *vice-versâ*. I saw the danger at once, and the lineman was getting very excited; so I immediately had all the signal wire leads disconnected and asked the railway officials to arrange to "flag" the trains through until the signal wires were put right. I thought it safer to have *no* signals than unreliable ones, and all those who know Dalston Junction Station will appreciate my feeling of relief when I had transferred the responsibility to the railway officials.

Passing on to underground work, the old gutta-percha wire system lent itself conveniently to almost any condition. Each wire being separately insulated could be taken direct either to the instrument or to a test box. Bakers' ovens caused some trouble owing to the heat under the paving causing the percha to melt. Other undertakers, such as gas, water, and hydraulic companies' workmen, would sometimes unwittingly cause damage when working by night through hanging naphtha lamps on our pipes in excavated holes. A peculiar case occurred in St. Paul's Churchyard, where a new building was in course of construction. We had two pipes containing gutta-percha wires under the footway in front of this building and these wires became faulty. On localising, the faults were proved to be in the section close to the new building, and on drawing out the cable the percha at one point was seen to have been subjected to heat. The contractors declared that they had had no fire at this spot; but on close examination of the ground I noticed that the paving stone had been removed at a spot behind the hoarding just over our pipes, and that a quantity of lime was lying about. I came to the conclusion that the lime had become wet, and so generated heat above the pipes sufficient to melt the percha. I tried the experiment in our depôt, and the result satisfied the contractors, who ultimately paid the cost of repairs.

While on the subject of gutta-percha wires it may be of interest to relate my experiences in connection with the socialist and unemployed riots of about twenty years ago. Two or three days before the "Black Sunday" riot in Trafalgar Square, my Superintending Engineer called me into his office and told me that the police authorities required certain special circuits, connecting up Old Scotland Yard with stations in the neighbourhood of Trafalgar Square and the station near the Magazine Barracks in Hyde Park.

In order to provide the latter it was necessary to increase the number of gutta-percha wires in a line of pipes across Hyde Park. A cable was laid out at the joint-box about the middle of the park, ready to be pulled into the pipes, when two or three Socialists came on the scene and began to make uncomplimentary remarks about Government men. I told the cable men not to reply but to get on with the work as quickly as possible. Presently, two of the Socialists stood on the railings and waved red flags, when others, in groups of twos and threes, came across the Park and formed a very ugly crowd. Our men could hardly keep from answering back, but as the crowd began to pull the wires about I quietly sent a man over to the magazine station asking for police assistance, and when a few constables appeared coming at the double, the Socialists scattered like rabbits and we were able to complete our work.

The next day, Saturday, I was informed by my superintending engineer (the late Mr. H. Eaton), that a big gathering of Socialists was expected in Hyde Park and Trafalgar Square on the Sunday, and that the police authorities anticipated that an attempt would be made to cut the wires connecting up the stations, by men who had worked for our Department. I volunteered to be on duty at Scotland yard with men and appliances ready for any emergency, and found many willing linemen to act with me.

On the Sunday there was a crowd of the most evil-looking ruffians from the east end, filling the streets of Whitehall and the neighbourhood, but Trafalgar Square was closely packed with hundreds of special constables, each armed with a truncheon. During the day we patrolled the routes of the wires but only one fault occurred, and that was on the circuit between Scotland Yard and the National Gallery. I managed to get through the crowd in course of time and found the stoppage was caused by an instrument fault. This was rather an important circuit, as soldiers were stationed here in case they might be required, and I believe they had a plentiful supply of buckshot cartridges in their pouches.

In the archway leading from Whitehall to Old Scotland Yard Police Station the police stood shoulder to shoulder four deep to keep the crowd from raiding the station, and at one time it was so threatening that the iron shutters were closed and the doors also. At last the mounted police by several flank movements managed to break up the crowds (also some heads) and cleared the streets. Altogether it was an exciting time; and I still retain my special constable's truncheon as a memento.

Some of my experiences have been tragic as well as humorous. I was once directing some alterations and crosses at a pole on the North London Railway, which was clipped to the viaduct wall of the line overhanging Chalk Farm Road. A wireman went up the pole, and as he leaned over to fix his vice and tongs to a wire I noticed a strange look in his face, and as he suddenly let go his tools and began to quiver I came to the conclusion that he was in a fit, and called to the lineman who was close at hand. He mounted the pole very quickly and lashed the poor fellow to the pole until his struggles and convulsions ceased, when we lowered him to the ground with a line and carried him to a place of safety. It was an exceedingly narrow escape from either falling into the street below (where a great crowd had assembled), or falling to the metals, where trains passed every few minutes. Needless to say, that man was not allowed to work up a pole again but was found employment as a battery-man.

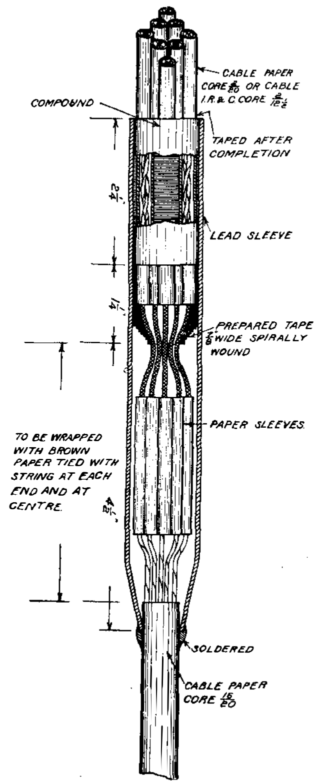
(*To be continued.*)

POTHEADS AND POTHEAD INSULATORS.

By E. Gomersall.

The methods of terminating paper insulated cables for connection to open wires or to distribution frames or other apparatus have in the past been the source of much discussion, and consequently a description of methods recently adopted with success will probably be interesting to many readers of the Journal.

Potheads of the form I propose to describe are suitable for terminating underground or aërial paper-core cable or silk and cotton-core cable, and the distributing wires may be lead-covered paper or I. R. & C. core cables, flame-proof, I. R. & C., or V. I. R. wire as may be desired. 1 illustrates a pothead for 16/20 paper-core cable with twin-wire lead-covered distributing cables. The method of making the pothead is as follows: The lead sleeve is dressed down at one end to a suitable size, and placed on the cable. The conductor joints are made between the cable conductors and the distributing wires, the completed joint being wrapped with insulating paper. The distributing wires are served with a wrapping of $\frac{7}{8}$-inch prepared linen tape, 1 to 2 inches wide, so that the sleeve, when slipped over, is a close fit. The tape wrapping is placed so that compound can be poured into the sleeve to a depth of at least two inches. The soldered or wiped joint is then made and the distributing cables at the other end of the sleeve are spread out so that the compound may find its way between them. Hot compound is poured into the open end of the sleeve, care being taken to fill it completely. The sleeve need not be warmed, but the compound must be hot enough to flow freely. When the compound has solidified the distributing leads are neatly bound with prepared tape close to and over the end of the cable. The most suitable compound for the purpose consists of 20 lb. G. P. scrap, 14 lb. resin, 14 lb. stearine pitch, with a little boiled oil added, if necessary, to temper the consistency.



1

When single or twin lead-covered cables are used for the distributing leads, the tape wrapping should cover the stripped ends of the wires as well as a short portion of the lead sheathing. The sleeve should be marked with a scratch to indicate the top of the tape wrapping.

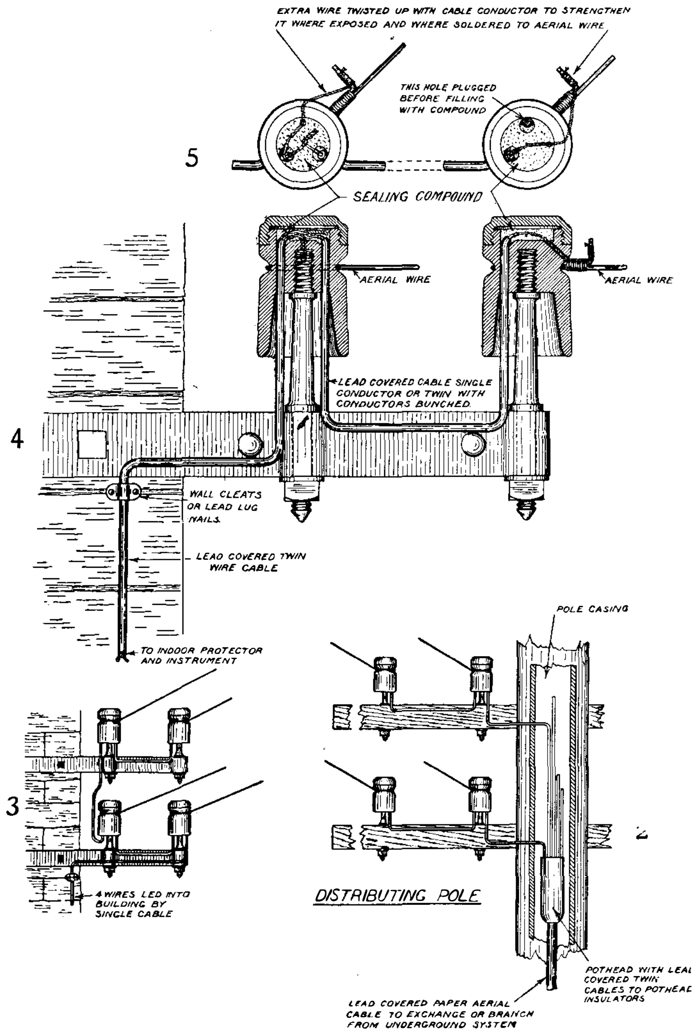
Perhaps the chief defect of potheads of other forms is that access to the joints cannot be obtained without destroying the pothead; cable terminal boxes have been largely used to overcome this difficulty. Potheads made as described are, however, free from this defect. To get at the joints it is only necessary to sweat off the soldered joint and gently warm the upper portion of the sleeve so as to soften the compound enough to permit of the sleeve being slipped down ; if the operation is skilfully performed, only the outer surface of the compound will soften. When the sleeve has been soldered in position again, the warming of the upper portion will be sufficient to melt the compound and make it an air-tight plug. With careful workmanship these potheads will withstand an air-pressure of 20 lb.

Apart from the merit already mentioned, the introduction of the pothead described permits of cables being terminated without the need of stores which have to be specially manufactured, and the process is less costly than cable terminal boxes or solid plugs of cast lead. Lead-covered distributing wires can be employed instead of perishable indiarubber-covered wire, and the lead-covered cables are not so liable to break as in plugs of cast lead. Possibly with a little modification the pothead can be adapted for distributing cables in footway boxes.

Pothead insulators.—When it is desired to connect an aërial or underground paper cable to open wires, lead-covered single or twin paper core, or I. R. & C. core, cable should be used for the leads, terminated in pothead insulators. This insulator is designed with a screw cover for the top, and, under the cover, a cavity with two holes through the body of the insulator between the shed and the spindle, and a third hole to the groove for the line wire. The insulators are made in two sizes, for terminating light and heavy wires, the overall dimensions being $4\frac{5}{8}$ inches by $2\frac{3}{4}$ inches and 5 inches by 3 inches respectively.

The bare wire is terminated in the ordinary way. The lead-covered cable is brought up through one of the holes to the cavity at the top of the insulator. If a single wire circuit is being dealt with the lead covering is stripped to about $\frac{1}{8}$-inch beyond where it enters the cavity, and a sufficient length of wire is bared of insulation to allow of the wire being threaded through the small groove and soldered to the tail-piece of the open wire. As a rule 20 lb. conductors are used for single-wire circuits ; the wire may be doubled back upon itself and twisted, or a separate short length of wire may be twisted up with it, where it is exposed to the atmosphere. Compound of the description already referred to is then poured into the cavity to efficiently seal the cable, the unoccupied hole in the insulator being plugged.

For metallic circuits two insulators are required and twin cable is used. The cable is taken to the insulator nearer the pole casing, and one of the conductors is connected to the open wire as



already described. The other is soldered to the conductor of a single-wire cable or to the bunched wires of a twin cable, which is led from the insulator on which the other bare wire of the pair is terminated into the cavity through the second hole.

2 shows a pothead and the method of distributing subscribers' circuits radiating from a distributing pole. **3** illustrates a method of leading from a horizontal bracket, and **4** and **5** show the arrangements in the cavity at the top of the insulator.

On poles where the double-wire circuits are in diagonal positions, as at ordinary terminal poles, the short cables between the insulators may be protected from injury by the feet of workmen, by strips of wood fixed vertically on each side of the pole, close to the arms.

The cables between the insulators on 8-wire arms may be secured to the arm combiners. On arms where **J** cupholders are fitted it is convenient to fix the cables on the under side of the arms. Lead lug nails are suitable for the purpose. Where the cables enter pole-casing they should be taken through holes slanting upwards.

The insulator, as at first designed, had two cups, but as the lead-covered cable between the cups was itself earth connected, the inner cup did not serve any useful purpose and it has been abandoned. The single-shed insulators illustrated will withstand an electrical pressure of 25,000 volts between the groove and the spindle.

The foremost advantage of the new insulator is that it permits of inexpensive lead-covered cables being taken direct to the insulators on a terminal pole, or, at an office, direct from the insulator to the protective fitting inside. G.P. leads with leading-in cups on the casing, G.P. tails on small lead-covered cables, or perishable india-rubber-covered leads are no longer necessary, and in their place we have a neat arrangement of sealed lead-covered cables, which for this class of work may be considered imperishable, and the services of a skilled G.P. jointer are not required.

Probably the usefulness of the pothead insulator is not limited to the type described. An insulator with two side-knobs has already been designed, and possibly it may be found convenient and economical to distribute larger cables from pothead insulators of larger dimensions.

THE TELEPHONING OF LONDON.

By W. Noble, A.M.I.E.E.

(*Continued from page* 22.)

Cables and Cabling.—At the outset of the telephoning of London the maximum sizes of cables adopted by the Post Office were 108-pair, with 40-lb. conductors for junction cables, and 217-pair, with 20-lb. conductors for subscribers' circuits, the last-named being increased later to 306-pair with 20-lb. conductors. More recently still the maximum size of subscribers' cables for short lines has been increased to 606-pair with 10-lb. conductors because experience had shown the possibility of using 10-lb. conductors, on lines having a total resistance within the 300-ohm limit allowed for local circuits. For short-distance *junction* circuits a reduction has also been made, from 40-lb. to 20-lb. conductors.

