Practical Aspects of Printing Telegraphy—I*

An Inventor on the Difficulties to be Encountered and the Way to Overcome Them

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IN a paper read before the Institution in 1905,† under the title of "Setting Type by Telegraph," an outline was given for the first time of the theoretical aspects of printing telegraphy. The author has always had in view the preparation of a second paper dealing with printing telegraphy from a practical point of view, especially in regard to the obstacles that stand, or formerly stood, in the way of the general introduction of printing telegraphs. The subject does not appear to have been treated in any publication, and as it is probable that these obstacles will, in time, acquire historic interest for telegraph engineers, it seems desirable to have them put carefully and fully on record. During the past ten years the author has had unique experience of these difficulties in New York, Boston, London, Birmingham, Manchester, Edinburgh, Berlin, Hamburg, Vienna, Stockholm, Gothenburg, St. Petersburg and Moscow, and the following paper embodies the results of that experience.

SUMMARY.

The paper is divided into three parts as follows: Part I., dealing generally with the field for printing telegraphy; Part II., dealing with the practical difficulties in the way of printing telegraphy; Part III., describing some printing telegraph apparatus designed to overcome these difficulties.

Part I. discusses the field for printing telegraphy, and it is shown that there is little scope at present for printing telegraphs in wireless work, in railway telegraph traffic, or on long ocean cables. Their use is chiefly in connection with land telegraph lines between centers of population, and it is shown that printing telegraphs will, in the future, perform a very important service in assisting the co-operation between telegraph and telephone. It is admitted that for transmission of intelligence over short distances the telephone stands unrivalled; but it is contended that for the transmission of intelligence over considerable distances the most efficient arrangement is a combination of the telephone and telegraph, the telephone acting as the collector and distributor for long telegraph lines. The reason is that the cost of long telephone lines is very great, while the labor cost of a telephone conversation is extremely small and the time saving is great. With the telegraph, on the other hand, the cost of the line is less than one-quarter of the cost of a telephone line; but the telegraph labor cost is very heavy and there is much loss of time. By co-operation between the telegraph and telephone the advantage of the cheap telegraph line is combined with the advantage of the low labor cost and time saving of the telephone. It is therefore contended that economic necessity will in future lead to a great increase in telephone-telegrams, or, as the British Postoffice already calls them, "phonograms." Printing telegraphs will form essential links in the telephone-telegraph network, because printing telegraphs are the only means by which the carrying capacity of telegraph lines can be greatly increased and the labor cost at the same time decreased.

Part II. is a long and detailed account of the difficulties that have been encountered in connection with the development and practical application of printing telegraphs. With the idea of forming an historical record of these difficulties, they have been fully and minutely described. It is pointed out in the first place that the saving of labor by the use of printing telegraphs cannot in the nature of things be very great; but that there is reasonable ground for expecting to save from 25 to 50 per cent in labor compared with the Morse key and sounder. The obstacles encountered in dealing with both commercial and press messages are discussed.

The difficulties in the way of making a copy for record of telegrams delivered are explained, and it is pointed out that wet-press copying is the only practical method of retaining copies of telegraph messages when printing telegraphs are used. The necessity for keeping copies of telegrams at all is not quite obvious.

When page-printing telegraphs are used a change is necessary in the telegraph forms used by various administrations. There are two kinds of telegraph messages, those sent from city A to be delivered in city B, and those sent from city A to be retransmitted in city B to city C. In city B nearly all telegraph administrations use two different kinds of telegraph

forms to distinguish these two kinds of messages. For a page-printing telegraph only one form for both kinds of messages is possible.

Numbering telegraph messages presented some difficulties in England when the Murray automatic printing telegraph system was introduced.

Counting the number of words in telegrams is a serious burden. There are so many Siamese twin words that are neither one nor two, that counting words is difficult, and the necessity for careful checking and counting considerably diminishes the number of telegrams that it is possible to transmit per hour. It also increases the labor cost. If it were possible to charge for telegrams in some way by time as in the case of the telephone, instead of by words, a lot of delay and labor would be saved.

Errors in telegrams, due to the telegraph line, to the telegraph machinery, and to the human operator, impose very serious limitations on the time and labor saving possible with printing telegraphs.