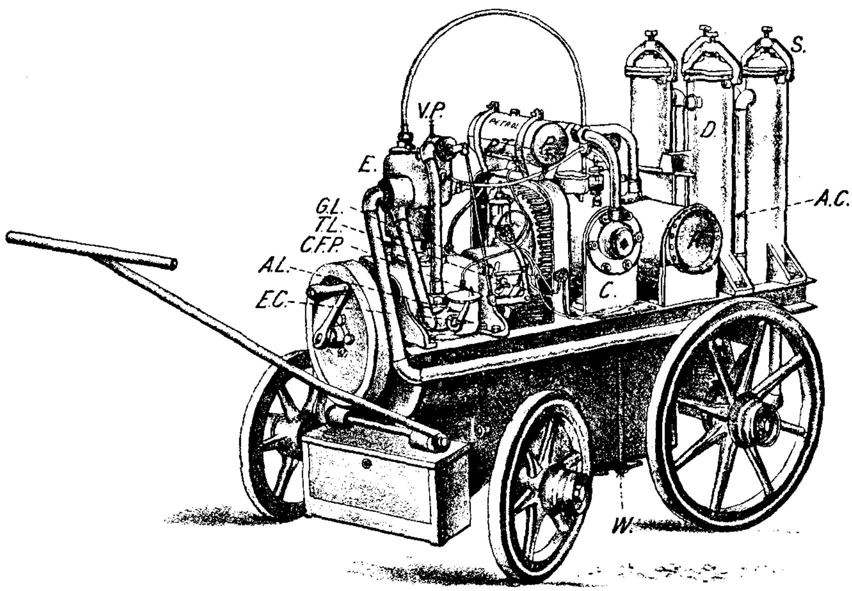
Another advance has taken place, viz. in the length of sections. At the commencement of the work the average distance between manholes was 150 yards, the standard is now 170 yards, increased in special cases to 180 and even 200 yards. The increase in the length of the cabling section was rendered practicable by the utilisation, some seven years ago, of the improved wire grip, which the writer had seen in Brussels. The employment of this grip has also effected an economy in time and material.

Portable Desiccators.—One appliance indispensable in the laying and maintenance of paper-core cables deserves mention, although it is now too well known to need description in this article, viz., the portable desiccator, which has aroused so much curiosity and wonderment on the part of London's millions. This machine was designed by the Post Office. The first type was hand-driven, the later type motor-driven. (1)

Besides being used for the drying-out of cables these desiccators are employed for making an air-pressure test on new cables, the electrical tests made on the completion of a main cable being followed by an air test. At the home end of the cable the air pressure is raised to about 30 lb., and when at the distant end it has reached about 29 lb. the desiccator is stopped. The pressure is allowed to equalise, generally reaching to about 25 lb. With gauges in at both ends the cable is left for 24 hours, and if the cable and jointing be sound throughout no fall in pressure should manifest itself.

Distribution.—Prior to the Post Office taking in hand the telephoning of London, distribution wholly underground had not been adopted by any administration. In America and some continental countries, where underground main cables had been employed, the distribution was effected either by a system of short open lines radiating from a ground-pole or roof-standard to which a main cable had been laid—sometimes called the "island" system of distribution—or by means of covered wires attached to the back walls of buildings—known as the "block" method. The Post Office being the first to adopt underground distribution on a large scale was faced with the problem of dividing up main cables into small cables for distribution.

CABLE DISTRIBUTION HEADS.—In the system of distribution

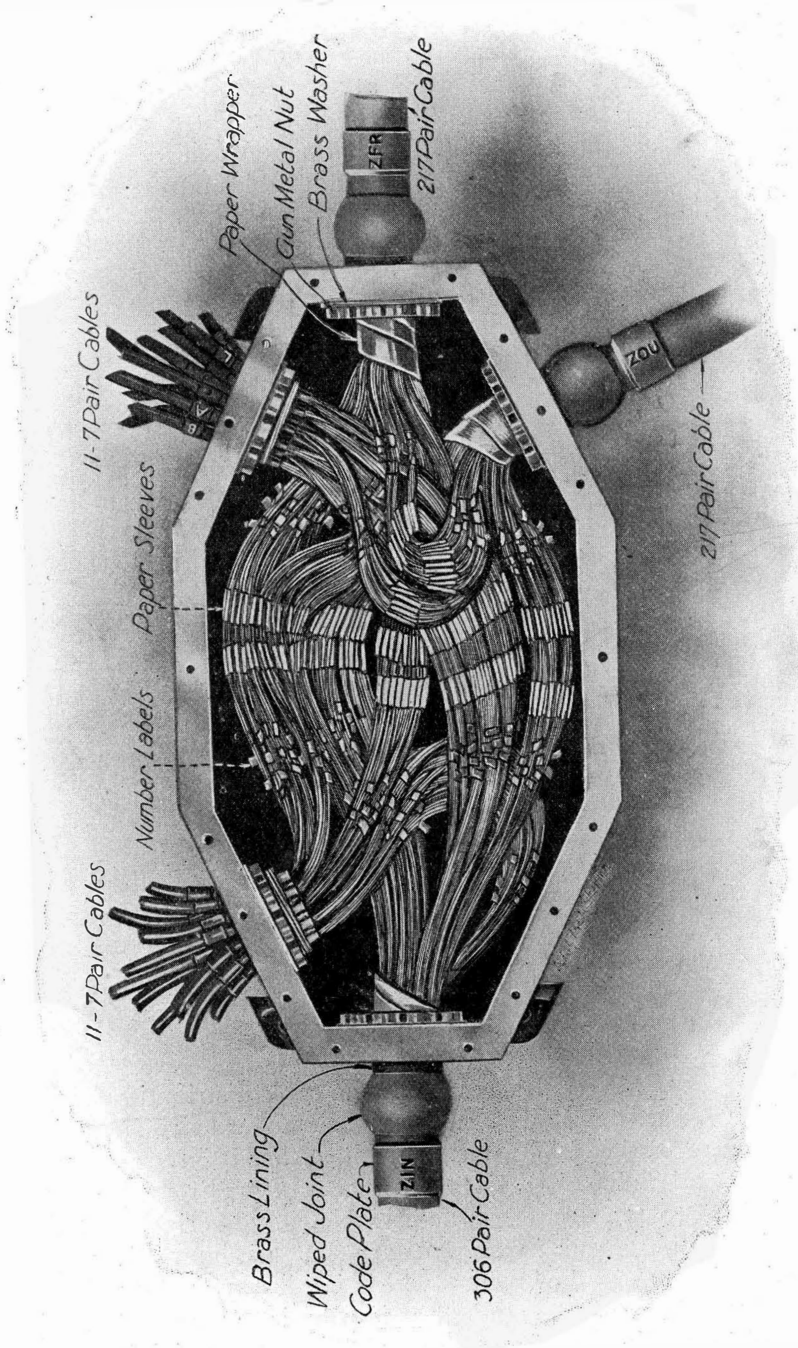


E. Petrol engine. *S.* Spider. *G.L.* Governor lever.
C. Compressor. *W.* Water tank. *A.L.* Air lever.
R. Air receiver. *A.C.* Accumulator and coil. *C.F.P.* Carburetter float pin.
D. Desiccator cylinders. *E.C.* Carburetter. *P.T.* Petrol tap.
P. Petrol tank. *T.L.* Timing lever. *V.P.* Valve pin.

I.—MOTOR-DRIVEN DESICCATOR.

introduced the main cables terminate in cable distribution heads, from which radiate distribution cables of the standard size of 7-pairs. One or more main cables terminate in a head into which are fixed gun-metal linings containing a number of 7-pair cables equal in total pairs to the size of the main cable. A description of the cable distribution head is unnecessary, but an interesting case illustrating its use is shown in **2** which is self-explanatory.

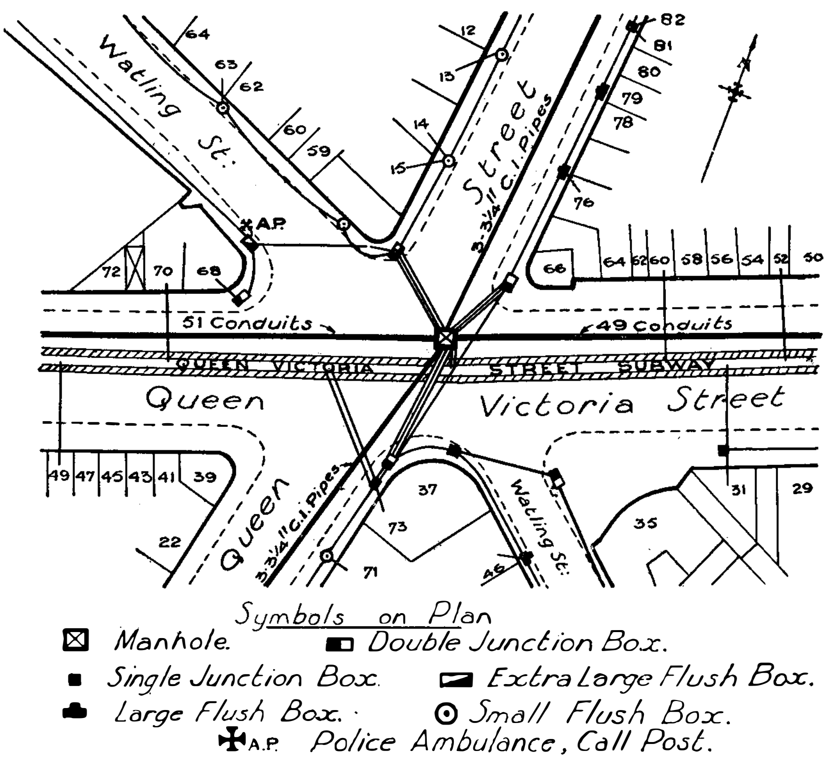
FOOTWAY PIPES.—The method of distributing along footways is illustrated in **3**. Connecting each manhole to the adjoining footways are three pipes, of 3-inch diameter in the outlying districts, and $3\frac{1}{4}$ inches in central London. These pipes terminate in double



2.—Cable Distribution Head.

junction boxes, about 4 feet 3 inches in length by 2 feet in width. From these boxes pipes branch in different directions. The illustration given shows a typical case in the Central District, and indicates service from a subway.

SUBWAYS.—There are in Central London a number of subways, and of these every possible advantage was taken for the accommodation of cables. The most interesting subway is that built by

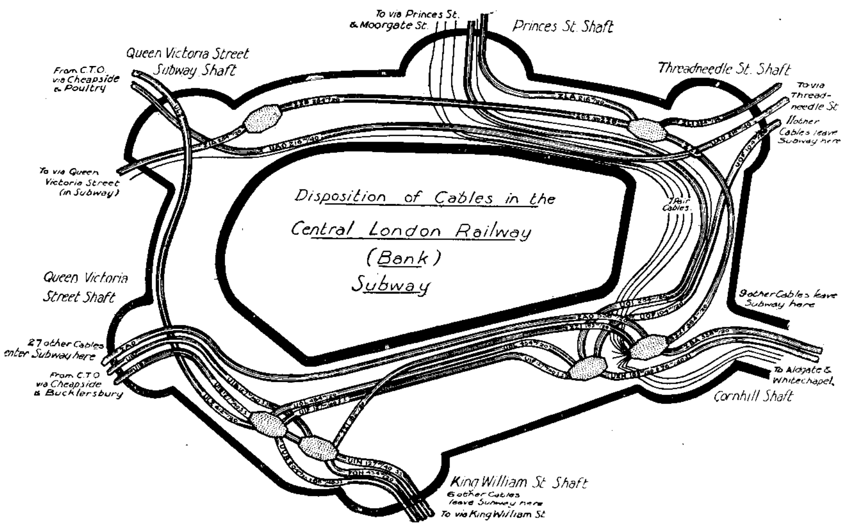


3

the Central London Railway Company at their Bank Station. Fig. 4 shows a plan of this subway and the disposition therein of some of the Post Office cables.

DISTRIBUTING JOINTS.—As the cable distribution heads provide for the sub-division of the main cables so provision is made for the diversion of the 7-pair and smaller cables by means of what are generally termed "*solid-joints*," of which there are four classes, the combinations being: 4 + 3, 4 + 2 + 1, 3 + 3 + 1, and seven single pairs. The one generally used is the last-named. It consists of six single pairs of lead covered cables grouped round one single pair in a solid plug of lead. To one end is jointed a 7-pair cable, the other end being free to provide for seven separate subscribers. If at the outset only one or two circuits are required at a point, one of the other classes of solid joint may be connected up or a double single-pair solid may be used. Later, as the service grows, another 7-pair cable may be laid and the whole of the first cable left for distribution at the original point. This form of distributing joint provides all the elasticity that is desirable in a new telephone system, but it has one inherent defect—the single pairs with their thin lead covering will not stand rough handling.

INDOOR WORK.—As might be expected the indoor wiring of large buildings in London formed an important feature in the work.



4

Various methods were adopted to meet the different conditions; three of the most important may be referred to.

First, in damp basements or where the main distribution has to be effected in front areas, a cable distribution head is installed and 7-pair cables run to the various floors. Then at convenient points they are sub-divided either by solid joints or at small test cases. A second method consists in the erection in the basement of an iron distributing frame (similar to the main frames in exchanges), from which run lead-covered cables or I.R. & C.C. leads in casing or conduits. In the third and most commonly employed system, a main cable is terminated at a distribution case of a size to meet the ultimate requirements of the building, and fitted with a number of connection strips to meet the present requirements.

The fixing of casing or conduits in hundreds of large buildings in central London occupied continuously a staff of experienced carpenters for over two years, provision wherever possible being made to meet future requirements over a long period of years. Many of the buildings dealt with contain at least 100 rooms, many over 200, and in one case the number reaches 660, and yet another, 800 rooms.

EXCHANGES.—At an early stage in the preparation of its scheme it was necessary that the Post Office should decide the question of the Exchange system to be adopted. A study of the telephone situation generally showed the superiority of the Common Battery system over all others then in use ; there was therefore no difficulty in deciding that that system should be adopted for the larger exchanges.

The Department were the first to introduce and has consistently employed automatic signalling on subscribers' circuits, and although not seeing its way clear to adopt the common battery system for exchanges of all sizes, it was decided that the principle of automatic signalling should hold universally, with the result that a common battery *signalling* system was adopted for the smaller exchanges.

Although the common battery system had already been fully developed in America, it was necessary, nevertheless, in order to meet the conditions in London, for the officers of the Post Office to devise numerous junction and extension circuit arrangements.

DIVERSION WORK.—No paper touching on the history of the telephoning of London by the Post Office would be complete without a reference to what was commonly called the Diversion Scheme.

Although for distribution work many miles of new pipes had to be laid in footways, there had to be utilised for the purpose the large amount of existing pipes, all of which were already occupied by gutta-percha covered wires in use for telegraphs and an extensive private wire system. In order to utilise these pipes it was necessary first to divert the working circuits from the gutta-percha covered wires into paper-covered cables. That this was no light task may be gathered from the fact that over 5600 miles of gutta-percha wire was re-covered in Central London alone. Some 5000 circuits had to be kept working while the transfer was in progress, and as it was necessary that the work should be carried out in short sections, the number of changes on each circuit per mile did not average less than ten, making some 50,000 changes in all. When it is remembered that the circuits changed over included not only all provincial as well as continental circuits, but the Metropolitan Fire and Police services, the care required in carrying out the work can be realised. Further, the situation was rendered the more difficult from the fact that on certain routes no second pipe was available, and various methods had to be adopted to clear the pipes of gutta-percha covered wires, as interruption cable could not be used in City streets.

The diversion work was one of the largest ever undertaken by the Engineering Department. In the Central District alone about 150 men were continuously engaged on it for over two years.

STATISTICS.—As giving some idea of the extent of the Post Office Telephone operations a few statistics of the outside plant in Central London alone, may be given :

Mileage of earthenware ducts and pipes	718
,, ,, main cable	384
,, ,, ,, ,, wires	151,079
,, ,, distribution cable	1,689
,, ,, ,, ,, wires	23,649
Number of manholes	619
,, ,, footway boxes	23,635

In this article no attempt has been made to do more than furnish the briefest possible outline of the work carried out by the Post Office in its share of the telephoning of London. To have embarked on details would have entailed the expansion of the article far beyond the limits of space allotted, and the writer must refer interested readers to his articles on the subject in the 'Electrical Magazine' for August, September, and October, 1904.

PROGRESS OF CONSTRUCTION WORKS.

DURING the month of March approximately 2100 poles and 1500 miles of wire were erected by the Department. In April approximately 1800 poles and 1800 miles of wire were erected. H-poles are counted as 2. The figures are exclusive of ordinary renewals and strengthening works, and also minor works. About 90 per cent. of the work was for trunk telephone purposes.

UNDERGROUND LINES.—Forty miles of pipe was laid in the month of March in connection with the extension of the main underground telegraph system. Twenty-two miles of cable were drawn in. About 17½ miles of pipe were laid, and 20 miles of cable drawn in during April. The figures include work done on the new underground routes between Manchester and Warrington, Birmingham and Bromsgrove, Durham and Stockton, Bristol and Falfield, and Exeter and Tavistock.

RICHMOND TELEPHONE EXCHANGE NEW C.B. EQUIPMENT.

By J. W. TURNER, A.I.E.E.

IT is expected that the new C.B. equipment which is to replace that of the C.B.S. type in use at present will be ready for service in July. A brief summary of the principal features may therefore prove interesting.

The exchange building is situated at 21 & 22, The Green, and was originally two residences. The capacity of the new equipment

SECOND FLOOR

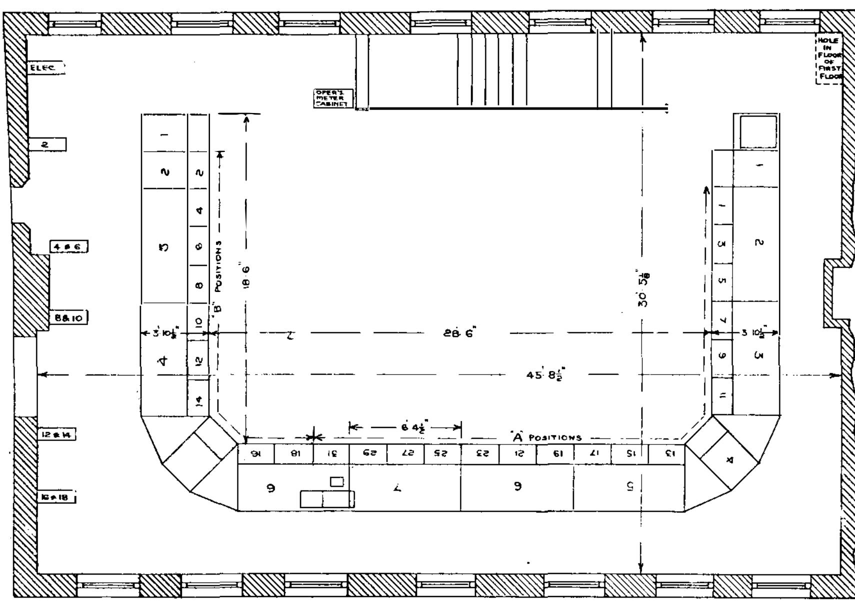


FIG. I

will be for, approximately, 2500 subscribers' circuits, and to cater for this equipment it has been necessary to remove the two stairways and build a central stairway to serve both houses jointly. The third (attic) floors of the two residences and the party wall between the rooms on the second floors have been removed, and in the large and lofty apartment thus formed the switchroom equipment will be placed.

Fig. 1 shows the proposed lay-out of the sections, and it will be observed that provision is made for 16 "A" and 9 "B" positions. Apparatus racks are to be provided for the "B" positions only.

Through the hole in the floor immediately below the rear of the last "A" position will be brought the repeating coil cables, and the multiple and other cables will arrive at the switchboard *via* the hole beneath the cable-turning section adjacent to the first section.

GROUND FLOOR

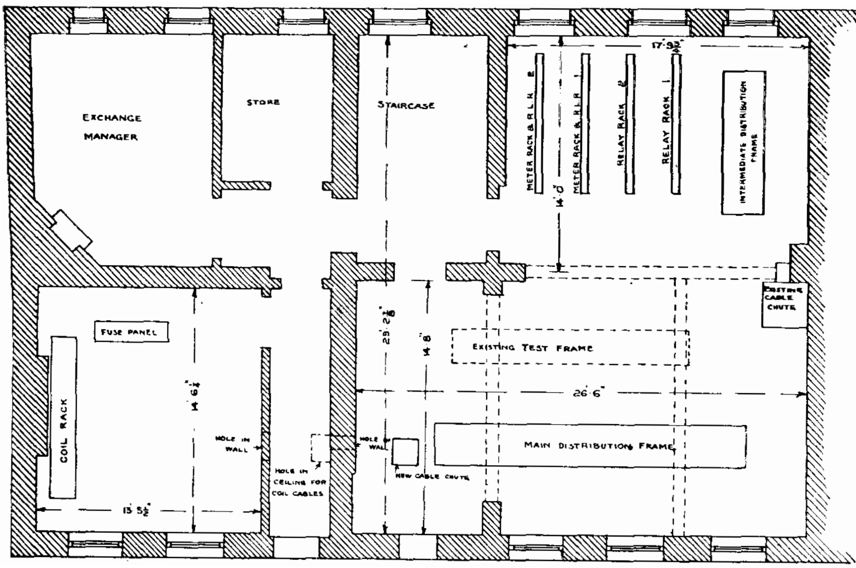
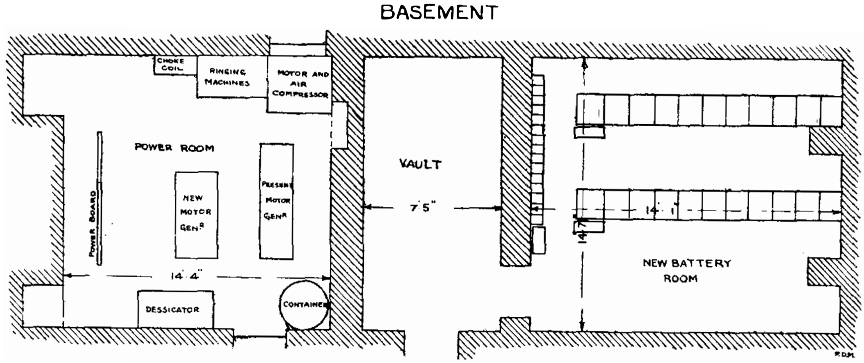


FIG. 2.

BASEMENT



3.—RICHMOND TELEPHONE EXCHANGE.

The suite of rooms upon the first floor is set apart for offices and operators' quarters, whilst the ground-floor, with the exception of the Exchange Manager's room, will be devoted to frames, racks and other test-room equipment. The apportionment of the ground-floor is given in Fig. 2. The existing C.B.S. test frame will be taken down when the C.B. equipment is brought into use. Two racks are to be provided for meters and resistance lamps. The meters, all of which will be within the range of convenient reading from the floor, will be mounted upon the lower portion of each rack, and the resistance lamps (300 to each bay) will be accommodated above.

The power and battery rooms are shown in Fig. 3. As far as possible the existing power plant will be utilised for the new equip-

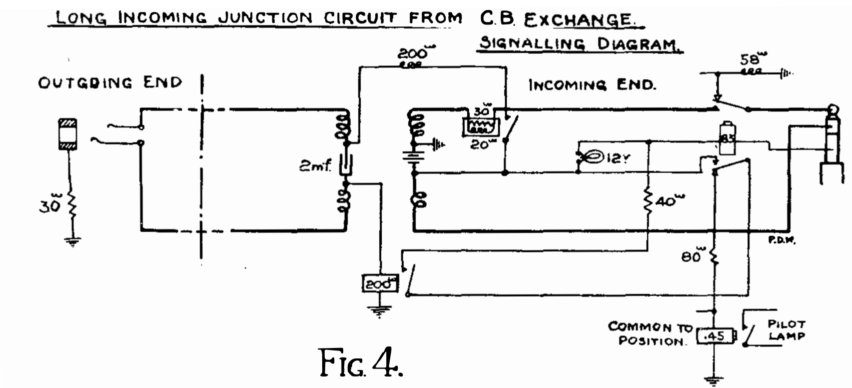


FIG. 4.

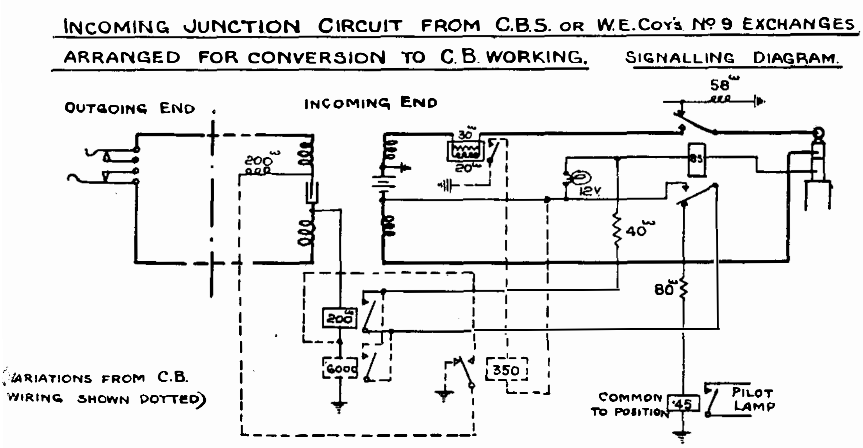


FIG. 5.

ment. It will be necessary, however, to instal new batteries, an additional motor-generator set and two ringing dynamotors, also to replace one of the panels of the power board by another of larger dimensions for the accommodation of interruptor and ringing switches, etc. The main batteries will consist of cells having an equipment of plates for an output of 480 ampère-hours at the nine-hour discharge rate. The boxes, however, will be large enough to take plates for an output of 720 ampère-hours at the same discharge rate. A meter battery consisting of fifteen cells of 60 ampère-hour capacity will be provided.

A cursory examination of Figs. 4 to 8 will reveal the fact that the signalling circuits on the junctions are to receive considerable modification. A new circuit for *long* incoming junctions from C.B.

INCOMING JUNCTION CIRCUIT FROM MAGNETO EXCHANGE ARRANGED FOR CONVERSION TO C.B WORKING. SIGNALLING DIAGRAM.

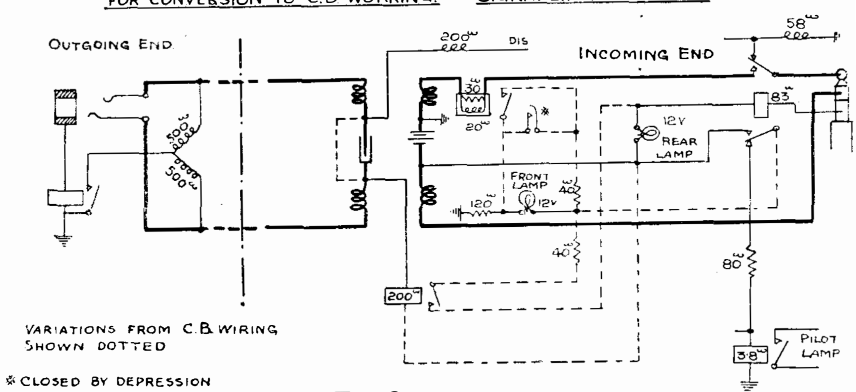


FIG 6

INCOMING JUNCTION CIRCUIT FROM TRUNK EXCHANGE SIGNALLING DIAGRAM

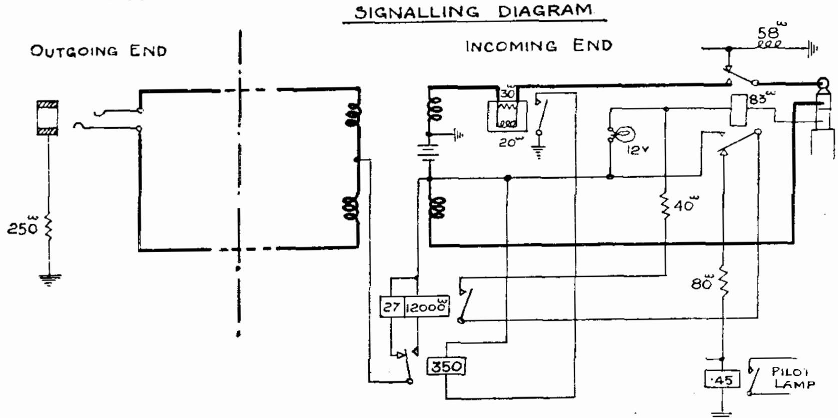
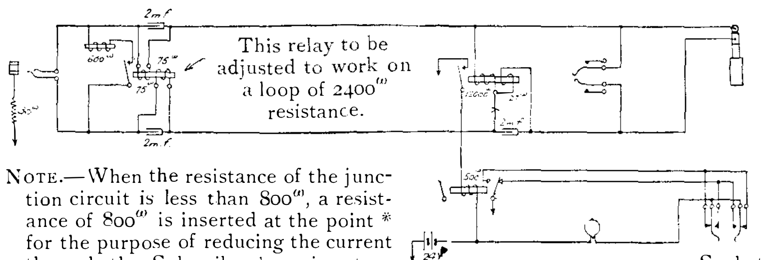


FIG. 7

exchanges is shown in Fig. 4. In Fig. 5 a junction circuit incoming from either C.B.S. or W. E. Coy's type 9 exchanges are given. This and the incoming junction circuit from a magneto-exchange (Fig. 6) are arranged for ready conversion to C.B. working. In both diagrams the variations from C.B. wiring are shown by means of dotted lines.