The variety of telegraph messages and the irregularity in the flow of telegraph traffic also greatly reduce the possible time and labor saving.

Traffic arrangements and hours of duty of operators are necessarily of a very complicated character in the case of large telegraph administrations, and the introduction of printing telegraphs leads to considerable variation of these arrangements. It is most difficult to introduce changes in the daily routine of large numbers of human beings. Of course, in the case of France, Germany, and other countries on the Continent of Europe, where the Hughes has been largely employed for more than a quarter of a century, such difficulties have long since adjusted themselves. It is in the Morse key and sounder countries that the introduction of printing telegraphs necessitates some changes of routine.

International telegraph traffic presents special difficulties because of the division of authority and difference in habits and ideas and customs and differences in language.

Alphabetical troubles are not the least that printing telegraph inventors have to encounter. Each country requires some variation in the telegraphic alphabet, and it appears to be a physical impossibility to devise a printing telegraph that will suit all languages. A curious illustration of this alphabetical difficulty is the confusion that exists in Great Britain through the use of the oblique stroke both for money and fractions. $\frac{3}{8}$ may be read as 3s. 8d. or as $\frac{3}{8}$. This confusion has led to monetary loss.

Code and cipher messages are the despair of telegraph administrations, but on the whole a good printing telegraph can handle such messages with less risk of error than the Morse key and sounder, and at least as expeditiously if proper methods are used. The essential condition is careful training of operators in working on typewriter keyboards without looking at the keys.

The use of envelopes and the addressing of telegrams present difficulties in the case of page-printing telegraphs. On the Continent of Europe envelopes are not used, and the telegrams have to be folded up in special ways varying with each administration. The printing of the messages must suit these methods of folding. This requirement is hard to fulfill in the case of a page-printing telegraph.

Finally, there are mechanical difficulties of construction. Printing telegraph machines belong to a theoretically bad group of mechanisms, in which the majority of the actions are striking instead of sliding or rolling, and it is only by close attention to details that success has been achieved.

Part III. gives a brief general description of the Murray automatic system and a more extended description of the new Murray multiplex system as an illustration of some methods by which it has been attempted to save time, line, and labor in telegraphy, and to overcome the difficulties enumerated in Part II.

PART I. INTRODUCTION.

For any distance exceeding a few miles, our sole physical means of transmitting intelligence at a speed greater than by letter post is the electric wave. There are only two possible methods of using the electric wave for signaling—namely, the guided wave along a wire (ordinary telegraph and telephone) and the unguided wave (light signals and "wireless"). Electric waves in the form of light have so many limitations that they are of no importance from the printing telegraph point of view, except as a local means of

printing, and further reference to them in this paper is not required. As the longer waves used in wireless telegraphy have a much greater range on the surface of the earth, no doubt in time wireless printing telegraphy will receive more or less attention, but it will not be of much importance, in this generation at any rate, because there cannot be any saving of line or line maintenance when there is no line. Any saving of labor that might be effected by wireless printing telegraphy is of trifling importance, because the wireless operator has to be in attendance in any case, and the speed of signaling is low. It is in submarine telegraphy, where it is impossible to use the guided electric wave, that wireless telegraphy has its great field, and in nearly all cases of ship telegraphy the work can be dealt with easily by one operator. Also the Morse key is the quickest means of communication (excepting the telephone). Hence in most wireless work, printing telegraphy would save neither line, labor, nor time. There is nothing else that it can save. Under such circumstances the extra cost and complexity of printing telegraphs would not be justified. Possibly for rapid transmission of wireless messages between two fixed centers, printing telegraphs may come into use, but not in the immediate future. Wireless printing telegraphy therefore does not require consideration, and we may confine ourselves to the guided electric wave as used with the telephone and telegraph, including underground and submarine cables. Transmission of intelligence so far as the guided electric wave is concerned may be classified into short-distance and long-distance telephone traffic and short-distance and long-distance telegraph traffic. Further subdivisions of telegraph work, which overlap more or less, are land traffic, cable traffic, news work, commercial and other ordinary short telegrams, railway work, and the stock ticker and urban news service.