A new feature is in evidence in the operation of the incoming junction from the trunk exchange (Fig. 7). It is arranged that if the trunk operator withdraws the junction peg from the jack at the trunk exchange before the called subscriber has replaced his receiver, the incoming junction or "B" operator receives a clearing signal. The 27^{ω} coil of the $12000^{\omega} + 27^{\omega}$ relay hitherto used by the Department upon incoming junctions from C.B. exchanges is not sufficiently sensitive for operation upon this circuit, and the Western Electric Coy.'s type, 2002A relay, having windings of the same resistance values but more sensitive in operation will, therefore, be employed.

Skeleton diagram of Junction circuit outgoing to Magneto Exchange, arranged for automatic signalling, and with long distance equipment at the outgoing end. Condensers in Subscribers' bell circuits.



NOTE.—When the resistance of the junction circuit is less than 800^{ω}, a resistance of 800^{ω} is inserted at the point * for the purpose of reducing the current through the Subscribers' receiver to a minimum, except in the case of exchanges where the Subscribers' receivers have been connected suitably as regards polarity.

FIG. 8.

MONITORS CIRCUIT. SUBSCRIBERS BOARD

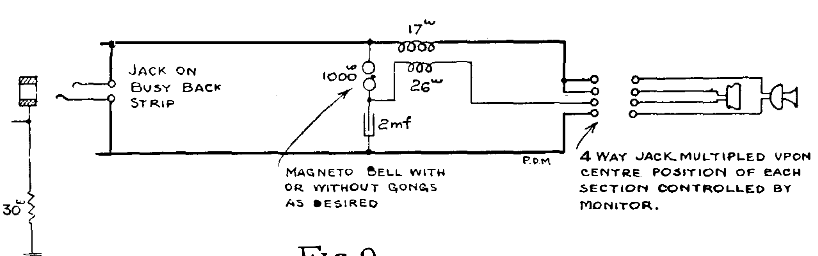


FIG. 9.

Fig. 8 shows an *automatic* outgoing junction circuit to a magneto exchange. This circuit provides for double supervisory signals at the "A" operator's position in the C.B. exchange. It will be observed that a condenser is necessary in the bell circuit of all subscribers' instruments connected to the magneto exchange.

The circuits shown in Figs. 7 and 8 were first introduced by the National Telephone Company.

Monitors' desks will not be provided. Facilities for the monitors making and receiving calls will be provided on the sections. The circuit for the "A" operators' monitor is given in Fig. 9. Calls originated by the monitor will be dealt with either by the monitor herself or by an operator at her verbal request, so that the provision of calling facilities is not necessary. The monitor controlling the junction positions will be provided with a circuit similar to that shown in Fig. 9, except that instead of the lines terminating upon a jack in the "Busy Back" strip, they will be extended to the I.D.F. for connection to a subscriber's line circuit.

The testing circuit for the Engineer's Desk is to be slightly modified by the introduction of (1) a combined key for speaking tests, (2) a voltmeter reversing key to enable "foreign" negative voltages between either A or B lines and earth to be detected, and (3) a key for the application of the "Howler" circuit.

In connection with the pending change from C.B.S. to C.B. working at the Richmond and Kingston exchanges, it will be necessary to make several temporary alterations to the C.B. exchange equipments and to some of the subscribers' C.B.S. installations; but owing to space limitations an account of these and of the arrangements for the transfer of subscribers' lines to the new C.B. exchanges must be reserved for a subsequent issue.

EXCHANGE WORKS IN PROGRESS.

TRUNK EXCHANGES.

THE following new, or additional, trunk exchange equipments are in progress:

	Trunk operators' positions.	Number of trunk circuits.
London Trunk Exchange	46	230
Manchester Trunk Exchange	46	230
Liverpool Trunk Exchange	84	420
Sunderland Trunk Exchange	4	20

The whole of the above work is being carried out by the British Insulated and Helsby Cables.

LOCAL EXCHANGES.

The following new exchanges are now in course of erection:

	Capacity, subscribers' lines.
Glasgow	10,000
Kingston	2,700
Finchley	1,000
Barnet	300

The undermentioned exchanges are being extended to their ultimate capacity:

	Ultimate capacity, subscribers' lines.
Hampstead	7,200
Victoria	5,400
Western	5,400

The Glasgow installation is being erected by the General Electric Company, Ltd.; the other six are being carried out by the Western Electric Company.

ARMY FINANCE.

By CHARLES HARRIS.

Abstract of Lecture delivered at the Staff College, November 23rd, 1907.
(Published by special permission of H.M. Stationery Office.)

BY "Army Finance" is meant, simply, the system of control of army expenditure. In order to guard against misappropriation, a searching and independent audit of expenditure is carried out by the Comptroller and Auditor-General and his department, independent of all the King's Ministers—even the Lords of the Treasury—and responsible to the House of Commons alone. To this officer the War Office has to render annually accounts showing how much was actually spent under each vote and sub-head of a vote; and his examiners are located in the War Office itself, as well as in the military commands, and have power to call for all books and papers connected with the expenditure included in the accounts. The primary object of the accounts is to show that the money spent has in fact been appropriated to the purposes for which the several votes were granted, and for this reason they are called Appropriation Accounts; but they also show a comparison between the money voted under each item of the estimates and that actually spent, and contain explanations of all the differences.

Parliament does not accept a small variation, either more or less, between the estimate and the actual result, provided there is a reasonable explanation, but insists that there shall be no excess on any one vote. If the total expenditure cannot be kept within the total of Army Votes, then the Secretary of State must submit to the House a Supplementary Estimate, before the close of the financial year, to make up the difference. If the excess expenditure on some votes is balanced by savings on others, then the War Office must write to the Treasury, satisfy them that the excess was unavoidable, and beg them to give temporary sanction to defray the excesses out of the savings on other votes; and later, when the accounts have been closed and the exact amounts of the excesses are known, the figures are formally reported to the House of Commons, and a clause inserted in an Act of Parliament (called the Appropriation Act) solemnly sanctioning the appropriation of the money so spent. If the War Office thinks it has enough money to last for the year, and therefore takes no supplementaty estimate, and then after all spends more than the total of Army Votes, the Secretary of State must submit to the House what is called an Excess Vote.

Decentralisation in matters of finance is an attractive doctrine; but however decentralised the actual spending of the money may be, the money spent ultimately centralises itself in the columns of the War Office ledger, and unless there is a good deal of central control it is not to be expected that the figures in that ledger will agree with those in the Parliamentary Estimates.

An important result of the system of Appropriation Accounts is that the arrangement or structure of the Estimates must be such that the expenditure can be shown in the accounts in direct comparison with the heads under which the money is voted. You can arrange or classify expenditure in two ways—according to its *nature* or according to its *purpose*. Thus you buy coal to run an electric lighting plant for a hospital, or you buy coal to run machinery in an ordnance workshop. In either case the nature of the expenditure is the same—a purchase of steam coal; but the purpose in one case is the care of the sick and in the other the repair, say, of artillery equipments. Similarly, you buy hay which may be eaten by a troop horse or by a horse hauling building materials. So far as estimates go, there is no more difficulty about arranging your expenditure according to purpose than according to nature: you can either group all the expenses of cavalry, infantry, hospitals and so on, under those heads, or you can group all pay together, all forage, all building work, all fuel and so on. The former method would make the estimates far more significant and intelligible, and I have been very much struck by the extent to which the German Army Estimates followed this plan; but in Germany they do not have to publish Appropriation Accounts, and the necessity of doing this compels us to adopt the second plan. For when you pay your bill for coal or for hay, you can write down the one as fuel and the other as forage at once; but you probably do not know what engine will be run with the coal or what horse will eat the hay. Our estimates, therefore, are arranged according to the *nature* of expenditure and without reference to its *purpose;* so that our accounts, which follow the arrangement of the Estimates, do not show the cost of any service, department, or branch of the army, or any other result of which the mind can lay hold as throwing light upon the economic merits of army administration.

Of course it would be within the reach of the science of accounting to keep books showing what each unit of cavalry, infantry and the rest cost in the year; what was the cost of a horse-transport or a mechanical-transport company of Army Service Corps, and how many tons each carried in the year; what was the cost of an ordnance depôt, and how much stuff passed through it in the year; and other results of that kind. These would approximate to commercial accounts; but only in one army department are anything that a business man would call accounts kept, and the difference between such accounts and Parliamentary Appropriation Accounts is well shown there—that is, in the Factories at Woolwich and elsewhere. The Appropriation Account for the Factories merely tells you that a million *odd* was spent on wages and a million *odd* on materials, without the faintest indication of what was got for the money. The manufacturing or business accounts tell you in detail all the stores produced, with the cost price of each; so that you can see that your new field gun cost so much and its carriage so much, and can judge on the one hand whether your contractors are charging you a fair price for the same thing, and on the other whether your gun factory is being economically run.

If you take a big business concern, such as a railway, you will find that the responsibility of the head of a department is brought home to him by means of accounts of this type—accounts which work to the cost of some economic unit, such as the train-mile, the passenger-mile, and so on. That man's promotion and future depend upon the results the accounts show, and if his costs are going up he has to answer for it to his directors, and they in turn to their shareholders. The directors, on the other hand, knowing that in the accounts they have the means of gauging his management and bringing him to book, can give him a free hand in his department; and these two factors, the free hand and the liability to be called upon to answer for the results obtained, together constitute real responsibility. But army accounts afford no indication whether administration is economical or not, and consequently the liability to be called to account, slips into the background, and the phrase "financial responsibility" is often used to denote simply the power to spend the public money unquestioned.

The bedrock principle of our national system of finance is that unless a special Act of Parliament to the contrary is passed, as is done when loans are raised, the expenditure of the year must be defrayed out of the taxation of the year; and any proceeds of taxation not actually spent in the year revert to the Exchequer and are applied to the reduction of the National Debt. Every shilling of the votes of this year that has not been actually spent by the 31st March next will have to be surrendered by the War Office to the Exchequer. In this way every year starts on the 1st of April with a clean slate, and there is no carrying over of unspent balances from one year to the next. Unfortunately, we cannot wipe the slate of liabilities in the same way, and it often happens when there are heavy contracts running for guns, building work, and so on, that the rate of progress turns out to have been overestimated and money is surrendered unspent at the end of one year which has to be paid in the following year, when it has not been taken in the Estimates and has to be "sweated" somehow out of the new year's programme.

Treasury control is exercised over expenditure in bulk and in certain respects over details. It is obvious that there must be a department to bring together the estimates of all the spending departments and review them as a whole before the Government can settle its financial policy for the year. All annual estimates have therefore to be submitted to the Treasury, and of course sufficient cause must be shown for important increases. But it is not enough to watch and control the immediate growth of expenditure: a most insidious form is that which adds little or nothing to the present votes, but pledges those of future years. For instance, when service pay was introduced there was no charge at all for the first two years, but men were being enlisted with rights to the extra pay all the time, and after two years the charge grew rapidly to over a million. The Treasury therefore requires all changes in numbers and rates of pay or pension to be submitted specially to it for approval; but expenditure on stores, which is generally non-recurrent as well as technical, is less closely controlled. Generally speaking, the Treasury works by regulation, and though these regulations are not orders of Parliament, the House of Commons takes cognisance of them, and insists on their being obeyed. For this purpose the House requires the appointment of an Accounting Officer, who is responsible to Parliament that all the expenditure of the army is conducted according to these regulations, and has to certify the annual account to the effect that all expenditure requiring authority higher than that of the War Office has been so authorised. To enable the Accounting Officer to carry out these duties, all payments are either made or audited by officers directly responsible to him, and if any payment is in his judgment contrary to regulation it is his duty to refuse to allow it; that is, if the money has not been paid to refuse to pay it, or, if it has been paid, to refuse to include it in the account and charge it back to the person who paid it. In thus refusing, he can only be overruled by the written order of the Secretary of State himself, who then becomes directly responsible to Parliament for the expenditure in question. The Accounting Officer in the War Office is the Director-General of Army Finance; but this rigid control over the public money is not peculiar to army affairs: in every department of the State there is an Accounting Officer with similar functions. I said a little time ago that true responsibility consisted of two elements: power to act, and liability to be called to account. The arrangements I have just described give the Accounting Officer the necessary power to secure the regularity of expenditure; the other element is supplied by the fact that every year, when the Comptroller and Auditor-General has audited the accounts and reported on them to Parliament, the Accounting Officer is called before a Committee of the House of Commons, the Committee of Public Accounts, there to answer for the whole expenditure of the army, and to make his defence for all that the auditor may have found to criticise.

At the head of the Finance Department is the Financial Secretary to the War Office, or Finance Member of Council, a Member of Parliament, with the Director-General of Army Finance, who holds the post of Accounting Officer, as his immediate assistant. Under the Director-General come three Directors—of Financial Services, Army Accounts, and Contracts. The duties of the Director of Contracts, a post which has only just been revived after being in abeyance for some years, stand rather by themselves. The actual making of contracts, though in some former organisations it was under the Financial Secretary, was not under the Accountant-General (the officer whose work corresponded generally with that of the Director-General of Army Finance).

The two directorates are divided into a number of branches corresponding to certain classes of work: a branch for making issues of cash and keeping the main ledger from which the Parliamentary Appropriation Account is prepared; a branch for examining such cash accounts as are not examined locally; a branch for administering the personnel of the Accounts Department; a branch for questions of pay; one for pensions; four branches dealing with the expenditure and accounts of the spending departments, viz., Supplies and Transport, Clothing and Stores, Ordnance, and Works; and lastly, a branch for dealing with the establishment of the army and with estimates and expenditure as a whole. The head of each of these branches occupies a dual position. As an officer of the Director-General of Finance he is responsible to him, in his capacity of Accounting Officer, for the regularity of all expenditure, and also for seeing that he is kept informed as to any questions having an important financial bearing, in order that he may advise the Finance Member on them. But he is also financial adviser to the Member of Council administering the Army Votes for the expenditure with which he deals. In this capacity he gives the Member of Council, and the Directors and other officers concerned, all information about the financial bearings of any question that may come up, so that (as I said before) financial considerations may be borne in mind in the earliest stages of formation of opinion. He also assists the Directors and Member of Council in framing the annual estimates for the votes concerned and controlling the progress of expenditure under them, as may be necessary.

In the Commands also, the local head of the Finance Member's department, the Chief Accountant, as he is called, has a dual capacity. As financial adviser to the General Officer Commanding he is attached to the staff, and stands to the general in the same relation as the head of a financial branch in the War Office does to a Member of Council. On the other hand, as the local representative of the Accounting Officer he is directly responsible to him for cash duties, for the keeping of regimental accounts (now that the company commander has been relieved of that duty), and for the audit of accounts of all kinds; and in this capacity he is necessarily in direct communication with the Accounting Officer at the War Office, just as the Accounting Officer is a sense independent of the Army Council and in direct communication with the Public Accounts Committee of the House of Commons. That is, if a Chief Accountant should be ordered by a General Officer Commanding to make a payment which he believes to be contrary to regulation, he must state his objection in writing, and the General Officer cannot overrule the objection without reference to the War Office, the Chief Accountant then making his own report direct to the Accounting Officer. In the German army a similar relation holds good between a Corps Commander and the Chief Intendant of his command.