It is not necessary in this paper to touch on the local transmission of intelligence over distances more or less within city limits. For this purpose the telephone and stock ticker and telautograph have reached a high state of development and form a group by themselves. The difficulties they have had to face have been almost entirely mechanical. No serious obstacles have been presented by the nature of the traffic they have to deal with. Hence they will only concern us in so far as they serve as feeders to the general telegraph and telephone network between centers of population.

For railway work printing telegraphs have hardly been employed at all up to the present, and as the telephone is gradually displacing the telegraph for most railway work in America, and therefore no doubt in time in other countries also, printing telegraphy does not appear to have any extensive possibilities in conjunction with railways, and it therefore does not require special discussion at present. In time, printing telegraphy will probably play a considerable part in connection with ocean cables, but up to the present hardly anything has been done in this direction, because the conditions to be fulfilled are extremely complicated. In the first place, there cannot at present be any line saving, because ocean cables are already utilized up to their full capacity. It will be possible to effect a slight saving of time and some saving of labor, but the apparatus will necessarily be of a very delicate and intricate character. The expenditure will necessarily be heavy, and the saving will not be more than about £300 or £400 a year on each cable, at each end. The saving of time is more important on the Atlantic cables, and reliable apparatus that would print messages in Roman type direct from the cable signals would be attractive to the cable companies in places like New York, where the cables terminate in Wall Street, the business heart of the city. Meanwhile, the attention of printing telegraph inventors is absorbed by land line work, and printing telegraphs for ocean cables have to wait. The application of printing telegraphs to news work will be dealt with later on.

So far as the present position of printing telegraphs is concerned, the Hughes tape printer carries the bulk of the telegraph traffic on the Continent of Europe, and it has done so for nearly half a century, about 3,000 Hughes instruments being now in use. Most of the telegraph traffic between Great Britain and the Continent is also carried by the Hughes, but this machine is employed outside of Europe only to a very slight extent. During the past thirty years the

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Baudot system, which may be described as a multiplied Hughes tape printer, has been developed and extended in France, until all the telegraph lines of any importance are equipped with it. During recent years it has also made considerable progress in Italy, Brazil, India and Russia. In Russia it is very extensively used, most of the leading towns in European Russia being connected by it. It has likewise secured some foothold in most other European countries, Paris being linked up by it to nearly all the capitals of Europe.

Great Britain has proceeded in very leisurely fashion, and so far has only coquetted with printing telegraphy, more or less prolonged flirtations having been carried on by the British Postoffice with the Hughes and Baudot, the Buckingham, the Murray automatic, the Siemens and Halske, and several other systems. The latest arrival, the Murray multiplex, may be described as the child of the British Postoffice, it having been developed with the assistance of that institution. The Murray automatic system has made most progress up to the present in Germany. It has also secured a foothold in Russia, Sweden, and Norway. It is in regular commercial use between Hamburg and Berlin, Berlin and Frankfort, Hamburg and Frankfort, Berlin and St. Petersburg, St. Petersburg and Omsk in Siberia (about 2,400 miles, with three repeating stations), Stockholm and Gothenburg, Kristiania and Bergen. A new installation with all the latest improvements is being established between London and Dublin. For various reasons, however, the use of the Murray automatic system is limited to long lines and underground cables, and there is consequently not a very wide field for it, especially in comparatively small countries like Great Britain. The Murray multiplex, on the other hand, is very well adapted for moderate distances, but it has not yet had time to come into extensive use. In the United States the Buckingham system was developed under the auspices of the Western Union Telegraph Company, and some sixty circuits are now equipped with the Buckingham system as improved by Barclay.

Printing telegraph inventors are still busy increasing the height of the printing telegraph scrap pile, as they have been doing for fifty years, especially in America, but the substantial results over the whole wide world are summarized in the foregoing paragraphs. These results are neither extensive nor brilliant, and it is an actual fact that less than £1,000,000 sterling would cover the value of all the printing telegraph machinery on the face of the earth to-day. This is the outcome of fifty years of constant labor by scores of inventors. We have only to compare this with the gigantic extension of telephone apparatus all over the world in only a few years to realize that there must be some hampering circumstances, some peculiar difficulties and obstacles in the way of printing telegraphy, when we compare its stunted growth with the enormous progress of the sister art of telephony. It is the intention in this paper to give a full and detailed account of these peculiar obstacles and difficulties, and of the exceedingly complicated conditions with which printing telegraph systems have to comply.