The expenditure of money—the purchase and manufacture of stores—cannot be conducted by regulation alone, and a control has to be applied. It is work of singular difficulty. Patterns are constantly changing; quantities change with the size and composition of the forces to be equipped, with changes in defence schemes, and so on; consumption is irregular; and, above all, when you have settled your programme for the year and got your estimates accepted, you are in the hands of the inventors and pattern experts on the one hand, and of the contractors who make the stores on the other. Long experience alone can enable you to discount the promises of these gentlemen sufficiently to spend your money, but not more than your money, by the end of the year; and this experience is supplied by the finance branches attached to the departments of the Quarter-Master-General and the Master-General of the Ordnance. These branches keep touch with all the orders given for stores, the deliveries and payments, so that they can advise the Directors and their assistants continually as to the progress of their expenditure, and can share with them the business administration of their votes, as distinct from the technical side of their duties.

THE RADIO-TELEGRAPH CONVENTION—AND AFTER.

THE current quarterly number of the 'Edinburgh Review' (April, 1908) contains an interesting dissertation dignified by the title of "The Politics of Radio-telegraphy," which deals with the legislative aspect of wireless telegraphy. The position of the art in relation to the Wireless Telegraphy Bill, which allocated discretionary powers to the Postmaster-General in the matter of erection and scope of radio-telegraph installations in the United Kingdom, and to the wider and all-embracing Radio-telegraph Convention of international import, is discussed in a free and easy manner.

The adoption at an early date by this country of the tenets of the Convention, ushers in a new era for radio-telegraphy. It places the art under complete government control, with a view to obtaining greater utility therefrom in regard to its application for communication with, and between, ships at sea. For this purpose wireless telegraphy is now invaluable, and the convention should, therefore, on the face of it, fulfil a useful and admirable function, if its regulations are reasonably and judiciously applied. The duty of applying the Convention scheme is largely vested in the Postal Telegraph Administration in this country. Necessarily the Navy is vitally concerned, and the Admiralty will therefore hold at least a watching brief in the matter.

In the article mentioned, the contributor refers to the determined effort made by the Marconi Company to nullify the Convention, or, at least, to modify its terms very materially indeed before acceptance by this country, an action which resulted in the appointment of a Select Committee of the House of Commons to inquire into and report on the pros and cons of the question, prior to any further steps being taken by the Government. Subject to the finding of this committee depended the ratification or rejection of the agreement arrived at by the British representatives at the Berlin Conferences. The evidence of various witnesses, expert or otherwise, taken by the Committee is commented upon, and the contributor expresses his surprise that a more decisive majority in favour of ratification was not obtained. The greater part of the article may be characterised as a tirade against the Marconi Company and all its ways, and though one may feel disposed to agree in the main with the conclusions of its author, many of the statements made convey the impression that there is at root a tinge of venom. Moderation in debate might well be counselled in respect of such arguments; for instance,as those adduced to belittle the credit of Marconi and extol that of his forerunners in the region of purely physical research on electric radiation. It is no doubt true that, were it not for the genius of Hertz stimulated by the mathematical insight of Clark Maxwell, Marconi would not have been able to carry his invention into practice, but it may also be equally true that had the petrol motor or the screw propeller never been invented, nor the laws of air resistance investigated, the hope of a complete solution of the problem of aërial flight would be small indeed. The satisfactory solution, however, is not yet achieved, and surely it is still open to the man of inventive genius and perseverance who shall satisfactorily solve the problem to obtain great and lasting credit thereby, even though it consisted (and this is highly probable) only in the proper practical application of known principles. It is no doubt true that the apportionment of credit is seldom made in accordance with the intrinsic worth of the work done, but that is a lottery in which the losers have no course but to take their ill-luck with a good grace, which becomes them better than vain revilings. Belittle it as one may, it cannot be gainsaid that Marconi has a rightful due as the pioneer of *practical* radio-telegraphy. His forerunners made no real attempt towards practical applications. Those who have closely followed and emulated the development of the system from its first crude form must fain admire the plodding persistency by which success was ultimately achieved. The conditions necessary to enable the oscillation-transformer to be usefully constructed and made to increase the range and reliability of the receiver before the properties of resonant circuits had been systematically investigated or fully appreciated in this connection, either by himself or others, is a feat in which the practical insight and perseverance possessed by Marconi stood him in good stead, for there can be little doubt that innumerable trials and innumerable failures preceded success in this direction alone.

Turning now to matters of more practical moment, as represented by the application and operation of the convention itself; the radio-telegraph engineer will recognise that, contrary to what might be expected, it is not easy to bring the aims of the convention satisfactorily into operation. The subject has a complexity peculiarly its own, especially on the technical side—a complexity which has perhaps been imperfectly appreciated even by those who framed the terms of the Convention articles. To take one aspect of the case; a fundamental object is to provide such a scheme of operation and organisation as shall enable the greatest utility to be obtained in the field of radio-telegraphy. To this end it is imperative that undue interference between stations be guarded against. In this relation the convention and its appended service regulations make provision under three heads, as follows:—

(*a*) Limitation of the electrical power taken by the radio-telegraphic plant.

(*b*) Limitation of range of wave-lengths to be used for specified kinds of communications and a specific wave-length for a certain specific purpose.

(*c*) Use of "syntonised" or "tuned" systems only.

With regard to the first provision it is to be noted that though the power used is a factor in determining the amount of disturbance produced in the ether by the operation of emitting electric waves, it is by no means the only, nor perhaps the most important, factor. The same limit of power is to be observed for all types of transmitting appliances, and in this respect alone there is scope for the production of almost unlimited disturbance. The antenna may be high or low, an effective and powerful or a poor and feeble radiator even with the limits of wave-lengths and syntonisation prescribed. It is conceivable that an effective type of transmitter could be used which would efficiently convert the low-tension electrical energy from the source directly into effective high-frequency oscillations, thus avoiding the usual transformation and other losses which account for the absorption of by far the greater part of the energy used. For instance, an electrostatic machine of efficient design driven directly by a one-kilowatt motor would furnish a means of producing prodigious disturbance, though it might not lend itself well to signalling purposes. But more important still is the fact that the disturbance produced is an inverse function of the rate of sparking, and that a system absorbing one kilowatt of electrical energy may, by a scheme of slow laborious discharges, release Jove's very thunderbolts at each spark. Such a system, if utilised for, say, the transmission of messages over long distances, would constitute a grave menace to all other stations within its range using approximately its wave-length, not only in virtue of the heavy disturbance produced, but by reason of the prolonged period which would be occupied in spelling out its tedious messages. There is also the question of how this limitation of power is to be observed in such cases as the supply of energy direct from the mains of an existing electric installation for lighting and power purposes, or even the simple case of power taken direct from accumulators. In both instances there are practical difficulties in the way of ensuring that power very considerably in excess of the stipulated amount is not drawn, very probably in ignorance on the part of the operator or other responsible official, of the meaning of the expression "electrical power." The idea of fuses and cut-outs will no doubt occur to the practical engineer in this connection, but these devices as often as not quickly fall into disuse in the absence of a systematic overhaul and inspection, perhaps for no other reason than that they are a source of some occasional trouble, or because it is not apparent that they are essential to the good working of the station. A number of other factors also enter into the question of power limitation which would occupy too much space to discuss fully, but it will readily be seen that simple legislation for a stipulated limit of power is not by any means all that is required to check undue interference. The second provision mentioned above, viz. wave-length limitations, is more effective so far as the avoidance of interference between stations having different ranges of wave-lengths is concerned. The wave-lengths used for naval purposes may, for instance, be entirely outside the scale of wave-lengths allotted to commercial stations and the mercantile marine, thus in general ensuring a strictly limited interference area as between the two distinct systems. It will be observed, however, that this provision does not touch the question of interference between stations having the same scale of wave-lengths allotted to them. Fine discrimination in the allocation of wave-lengths is, moreover, at present a matter of impossibility, in the absence of a definite standard of wave-length measurement. No doubt this weakness will shortly be rectified. The third provision is open to the objection that it is extremely difficult to specify what is and what is not a "syntonised" system. "Syntony" and its co-related "resonance" are the very life and soul of all radio-telegraphy. Without invoking the aid of resonance effects and syntony it is not too much to say that high-frequency oscillations would not be amenable to the purposes of radio-telegraphy. Hence every system of radio-telegraphy extant is a syntonic system, and capable of being "syntonised." It is only a question of the degree to which this property is possessed that can differentiate a so-called "untuned" from a "tuned" system, and in this fact lies an obstacle to the introduction of an entirely satisfactory definition of the term. Without some kind of definition the provision is of course quite futile. Again, the syntonisation of radio stations to one another is mutual, that is, it is a joint function of the transmitter at the one station and the receiver at the other, and the degree of syntony is therefore determinable equally by the transmitter or the receiver. Strictly speaking, therefore, there should be a definition of a syntonised transmitter and a syntonised receiver. In this lies a possibility which appears to commend itself for adoption in lieu of a simpler and less involved definition, viz. that a transmitter be regarded as syntonised when the closed oscillatory circuit is coupled to the aërial system to just such an extent that under the best working conditions maximum range of communication is obtained, and that a receiver be likewise so regarded when its closed oscillatory circuit is coupled to the aërial system only to the extent necessary to ensure maximum range of communication. To make this clear it should be explained that the degree of coupling determines the freedom, or rather want of freedom, of the oscillatory circuit, and therefore the want of persistency of the waves generated in each train of an impulse, that is, the less the coupling between the oscillatory circuit and the aërial system the greater the persistency of the train of waves, and the sharper the tuning obtainable. The amplitude of undulation of the waves also suffers, however, so that a point is quickly reached when any weakening or lessening of the coupling reduces rather than increases the range of communication. It is true that in some transmitting systems there is no separate oscillatory circuit, the aërial system itself being made to fulfil the purpose. These would require to be specially dealt with from the point of view that they would be restricted to operate with only such power as would determine an interference no greater than that from a transmitter with coupled oscillatory circuit, properly adjusted as defined above.

So far interference between stations has been dealt with in this article mainly as a question of amount of disturbance imparted to the ether. But to make a complex question yet more complicated it has unfortunately to be recognised that the disturbance in the ether is only one factor in the interference problem. Disturbance may be defined as the maximum amplitude of wave-undulation generated. Interference between stations depends also on:

(*a*) Characteristics of wave-transmission.
(*b*) Characteristics of receiver.
(*c*) Location and proximity of stations.

With regard to (*a*) the length of wave has some bearing on the matter as long waves have a greater range than short ones, and some types of wave detectors are more responsive to long waves than short, and *vice-versâ*. Thus, the magnetic and electrolytic detectors are more responsive to long waves than the carbon-steel and other detectors of the coherer type. The damping co-efficient has also to be taken into account in that it affects the "percentage freedom" due to difference of tune. Next, and by no means least, is the intermittency factor, that is, the rate of succession of wave-trains emitted. With the auditive receivers now in general use the note due to the particular intermittency of the transmitter is quite distinctive, so that it is possible to read the signals from a particular station irrespective of other and possibly stronger signals audible from another station using the same wave-length, interference being in this way very greatly minimised. This feature becomes especially pronounced where rapid rates of sparking, which produce distinctive notes in the receiver, are concerned. In all such cases, however, thoroughly practised and expert operators are necessary to enable accurate and safe transmission to be accomplished under these conditions of interference.

With regard to (*b*) there are still more factors concerned, such as sensitiveness of receiver, degree of susceptibility to tuning, maximum amplitude required to effect response under specified degrees of dissonance of tune, method of response (auditive or recording), etc. In the continuous wave-systems which are now being developed there are yet other aspects of interference to be dealt with. The Peddersen "tikker" receiver owes its sensitiveness quite as much to its property of making use of a very long series of waves and storing the energy by cumulation as to its degree of susceptibility to tuning.

Directive systems of wireless telegraphy are also in course of development, and one at least is of such a nature that in a specified direction no interference whatever results. In other directions the interference varies with the angle to the direction of *nil* radiation.

Transmitters using coupled oscillatory systems emit subsidiary waves differing in length from the main effective wave. Likewise coupled oscillatory circuits in the receiver exhibit a degree of responsiveness to certain waves differing in length from those effecting the main response. Transmitters in which the aërial system is pre-charged and is the only part in which oscillations take place and receivers used directly in the aërial system are free from this defect, but introduce others which may in certain circumstances prove even more troublesome. Pre-charging of the aërial introduces trouble due to electrostatic induction over a certain range, similar to the interference produced by atmospheric electrical disturbances against which tuning is not altogether effective, because the conductors affected will always oscillate at their own particular fundamental rate whenever the electrostatic induction is suddenly diminished or suddenly increased. For this reason although subsidiary waves are not inherent to transmitters using pre-charged aërials they are doubtless liable to set up subsidiary waves by causing other conductors in the proximity, or even in the station itself, to emit waves.

That the location of a station with regard to the nature of its surroundings, hills, foliage, etc., will have an important bearing on the interference in different directions will be obvious.

Enough has perhaps been said to indicate the nature of the problems which have to be faced and much more thoroughly investigated than has yet been done if anything like exactitude is to be aimed at in defining interference between stations. To interpret and apply the terms of the International Convention in a reasonable and just manner involves a close engineering knowledge of the art, and the matter will require delicate handling. The Convention itself does little more than touch the fringe of the subject, and it is on its intelligent and reasonable interpretation that its usefulness will largely depend.

ON THE PROPAGATION OF PLANE ELECTRO-MAGNETIC WAVES ALONG A PLANE CONDUCTING SURFACE, AND ITS RELATION TO WIRELESS TELEGRAPHY.

By J. ZENNECK.

(Translated by H. HARTNELL, A.M.I.E.E.)

A. PROPAGATION OF PLANE ELECTRO-MAGNETIC WAVES ALONG A PLANE CONDUCTING SURFACE.

THE following symbols will be used :

E = Intensity of electric field.
M = Intensity of magnetic field.
ε = Dielectric constant.
μ = Permeability.
σ = Conductivity.
$\nu = \pi \times$ frequency.
$\iota = \sqrt{-1}$.
$v = \frac{1}{4\pi}$ in C.G.S. system.

Quantities without suffix relate to the conductor, with suffix 0 to the air.

The author deals with the propagation of electro-magnetic waves along the surface of an infinite plane conductor, having considerable resistance.

This investigation is of great interest in the theory of wireless telegraphy. The cases of a perfect conductor and of a fairly conducting liquid mass, such as sea-water, have already been studied by E. Cohn and K. Uller.

I *Fundamental Equations.*

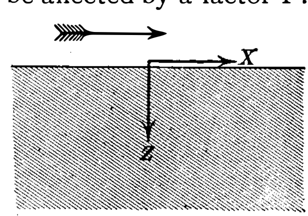
Taking the direction of X, as shown by the arrow (Fig. I) as the direction of propagation, and choosing the axes of co-ordinates as indicated, we may at once write :

(I) $\quad E_y = M_x = M_z = 0.$

The remaining components of the field will be affected by a factor F.