For this purpose it is necessary first to get a clear, general view of the practical processes employed in the transmission of intelligence by the telephone and by the telegraph. In doing so we have to bear in mind that in the transmission of intelligence there are four economies of fundamental importance, namely:

1. To save time.
2. To save labor.
3. To save line.
4. To save office equipment.

Everything turns on these four vital points. They are all more or less antagonistic economies. Time, for instance, can be saved by increasing labor cost or vice versa. Good management is a question of balancing these economies against one another so as to secure the maximum result. Investigation shows that it is far more important to save time, labor, and line than to save office equipment. Heavy expenditure on office equipment in the shape of printing telegraph machinery is therefore one of the inevitable developments of the future. As will be seen presently also, the necessity for co-operation between the telegraph and telephone will compel development in the same direction. That the relation of the telephone to the telegraph has an important bearing in regard to printing telegraphs will be seen from the following considerations: In the case of the telephone the sender and receiver of a message are put in direct communication, and there is no intermediate labor whatever. This result, however, is only obtained over anything more than moderate distances by heavy expenditure on telephone lines. Two expensive copper wires are needed for the telephone in place of one cheap iron wire for the telegraph. The telephone

line expenditure, in fact, is so heavy for long distances that beyond about 1,000 miles the cost becomes almost prohibitive. The theoretical reasons for the great differences between telegraphic and telephonic methods were given in the paper on "Setting Type by Telegraph," already referred to* and it is only necessary here to deal with the practical aspects of the matter. In the case of the telephone there is no scope for machinery, so far as the actual transmission of the message is concerned, because there is no labor at all beyond speaking and listening. The cost of a telephone message over a short distance is therefore very small—2d. for about 200 words sent and 200 received in reply—and there is absolutely no delay or loss of time except in getting connected. Obviously the telephone saves enormously in time and labor, that is to say, in two out of the four vital elements of cost. It is this enormous economy that has led to the expenditure of such immense masses of capital in the extension of the telephone service all over the world. In the case of the telegraph the conditions are almost exactly opposite, and the telegraph at present is more or less crushed between the upper and nether millstones of the telephone and the letter post. It is only over long distances that the telegraph stands supreme, and it does so because of the very low cost of the telegraph line compared with the telephone line. The relative value of the telegraph increases and the relative value of the telephone decreases rapidly in proportion to the distance.

Let us take the case of a business man in London who wants to communicate with a man in Birmingham, a short distance of about 120 miles. If he telephones he gets direct communication in a few minutes and at no great cost. (There is, of course, often considerable delay in getting a trunk connection, but it is much less than the delay in getting a reply by telegram.) If he telegraphs he has first to dictate the telegram to a clerk, who writes it out and hands it to a message-boy, who takes it to the nearest telegraph office and hands it to a counter-clerk, who counts the number of words and collects payment. A messenger then takes it and puts it in a pneumatic tube, by which it goes to the London central telegraph office. Here a messenger takes it out of the tube and it goes to a table sorting clerk, then to a messenger, who again puts it in a pneumatic tube to one of the telegraph galleries (operating halls). Again in the gallery it goes through the hands of a sorting clerk, and then a distributor takes it to the circuit box, where it is dealt with by the traffic clerk of the circuit. An operator then telegraphs it over the line to Birmingham, where it is received by another telegraph operator. It is taken away by a collector to a delivery officer to be enveloped and addressed. Then finally a messenger takes it to the addressee. In the case of the messages passing from city A through city B to city C the human chain is still further extended, but taking the foregoing as a fair average journey for a telegram, we see that between the sender and receiver of the message there are no less than fifteen middlemen. In the case of long-distance messages this chain of middlemen may easily extend to twenty or thirty. Not only is there heavy labor cost, but also much time is lost in this elaborate process. The result is that not only does an average telegram take an hour or more to reach its destination, but the excessive labor employed in handling it makes it very costly. Instead of 2d. for about 400 words, a telegram costs 6d. for 12 words—that is to say, 1d. for 2 words instead of 1d. for 200, as in the case of the telephone.