(I*a*) $\quad F = e^{\iota(\nu t + sx)}$

s being a constant to be determined.



I

Maxwell's equations are then :

$$(\sigma + \iota\nu\varepsilon)E_z = -v.\iota.sM_y,$$

$$(\sigma + \iota\nu\varepsilon)E_x = v.\frac{\partial M_y}{\partial z},$$

$$\iota\nu\mu M_y = v.\left(\frac{\partial E_x}{\partial z} - \iota s E_z\right)$$

For air, their solution is of the form:

$$(2)\quad \begin{cases} M_{0y} = a_0\, e^{-\iota r_0 z}.\,\mathrm{F}, \\[6pt] E_{0x} = -\,\iota r_0.\,\dfrac{v}{\sigma_0 + \iota\nu\varepsilon_0}.a_0 e^{-\iota r_0 z}\,\mathrm{F}, \\[10pt] E_{0z} = -\,\iota s.\,\dfrac{v}{\sigma_0 + \iota\nu\varepsilon_0}.a_0 e^{-\iota r_0 z}\,\mathrm{F}, \end{cases}$$

and for the conductor:

$$(3)\quad \begin{cases} M_y = a e^{+\iota r z}.\mathrm{F}, \\[6pt] E_x = \iota r.\,\dfrac{v}{\sigma + \iota\nu\varepsilon}.a e^{+\iota r z}.\mathrm{F}, \\[10pt] \mathrm{E}_z = -\,\iota s.\dfrac{v}{\sigma + \iota\nu\varepsilon}.a e^{+\iota r z}.\mathrm{F}. \end{cases}$$

Between the quantities r, r_0, s, we have the following relations:

$$(4)\qquad r_0^2 + s^2 = -\,\frac{\iota\nu\mu.(\sigma_0 + \iota\nu\varepsilon_0)}{v^2},$$

$$(5)\qquad r^2 + s^2 = -\,\frac{\iota\nu\mu.(\sigma + \iota\nu\varepsilon)}{v^2}.$$

The limiting conditions give also:

$$a = a_0,$$

$$(6)\qquad \frac{r_0}{\sigma_0 + \iota\nu\varepsilon_0} = -\,\frac{r}{\sigma + \iota\nu\varepsilon}.$$

From equations (4) (5) and (6) we have:

$$(7)\quad \begin{cases} s = -\sqrt{-\,\iota a.\,\dfrac{(1 + \iota q)\,(\beta + \iota q_0)}{(1 + \iota q) + (\beta + \iota q_0)}}, \\[12pt] r_0 = +\sqrt{-\,\iota a.\,\dfrac{(1 + \iota q)^2}{(1 + \iota q) + (\beta + \iota q_0)}}, \\[12pt] r = -\sqrt{-\,\iota a.\,\dfrac{(\beta + \iota q_0)^2}{(1 + \iota q) + (\beta + \iota q_0)}}, \end{cases}$$

Using for brevity:

$$a = \frac{\sigma\mu\nu}{v^2},\quad q_0 = \frac{\nu\varepsilon_0}{\sigma},$$

$$\beta = \frac{\sigma_0}{\sigma},\quad q = \frac{\nu\varepsilon}{\sigma},$$

2. *Calculation of the Various Constants.*

The frequency in what follows is taken as 10^6/sec ($\nu = \pi\, 10^6$/sec), corresponding to a wave length in air of about 600 mètres. We shall show later how the curves drawn on this assumption may be used for other frequencies.

The conductivity of the conductor will be assumed to be between $\sigma = 10^{-9}$ and $\sigma = 10^{-17}$ C.G.S. The conductivity of a 5 per cent. solution of NaCl is about $0{\cdot}6 \times 10^{10}$ C.G.S., whilst that of dry sand is about 10^{-17}.

The influence of the conductivity of the air is at first assumed to be *nil* ($\beta = 0$).

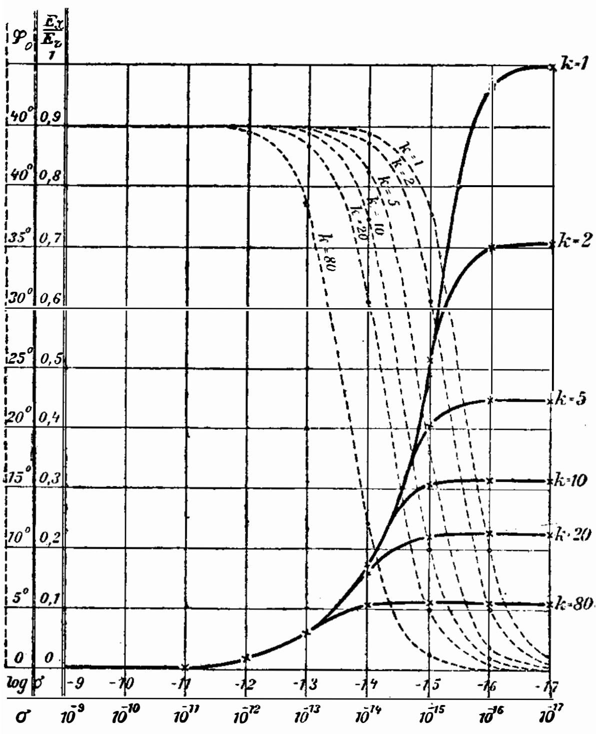
The dielectric constant of the conductor is assumed to vary between that of air and that of water. $k = \frac{\varepsilon}{\varepsilon_0} = \frac{q}{q_0}$ will consequently vary between 1 and 80.

3. *The Direction of the Electric Field.*

(1) Equations (2) and (7) give for air:

$$(8) \quad \begin{cases} \dfrac{E_{0x}}{E_{0z}} = \dfrac{r_0}{s} = -\sqrt{\dfrac{\iota q_0}{1 + \iota q}} = -\sqrt{\dfrac{q_0}{\sqrt{1+q^2}}}.e^{\iota \phi_0}, \\ \tan 2\,\phi_0 = \dfrac{1}{q}. \end{cases}$$

(2 ϕ in the first quadrant).



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The curves in Fig. **2** give the absolute values of the ratio.

$$\frac{|E_{0x}|}{|E_{0z}|} = \sqrt{\frac{q_0}{\sqrt{1+q^2}}}$$

(full curve) and of the angle of phase ϕ_0 (dotted curve).

(*b*) For the conductor we have from equations (3) and (7)

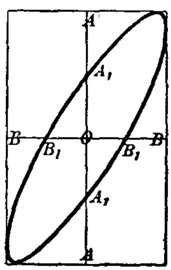
$$\frac{E_x}{E_z} = -\frac{r}{s} = -\sqrt{\frac{\iota(1+\iota q)}{q_0}} = -\sqrt{\frac{\sqrt{1+q^2}}{q_0}}.e^{-\iota\phi},$$

$$\tan 2\,\phi = -\frac{1}{q},$$

(2 ϕ in the 2nd quadrant),

i. e. $\phi = 90^0 - \phi_0,$

Since $\frac{|E_x|}{|E_z|} = \frac{1}{\left|\frac{E_{0x}}{E_{0z}}\right|},$



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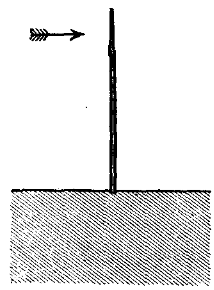

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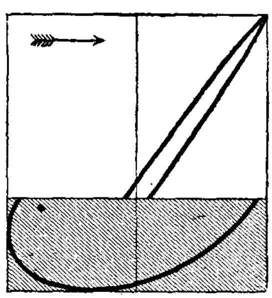

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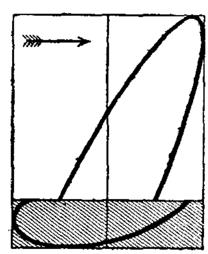

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we can from the curves of Fig. 2 also obtain the corresponding values for the conductor.

If we desire to use the curves for other frequencies, it may be observed that the quantities q and q_0 only contain the ratio $\frac{\nu}{\sigma}$, and that consequently an increase or decrease of the frequency acts as a decrease or increase of the conductivity. Looking at the curves in Fig. 2 we see that neither in the air nor in the conductor is there a pure alternating field. The resultant electric field may be represented by a vector whose extremities during a period move in an ellipse (Fig. 3), the ellipse being such that—

$$\frac{OB}{OA} = \frac{|E_x|}{|E_z|},$$

$$\frac{OA_1}{OA} = \frac{OB_1}{OB} = \sin\phi.$$

The most interesting cases in practice are the following:

1. $\dfrac{|E_x|}{|E_z|}$ small compared with 1 (Fig. 4).

The electric field, in the air and in the conductor, is, practically speaking, a pure alternating field. The lines of force are nearly perpendicular in the air and nearly parallel to the conducting surface in the conductor. From Fig. 2 it may be seen that this case is realised if the conductor possesses a conductivity which is not much less than 10^{-12} or 10^{-13} C.G.S. units. The dielectric constant of the conductor is in this case negligible.

2. $\dfrac{|E_x|}{|E_z|}$ not very small, the angle of phase ϕ_0 very small (Fig. 5).

In air the field is alternating, and its direction makes a considerable angle with the normal. On the other hand, in the conductor the field assumes a distinctly elliptic form. The curves in Fig. 2 show that this case occurs when the values of the dielectric constant are small; the lower the conductivity the more marked is this effect.

3. $\dfrac{|E_x|}{|E_z|}$ and the angle of phase ϕ_0 both considerable (Fig. 6).

The field in air is elliptical. The conditions in this case are that the dielectric constant be small and the conductivity σ about 10^{-15} C.G.S. for the frequency assumed above.

(*To be continued.*)

INSTITUTION NOTES.

PROCEEDINGS OF THE COUNCIL.

MEETINGS of the Council were held at Buxton on April 1st and 2nd, 1908, and in London on April 11th and 13th, 1908, under the chairmanship of Mr. J. W. Woods.

The following notes of general interest to members of the Institution have been extracted.

The proposal to establish a Heaquarters and Reading Room in London has been carefully considered by the Council, but it was decided to postpone further action, pending the settlement of certain outstanding questions affecting the finances of the Institution.

The Council have pleasure in stating that a section of "corresponding members" has been formed, to which officers of Colonial and Foreign Administrations will be admitted.

The necessary steps have been taken to secure an alteration to the rules of the Institution, and it is anticipated that our colleagues will welcome the opportunity to share in the privileges of membership.

Full details of the scheme may be obtained on application to the Secretary of the Institution (see p. xv).

The routine work connected with the Institution has grown to such an extent that it has been essential to provide the Secretary with some relief. The Council have arranged to appoint a Librarian, who will act as Secretary to the Library Committee, and whose duties will include the control and distribution to members of books, periodicals, and printed papers.

The question of revising the arrangements, as regards circulation of technical periodicals, is receiving the earnest attention of the Council, and a circular on the subject will be issued to members at an early date.

ANNUAL REPORT.

The following short extracts have been taken from the report of The Second Annual Meeting of the Institution which was held at the St. Bride Foundation Institute, Bride Lane, E.C., on Monday, April 13th, 1908.

The chair was taken by the President, Major W. A. J. O'Meara, R.E., C.M.G., in the presence of the Officers and Council and about 100 members.

In presenting their report on the second year's working of the Institution of Post Office Electrical Engineers, the Council congratulated the members upon the progress which had been made in consolidating the results of the initial session

MEMBERSHIP.

No. of members on roll during 1906–7	763
Deaths and retirements during 1906–7	8
No. of members on roll March 31st, 1907	755
Transfers to other Departments and names subsequently written off	7
Actual membership March 31st, 1907	748
Resignations taking effect April 1st, 1907	63
Actual membership April 1st, 1907	685
New members enrolled during 1907–8	83
	768
Deaths and retirements during 1907–8	13
Actual membership March 31st, 1908	755

As regards the distribution of the members, the following statement indicates the strength of each Centre on March 31st last year and on March 31st this year:—

CENTRE.	MARCH 31ST, 1907.	MARCH 31ST, 1908.
Metropolitan (including the Southern District of England)	360	351
Eastern	36	34
South Midland	42	43
North Midland	31	35
North Eastern	43	43
Northern	41	38
North Western	30	33
North Wales	45	53
South Wales	40	44
Scotland East	22	21
Scotland West	20	26
Ireland (North and South)	38	34
	748	755

The Council have deemed it desirable that there should exist some means whereby officers retiring from the Service may, at the discretion of the Council, be enabled to continue in touch with the Institution and its work. Sir John Gavey, C.B., and A. W. Heaviside, Esq., I.S.O., have accordingly been elected Honorary Members.

The Council have also had under consideration, at the suggestion of the President, the question of enabling officers of Colonial and Foreign Administrations, who are engaged in telegraph and telephone engineering work, to identify themselves in some way with the Institution; and, actuated by the desire to secure the widest interchange of ideas on all subjects of professional interest, they have arrived at the conclusion that both the members of the Institution and their *confrères* in other parts of the world would benefit by the provision of a suitable method of attaining the proposed object. They therefore recommend the establishment of two classes of "corresponding members," namely,

"Colonial corresponding members," at a subscription of half a guinea per annum, and—

"Foreign corresponding members," at a subscription of one guinea per annum.

The privileges of these members would consist in the receipt of a copy of each paper printed by the Institution, and of the 'POST OFFICE ELECTRICAL ENGINEERS' JOURNAL.'

INSTITUTION MEDALS.

The Council have great pleasure in notifying that they have awarded the Institution Medals for the year 1906-1907 as follows:—

Senior Silver Medal: Mr. J. E. Taylor, for his paper on "Electric Wave Propagation."

Senior Bronze Medal: Mr. J. G. Hill, for his paper on "Telephone Transmission."

Junior Silver Medal: Mr. A. O. Gibbon, for his paper on "The Construction of Underground Telegraphs in the Provinces."

Junior Bronze Medal: Mr. J. S. Brown, for his paper on "Telephone Trunk Signal ling Arrangements."

THE LIBRARY.

The Council have pleasure also in stating that, with the view to enhance the value of the Library, the Committee have concluded arrangements for the exchange of publications with the following scientific and learned societies, viz.:—

The Royal Institution.
The Physical Society of London.
The Institution of Mechanical Engineers.
The Institution of Electrical Engineers.
The American Institute of Electrical Engineers.
The Incorporated Association of Municipal and County Engineers.
The Institution of Junior Engineers.

The total number of books in the Lending Library is now 680, representing 474 separate works, the 206 extra copies of books in considerable demand being distributed among 92 separate works. The issues from the commencement now reach a total of 1400, the average period of loan being about twenty-five days. The demands have been distributed very evenly over the various sections, and only about 70 volumes have not yet been issued.

The experience gained during the earlier stages of the work of the Library Committee led them to the conclusion that the value of the Library to the members of the Institution would be greatly enhanced by the inclusion in the catalogue of a brief synopsis of the contents of each work, and accordingly it was decided to undertake the preparation of a new catalogue. This labour has been progressing gradually during the past winter, and it is hoped that before the opening of next session the new catalogue will be in the hands of the members.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

In the course of the year, His Majesty the King granted a Charter for the formation of the "Imperial College of Science and Technology," and the Council, in pursuance of the objects of the Institution, took steps with the view of submitting a petition asking that the Institution should be allowed to nominate one Member of the Governing Body. The proposal was placed before the Secretary to the Post Office, who, owing to the short period which had elapsed since the formation of the Institution, was unable to give his support. In these circumstances the matter was allowed to drop; but it is the hope of the Council that, at a later date, the subject may be revived, and that the Institution may be successful in its efforts to establish its connection with the progress of technical education.

LOCAL CENTRE NOTES.

EASTERN CENTRE.

THE second meeting of this Centre was held on March 30th, when two papers were read as follows:

"Notes on the Construction and Maintenance of a Small Power Pneumatic Installation." Mr. F. S. Parkinson.

"Engineering Economies." Mr. A. Evans.

Mr. Parkinson's papers detailed the result of recent experience obtained in connection with the laying of a pneumatic tube at Norwich, between the Head Post Office and the Market Place B.O. The paper was illustrated by a number of drawings and was full of explanations as to the methods adopted in overcoming difficulties which had arisen during the construction of the installation, methods which cannot be found in any text-books. One ingenious feature of the installation is the fitting of a starting switch which enables the motor and pump, situated in the basement, to be started from a remote point by means of an ordinary single-pole switch. An interesting discussion took place and much valuable detailed information was elicited.

The paper contributed by Mr. Evans was devoted to the processes of wire running. Mr. Evans has developed, it is believed, what is a new method of attempting to analyse the cost of the several ways of carrying out this work, and his analysis showed some striking differences due to the various methods which obtain. The discussion on this paper was unfortunately much curtailed owing to lack of time.

The concluding meeting of the Session was held on April 27th, when a very interesting paper was read by Mr. E. H. Shaughnessy on "Submarine Cable Laying and Repairing." The lecture, which was illustrated by some excellent lantern slides, described in detail the laying of a submarine cable between Galveston, Texas, and Coatzacoalcas, as well as the surveying of the Mexican Gulf from South of Vera Cruz, and also dealt with the picking up and repairing of a faulty cable about 100 miles from Galveston. The description of the method of deep-sea sounding and shallow water (up to 100 fathoms) sounding was particularly interesting.

During the discussion which followed, Mr. Jenkin mentioned that he had seen the process of laying shore ends on the east coast very many years ago, and stated that the methods now adopted presented no marked departure from those which were in use at that time.

Many details in connection with the laying, repairing, and buoying, etc., of cables were discussed, and also the methods employed for keeping test on a cable during the whole process of laying.

The chair was taken on each occasion by the President, Mr. J. Jenkin, and the meetings, which were exceedingly well attended, terminated with a hearty vote of thanks to the lecturers.

NORTHERN CENTRE.

The last meeting of the 1907–8 session was held on April 13th, when a paper was given by Mr. J. W. Graham on "The Rate Book."

The title of the lecture did not lead one to think that it would be particularly interesting, but in the hands of Mr. Graham, who is an expert in stores matters, it proved one of the most instructive of the session. The lecturer dealt with the rate-book in sections, and from each section took several items, and explained in detail their construction and uses

An interesting discussion followed, in which a large number of members took part.

A hearty vote of thanks was passed to the retiring Committee, particular reference being made to the Chairman, Vice-Chairman, and Secretary, to whose interest and energy the great improvement on the previous year's working was due.

The prospects for next session are very bright.

SCOTLAND, WEST CENTRE.

Four successful and well-attended meetings have been held during the past few months, at which papers of a very interesting and highly instructive character were read by the following gentlemen:

November, 1907.—"Telephone Transmission Efficiency." Mr. T. Hetherington.

February, 1908.—"Underground Construction." Mr. G. H. Comport.

March, 1908.—"Graphs: Some Examples of their Application in Connection with Works and Maintenance." Mr. A. S. Angwin, B.Sc.

April, 1908.—"Post Office Removals." Mr. J. Lockhart.

The encouraging remarks made at these assemblies by the Chairman, Mr. D. M. Stewart, and Vice-Chairman, Mr. W. McNair, relating to the utility and progress of the Institution, were much appreciated.

NORTH-WESTERN CENTRE.

The last two meetings of the 1907-8 Session were held on Marth 4th and 30th, the following interesting papers being read :

March 4th.—" Notes on Brickwork and Road Construction." Mr. W. B. Smith.

March 30th.—" Wireless Telephony." Mr. R. Lawson.

METROPOLITAN CENTRE.

THE Metropolitan Centre Meetings of the coming session have been arranged to take place on the second Monday of each month, October to March inclusive, and the Annual Meeting of the Institution—which, by rule, is the last meeting of the Metropolitan Centre—on the third Monday in April, 1909. The programme of visits commences on September 7th, and will continue on the first Monday in each month. The series of visits will include the Stores Department (Central Depôt), Mount Pleasant and Holloway Factories, Messrs. Siemens Bros., the Robertson Lamp Works, Chelsea Power Station, and the Cable Ship " Monarch."

NORTH-EAST CENTRE.

The Local Committee are pleased to report that a position for the Reference Library has been found in the General Office. A list of the books authorised for the library has been prepared and will be distributed when the few outstanding volumes are received It is hoped that the more prominent display of the books will result in an extended use of the Library.

The last meeting of the 1907-8 Session was held on April 13th, when our genial representative from Bradford, Mr. Bailey, gave a most instructive paper on " The Transfer of the Bradford Trunk Exchange : Some difficulties and how they were met."

The subject was handled in a most entertaining way, and much valuable information not to be found in any text-book was obtained.

SOCIAL.

NORTHERN CENTRE.

A GOLF match between the Engineering and Surveyor's staffs was played on May 21st over the Town Moor course, when our men were severely beaten, Mr. A. Scott being the only player on our side to win his game.

Mr. Pullen's men are much elated over their success, but better luck may be ours next time.

The Royal and ancient game is not the only one that commands the attention of our staff. A Bowling Club has been formed and promises to be very successful. The Committee have already arranged a two bowl handicap and a rink competition, and there are more to follow.

A Swimming Club is also a future possibility.

NORTH-EAST CENTRE.

The Annual Cricket Match between the Clerical Staff and the Leeds Linemen took place at Roundhay Park on June 2nd, and resulted in a victory for the Clerks. On behalf of the latter, Mr. Whitfield's performance with the ball is worthy of special mention, 8 wickets falling—all clean bowled—at a cost of 7 runs.

CHESS CLUB NOTES.

METROPOLITAN CENTRE.

THE Annual Supper of the Chess Club was held at the Manchester Hotel, Aldersgate Street, on April 2nd. The President, Major O'Meara, was in the chair, and eighty-seven members and friends were present. The toast of " The Club " was proposed by Mr. G. Morgan (Controller of Stores), and the toast of " The Chairman " by Sir John Gavey, C.B. An excellent musical programme was presented, and, as on previous occasions, the function was a most enjoyable one.

The final match of the session took place at "Ye Mecca" on March 31st, when the 2nd Team beat the Controller of Stores' 2nd Team by $6\frac{1}{2}$ to $3\frac{1}{2}$

Mr. R. A. Wells won the Championship of the Club for the 1907-8 season with a score of $11\frac{1}{2}$ out of 14 games played, and the Handicap Tournament was won by Mr.W. D. Frewin.

VISITS TO MANUFACTURERS' WORKS, ETC.

SCOTLAND WEST CENTRE.

On April 16th, a visit was paid to Messrs. The Craigpark Electric Cable Company's Work, Springburn, Glasgow, manufacturers of Flameproof G. P. and Lead-covered Cables. The visitors were greatly interested in the processes of manufacture, which were minutely described by the Company's Officials.

NORTH-WESTERN CENTRE.

By the courtesy of Mr. Frederick Smith, the members of the North-Western Centre of the Institution paid a visit to Messrs. F. Smith & Co's. Wire Drawing Works, Salford, Manchester, on March 4th and 5th.

The greatest pains were taken by Messrs. Arthur Smith and W. H. Childs to explain the various processes, from the heating of the copper ingots to the finished wire. Everything proved of the greatest interest and extremely instructive, and the thanks of all concerned are due to the gentlemen above mentioned.

COLONIAL AND FOREIGN NOTES.

Contributions are invited from readers abroad.

CORRESPONDENCE.

To the Editors of THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL.

EDUCATIONAL QUALIFICATIONS.

I SHOULD like, if the exigencies of space in our new JOURNAL will permit, to submit to my fellow members of the Society of P.O. Engineers one or two impressions that seem to me to be worth emphasising in connection with the meeting of March 9th, when Sir John Gavey read his very welcome paper upon the "Training of a Telegraph Engineer."

Most of those who subsequently took part in the discussion gave expression to the feeling that we nearly always have when a high standard is set before us—it is too high for me. The feeling is perfectly natural—its expression needs cool judgment. In this instance the general impression conveyed was probably not that which the speakers intended. Every member doubtless recognises that the change in the qualifications possessed by the average engineer of to-day as compared with those possessed by the average engineer of, say, twenty years ago, is of a revolutionary character; the advance, to say the least, is remarkable. It is no disparagement of the work done by those older men to say that the continued development of the system compelled the creation of a new type of engineer. In the same spirit, it must be recognised by any judicial mind that the foremost position claimed for and largely admitted to be held by British telegraphy is due, not to those whom we ordinarily refer to (somewhat euphemistically, perhaps) as the older type of engineer, nor to us who to-day give the Department of our best, but rather this premier position has been earned by a select few (how few perhaps we hardly realise) whose work was that of pioneers, and from whom we have received this splendid position, which it is to be our privilege to maintain. Such men worked among their colleagues and were oftentimes not recognised as the giants they were; such men are working out their destiny in our midst to-day, whom, in the times to come when they shall have "arrived," we shall all feel sure that in the earlier days we recognised as "coming men." There is room and always will be room for the real genius to find his way to the top, unless, of course, he expects to be wafted there without the effort of climbing. All this leads to the real point that, for the average man, higher education is increasingly essential in the making of an engineer, and we shall be well advised if we learn to welcome the inevitable.

So far as the P.O. engineers are concerned there is a disturbing (although it might even be claimed as a steadying) factor—permanency of appointment. A commercial firm can afford to employ in a subordinate position a pushing, energetic man of very mediocre capacity, so long as he can do the work required, because as soon as he ceases to be able to meet the demands made upon him his services can be dispensed with, and a new up-to-date man brought in. In the P.O. Engineering Branch such conditions cannot rule. An engineering officer must, as far as can be estimated, be potentially capable of performing at a later time the duties of a comparatively high position, or he should not be given a permanent appointment. Otherwise, no matter how zealous he may be, lack of promotion will ultimately break his spirit; or should his usefulness lead to the condonation of his lack of ability he will find himself in a pitifully false position, and the *status* of his more highly endowed colleagues will suffer depreciation.

I fear I have already occupied too much space without touching upon what I look upon as a very important feature of the discussion—the Chairman's speech. Major O'Meara showed us that the educational and scientific demands being made upon the staff even now are behind those made by some other telegraph administrations, but on this point he is himself contributing a paper. I am not quite sure, however, that the true inwardness of another point of his speech was fully appreciated, and I think it very important for the promotion of good understanding that it should be made quite clear. The sidelight that he threw upon the claims being made was probably fresh to a large proportion of those to whom he spoke—it was to me, although I had quite recognised its probability. It was this, that while many of the staff have apparently felt that oppressive educational demands are being made by the new Engineer-in-Chief, he was able by a casual remark to show that he, as well as the late Chief, has been and is contending with the Civil Service Commissioners to secure the most favourable conditions possible for the present staff. It is not often that a Chief is in a position to let his subordinates see so far behind the scenes, and it may well be hoped that this little incident will tend to strengthen that feeling of good understanding and loyalty to the head of the Branch which is so important to the well-being of the whole staff. If our Institute or our Magazine wants a motto, let it be "Each for All."

A. J. S.

ESTIMATING PROCESSES.

THERE are few officers who have had to deal with estimates for overground works, who, at some time or other, have not felt that there was room for very considerable improvement in the method of preparing them. Changes in the authorised method of compiling such estimates have not been frequent. The most sweeping reform that has ever been effected was that which took place in 1907, when the Department authorised the adoption of the present system by which the minor stores are assembled into groups instead of being shown separately. The relief afforded by the alteration is very considerable, so far as the Superintending Engineer is concerned, but it affects the Sectional Engineer hardly at all. The latter has still under the new arrangement to make his survey, although not quite so minutely, prepare his summary of stores, and then classify them. This classification necessitates only a fraction of the entries in the estimate which were involved by the previous process, and, as he has a certain amount of latitude given to him in his choice of smaller stores, he is able to prepare the required details somewhat more readily than under the old system. He has, however, still to submit full details of the stores required on his requisitions. The Superintending Engineer, who is responsible for the checking, pricing, and preparation of the estimates for headquarters, has his detail work reduced to about one half of what it was formerly.

A suggestion has been received from Mr. Hook, Estimates Engineer at Nottingham, to the effect that the system of classifying stores should be still further extended, so that an Engineer may be able to requisition minor stores on a mileage or similar basis instead of having to show them in detail as at present. He contends that the scheme of classification is only half applied, and that by the adoption of his suggestion relief would be given to the officer most in need of it. A copy of Mr. Hook's proposal has been circulated to all the Estimates Engineers in the Kingdom, and the expressions of their opinions have been invited. These opinions have been summarised, and while the advantages, such as the saving in clerical labour, and freedom from delay owing to the non-arrival of small items of stores are recognised, it is thought that the disadvantages somewhat outweigh them. The principal objections urged are—(*a*) There is no provision for the frequent variation in the class of small stores required (*e.g.* various kinds of insulators, spindles, bolts, etc.); (*b*) higher freight charges would be incurred owing to the railway companies charging all stores in mixed parcels at the higher rates: (*c*) stores which are at present received direct from contractors would have to pass through a stores depôt; (*d*) such a system would not be suitable from an auditing point of view, as unnecessary unpacking and repacking would be involved.

One objection which several of our correspondents raised does not hold good. They contended that, owing to the variation in the number of poles per mile on open lines, different groups of stores would have to be provided to meet the varying conditions, or excesses and deficiencies would be met with. Such variations in the number of poles can readily be provided for by increasing or decreasing the number of miles on which the subsidiary stores required are calculated, *e.g.* if the average number of poles per mile provided for in the standard lists was thirty, and small stores for a ten-mile stretch of thirty-three poles to the mile were required, then the quantity of subsidiary stores asked for should be

$$\frac{\text{Actual number of poles per mile} \times \text{total mileage}}{\text{Average number of poles}} = \frac{33 \times 10}{30} = 11 \text{ miles.}$$

The objection raised to the absence of flexibility which would result from the stores being assembled in the manner suggested is a serious one. It would obviously be impracticable to assemble subsidiary stores covering all types of bolts, insulators, spindles, etc., and all such cases which were out of the ordinary would involve separate requisitions.

The other objections do not require special reference.

It is doubtful if construction work would improve under such a system, as there would frequently be cases where stores had been received which were not quite proper for the work, but which could "at a pinch" be made to do; and as it would be simpler to use them than wait while others were supplied, it is probable that in many cases they would be used.

The Estimates Engineer at Cardiff, Mr. W. Scott, suggests the following alternative scheme:—"Taking it for granted the Engineers must make up a detailed estimate let it come into the District Office, and be copied on the Stores Sheet in detail as heretofore, but priced on the new mileage basis. When authorised, the Engineer should simply requisition 'Stores, as per W.O.———to be despatched to———,' or 'Stores, as per W.O.———with following departures, to be despatched to———.' This would include the apparatus requirements also. In the case of an estimate covering a long length of line needing stores to be delivered at more than one station, the estimate could be made up sectionally, as now done by many Engineers, if not all on one form, each section bearing a distinctive letter commencing at 'A' the requisition would then be made out, 'Stores as per W.O.———"A" to———"B" to———,' and so on. It would be desirable to re-arrange the estimate form which is now made out in the most useful style to meet all requirements. The Delivery Notes would be compared with the estimate instead of as now with the requisitions. The detail requisitions would have to be prepared in the District Office, where the clerical labour would be slightly increased in copying the estimate under the mileage system, but I believe relief would be given to the Engineer who needs it most."

This proposal has its advantages and the Engineer stands out as being something more than an automatic recipient of anything the Stores Department like to send, as he has the demanding of each individual item of stores that he considers should be used.

The making out of requisitions is, after all, not one of the highest duties and while any unnecessary work should be avoided standardisation can be carried too far. Some time ago a suggestion was made to Head Office to adopt an entirely different system of estimating. The delay which takes place between the preparation of the preliminary and the working estimates is frequently a serious matter. It was therefore suggested that as it was found that preliminary estimates prepared in the Superintending Engineer's office were on an average within 5 per cent. of the actual cost of works that (in view of the fact that the Superintending Engineer is permitted to depart from his Works Estimate without authority within a range of 10 per cent.) the so-called Works Estimate was an unnecessary refinement and could be dispensed with. The procedure in such a case would be as follows: On receipt of a "request for estimate" form from Headquarters the Superintending Engineer would ask the Sectional Engineer to report what, if any, strengthening, new arms, or line alteration would be needed on the lines concerned. Such information the Sectional Engineer can readily obtain; frequently without leaving his office. The Superintending Engineer, on receipt of these details, would price them at standard rates, submit estimates to Headquarters and receive authority. When this was received, details similar to those supplied to the Engineer-in-Chief would be sent to the Sectional Engineer. The latter would then make his survey on the lines laid down on the estimate and submit requisitions of the stores required. The requisitions would be scrutinised in the Superintending Engineer's office so that it could be seen whether the class of stores asked for was proper to the kind of work in hand and if correct they would, after being entered on a Stores Sheet, be passed forward for execution. The whole estimate would be viewed from a money standpoint, and when the authorised amount had been passed through the accounts it would be assumed that the work was finished and the Engineer would be asked to report completion. On the completion of the work, if everything was in order, the W.O. would close automatically and best feature of it all, as there would be no detailed estimate there could be no departures from it and consequently no explanations of departures. It is also contended that the system would ensure economy in the use of stores as there would not be any tendency to use them "lavishly" to prevent excess credits on the order and consequent explanations.

The proposal was considered by experts in Engineering Accounts and Auditing, and was said to satisfy all requirements.

It was also considered by the Superintending Engineer's committee, but as the present system had only just been introduced it was decided that until a more extended trial had been made of it a change would not be justified.

There is still plenty of room for reform and suggestions such as those of Messrs. Hook and Scott will I am sure be welcomed in the JOURNAL.

H. BROWN.

STUDENTS' SECTION.

IN this section, so far as space allows, answers will be given to any questions of general interest from an educational point of view. Queries should be addressed to the MANAGING EDITOR.

CITY AND GUILDS TELEPHONY EXAMINATION. HONOURS GRADE, 1907.

QUESTION 11.—A telephone underground circuit 20 miles long has the following constants:

Resistance: 88 ohms per mile loop.

Capacity: 0·07 m.f. per mile (wire to wire).

Assume inductance and leakance negligible, and that speech waves have an average frequency of 800 alternations.

What will be the attenuation constant and what percentage of current will reach the distant end?

Answer.—The attenuation constant β of any telephone loop is given by the formula—

$$\beta = \sqrt{\tfrac{1}{2}\sqrt{(r^2+p^2l^2)(s^2+p^2c^2)}+\tfrac{1}{2}(rs-lcp^2)}.$$

where—r = resistance in ohms per mile of loop.

,, $p = 2\pi$ times the frequency of speech waves.

,, l = inductance per mile of loop in henrys.

,, s = leakance = $\dfrac{1}{\text{insulation resistance in } \Omega\text{'s}}$ per mile of loop.

,, c = capacity per mile (wire to wire) in farads.

If the inductance and leakance be negligible the formula is capable of great simplification, for $l = o$ and $s = o$, and

$$\begin{aligned}\beta &= \sqrt{\tfrac{1}{2}\sqrt{(r^2+o)(o+p^2c^2)}+\tfrac{1}{2}(o-o)}.\\ &= \sqrt{\tfrac{1}{2}\sqrt{p^2c^2r^2}}\\ &= \sqrt{\frac{pcr}{2}}\end{aligned}$$

Inserting the values given :—

$$\begin{aligned}\beta &= \sqrt{\tfrac{1}{2}\times 2\pi\times 800\times 0{\cdot}07\times 10^{-6}\times 88}\\ &= \sqrt{\tfrac{1}{2}\times 2\times\frac{11\times 2}{7}\times 8\times 100\times\frac{7}{100}\times 10^{-6}\times 11\times 8}\end{aligned}$$

Cancelling out, this becomes :—

$$\begin{aligned}&= \sqrt{2\times(11)^2\times(8)^2\times(10^{-3})^2}\\ &= 0{\cdot}088\sqrt{2}\\ &= 0{\cdot}124 = \text{attenuation factor.}\end{aligned}$$

If an alternating current of unit strength be impressed upon a circuit at the transmitting end, the strength at any distance d in miles from such end is given by the expression $e^{-\beta d}$ where e is the base of the Naperian or natural system of logarithms and equals $2{\cdot}718$ approximately. β is the attenuation factor above mentioned. If i be the current strength at distance d then—

$$\begin{aligned}i &= e^{-\beta d}\\ &= e^{-0{\cdot}124\times 20}\\ &= \frac{1}{e^{2{\cdot}48}}.\end{aligned}$$

This may be evaluated direct by the aid of a table of natural logarithms or by conversion to the base 10 as follows :—

$$e = \frac{1}{10^{0{\cdot}4343}}$$

$$\therefore i = \frac{1}{10^{0{\cdot}4343}\times 2{\cdot}48} = \frac{1}{10^{1{\cdot}077}},$$

which, by inspection is rather less than one tenth. More accurately, by logarithmic calculation it is found to be $\frac{1}{11{\cdot}9}$ of the current at the transmitting end, or $\frac{100}{11{\cdot}9} = 8{\cdot}4$ per cent.

STAFF CHANGES.

NOTE.—It should be clearly understood that these lists are unofficial; but every effort is made to render them accurate and complete.

BRITISH POST OFFICE.*

ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	Appointment.	Previous Service.
L. S. Connell	Asst. Submarine Super.	S.C. & T., Dundee, 1883; Tel., Edinburgh, 1883; Jr. Clk., E.-in-C.O., 1885; Sub-Engr., 1890; Engr., 2nd Cl., 1897; 1st Cl., 1905.
C. G. Roach	Engr., 1st Cl.	S.C. & T., Gloucester, 1886; Tel., C.T.O., 1891; Sub. Engr., 1897; Engr., 2nd Cl., 1900.
J. R. Matthews	Engr., 1st Cl.	Engr., 2nd Cl., 1902.
T. Adams	Senior Clerk (Prov.)	Tel., Liverpool, 1889; Jr. Clk., E.-in-C.O., 1899.
S.W. J. Crawford	Senior Clerk (Prov.)	Tel., Glasgow, 1890; S.C. & T., Rothesay, 1892; Jr. Clk. E.-in-C.O., 1900.

RETIREMENT.

W. E. Hitch	Engr., 2nd Cl.	Tel., C.T.O., 1883; S.C. & T., Great Yarmouth, 1888; Relay Clk., E.-in-C.'s office, 1892; Engr., 1896.

DEATHS.

T. W. Lapham	Suptg. Engr.	Roy. Engrs.; P.O., 1883; Tel., C.T.O., 1885; Insp. Eng. Dept., 1885; Engr., 1st Cl., 1891; Asst. Suptg. Engr., 1897; Staff Engr, 1st Cl., 1905; Suptg. Engr., 1907.
C. J. Hall	Asst. Submarine Super. (Dover)	Navigating Offr., "Monarch," 1883; Insp., 1891; Engr., 1st Class, 1899; Asst. Submarine Super., 1905.

ABBREVIATIONS.

Asst., Assistant; C.C. & T., Counter Clerk and Telegraphist; Ch., Chief; Cl., Class; Clk., Clerk; Cont., Controller; Div., Division; Engr., Engineer; Exr., Examiner; Gr., Grade; Hd., Head; Hr., Higher; Insp., Inspector; Jr., Junior; Lr., Lower; Offr., Officer; Over., Overseer; P., Postal; Pn., Postman; Prin., Principal; Prob., Probationary; Prov., Provinces; Sec., Secretary; Sen., Senior; S.C. & T., Sorting Clerk and Telegraphist; Sr., Sorter; Stg., Sorting; Sta., Stationary; Supply., Supplementary; Sur., Surveyor; Super., Superintendent or Supervisor; Tech., Technical; Tel., Telegraphist; Temp., Temporary; Wtg., Writing.

Dist., District; E., East; I., Ireland; Met., Metropolitan; M., Midland; N., North; Scot., Scotland; S., South; Wa., Wales; W., West.

* It is hoped to include similar information from Colonial Administrations in future issues.

OBITUARY.

Thomas William Lapham.

Universal sympathy has been aroused throughout the Engineering Department by the untimely death of Mr. T. W. Lapham, the recently appointed Superintending Engineer of the East Scotland District. The occurrence is rendered the more regrettable by reason of the very limited period which has intervened since he assumed office at Edinburgh in November of last year.

Mr. Lapham commenced his telegraphic career as a boy telegraph clerk in the corps of Royal Engineers in 1862. Four years later he was one of a group of twelve selected for service in Persia, where he took an active part in the erection between Bushire and Teheran of the pioneer telegraph line connecting Europe with India, for which, in conjunction with other Royal Engineer colleagues, he was accorded the commendation of the Indian Government.

He returned to England in 1878, and continued his military service in the Southern District as Inspector in charge of the Post Office Telegraphs at Exeter, Bristol, and New Cross, at which latter place he completed his service with the 2nd Division of the Telegraph Battalion, Royal Engineers, as Company Sergeant-Major in 1883. Immediately afterwards he was temporarily attached to the Head Office Staff of the Engineer-in-Chief, and engaged at the Gloucester Road Factory in the examination of apparatus in connection with the introduction of sixpenny telegrams.

In 1885 he was established on the permanent staff of the Post Office in the rank of Second Class Inspector. In that capacity he took charge of the Leicester Section of the North Midland District, where within ten years he had passed through the grade of First Class Inspector, and been promoted to the position of Assistant Superintending Engineer. Transferred to London only four years ago he successively occupied the positions of Assistant Superintending Engineer in the Central Metropolitan District, and First Class Staff Engineer at Headquarters.

His uniformly courteous and genial disposition, and the readiness with which he afforded his colleagues and subordinates the benefit of his extensive and varied experience, speedily secured for him universal high esteem.

The large and influential body of officials who attended his funeral at Morningside Cemetery, Edinburgh, on April 29th last, afforded eloquent testimony to the appreciation of his sterling qualities by his newly-found colleagues and friends in that city. His death, occurring, as it did, just when he had attained a position which it had been his ambition to secure, and to which his long and varied service in many climes so well fitted and entitled him, has evoked widespread and sincere regret. W. B.

Henry Pomeroy.

Since our last issue it is our melancholy duty to record the somewhat sudden demise of Mr. Henry Pomeroy, late Superintending Engineer of the Midland Ireland District, which took place at his residence, Dollymount, Dublin.

Mr. Pomeroy retired under the maximum age limit clause in 1906, when he was made the recipient of a handsome presentation of plate from his many friends and colleagues in the Department, and it is with deep regret that the announcement of his decease has to be made within such a short period of that event.

For over forty-five years Mr. Pomeroy, although a Wiltshireman, was a well-known figure in Post Office and railway circles in Ireland, and by his charm of manner and genial good nature had endeared himself to a host of friends throughout the districts visited in the course of his official duties.

Mr. Pomeroy joined the Electric and International Telegraph Co., under Messrs. Culley, in 1858, after putting in a few years' service in the telegraph department of the Great Western Railway under Mr. Spagnoletti; was for some time in the Government Telegraph Office, Amsterdam, and joined the Engineering Department of the above-mentioned company in Dublin in 1862, since which his entire service has been spent in Ireland. He was transferred to the Post Office in 1870 and appointed superintending engineer of the southern district with headquarters at Cork in 1878, on the death of the late Mr. T. H. Sanger, the last to hold the old title of Divisional Engineer. Mr. Pomeroy continued at Cork until transferred to Dublin in 1901, where he continued until his superannuation in 1906.

In the early days of the telegraphs Mr. Pomeroy was regarded as a brilliant technical man, and took a deep interest in the introduction of the telephone, establishing in the early eighties single wire exchanges at Cork, Limerick, and Waterford, the subscribers' circuits being amongst the first erected by means of hard drawn copper wire. In recent years he was more specially interested in construction work, and in this connection always acted up to the belief that close personal supervision and inspection were better means of securing satisfactory work than the mere issuing of instructions.

Although a strict disciplinarian, Mr. Pomeroy possessed in a rare measure the full confidence of his staff that they could rely upon him to look after their interests, which tended in no small degree to the smooth working of the district in those days of strenuous labour in the Engineering Department.

T. P.