The vital importance of printing telegraphs lies in the fact that they can greatly reduce the present waste of line and labor in telegraphy, and that they render it possible to foster the growing co-operation between the telegraph and the telephone. The telegraph and telephone are each strong where the other is weak. We can set out the points in tabular form thus:

	Telegraph.	Telephone.	Telegraph-Telephone
Time	Wasteful	Extremely econom.	Fairly economical
Labor	Wasteful	Extremely econom.	Fairly economical
Line	Very econom.	Very wasteful	Very economical
Office equipment	Cheap	Expensive	Expensive

If we utilize the telephone as the short-line feeder and distributor for the long-line telegraph we get the ideal co-operation shown in the last column of the table. The cost of office equipment will be increased, but this will be outweighed ten or twenty fold by the economies of line, labor and time.

If telegraph messages were charged for like telephone messages, by time instead of by the number of words, a lot of the labor cost would fall away. A

* Journal of the Institution of Electrical Engineers, vol. 24, p. 555, 1905.

merchant would then ring up the nearest telegraph office. He would be switched onto the required circuit, and he would dictate his message direct to a telegraph operator, who would type it on a rapid keyboard tape perforator. The perforated message would run through an automatic transmitter, and would be printed automatically direct from the line signals at the distant station, from which point it would be telephoned at once to the addressee. In this way the elaborate telegraph labor chain would be reduced from twelve or fifteen to about four, with corresponding reduction in the cost and saving of time. This may be an impossible ideal, but there is no reason why there should not be some approximation to it. Indeed, this telephone-telegram idea is already slowly emerging into everyday use. The British and other administrations now accept and deliver telegrams by telephone, and the British Postoffice has actually coined the special name of "phonograms" for such telephone-telegrams. As telegrams can already be sent to or from a telegraph office by telephone, it is only a question of time for several more links in the long telegraph labor chain to be cut out, and messages will be sent by telephone direct to the particular telegraph circuit over which they are to be transmitted. There will be no more difficulty about, that than there is in handling trunk telephone calls. It will be noticed, however, that the success of such an arrangement is conditional upon the rapid handling and transmission of the messages. If a merchant wished to dictate a message over the telephone direct to a telegraph operator on a particular circuit, and if he had not only to await his turn, but also to dictate at the crawling manual speed of the Morse key and the operator writing at the other end of the telegraph line, the arrangement would never come into popular favor. The message should be recorded on perforated paper tape from dictation over the telephone at a speed of at least sixty words a minute, or it should be recorded at this speed or more on a typewriter at the circuit over which it is to be transmitted. Also the best the slow Morse key can do is to give two simultaneous transmissions in one direction on one telegraph wire. To handle "phonograms" under ideal conditions there should be a system giving either high automatic speed of transmission or at least four simultaneous transmissions in each direction on busy lines, and the speed of each transmission should be a steady average of at least forty words a minute.

Not only would quick handling and transmission of messages be necessary, but also quick reception and printing of the messages at the other end of the line ready for transmission by telephone. Printing telegraphs are a necessity for such methods of handling telegrams. Even in the case of the general public, who would continue to hand in their telegrams in the usual way at telegraph offices, much time and labor would be saved if the messages could be sent by telephone from the local telegraph office direct to the trunk telegraph line and recorded on a keyboard perforator in the form of perforated paper tape, ready for automatic transmission. The chief stumbling-block at present in the way of this arrangement is the practice of charging for telegrams according to the number of words. An incredible amount of time and labor is wasted in counting the number of words in telegrams. The telephone prospers without counting and recounting words. The telephone does not reckon "three-halfpence" as one word and "three hundred" as two words, to say nothing of other telegraphic word-counting absurdities. A rational system of charging for telegrams is badly needed, but it is difficult to imagine what plan could be substituted for the present clumsy but practical arrangement.

In addition to the telephone as a local collector and distributor of telegrams, there appears to be a field for the small step-by-step printing telegraphs generally known as stock tickers. The Siemens and Halske teletyper is a good example of this class of machine. From a technical point of view it is an admirable little instrument, and on the Continent of Europe it is being exploited commercially with considerable vigor and success. It is very largely in use in Germany, Berlin and several other leading German cities having ticker exchanges in connection with the head telegraph offices arranged somewhat on the lines of a telephone exchange. Any subscriber can send telegrams to the head telegraph office or receive them by means of the teletyper. By having one or two of these little instruments at each important circuit, and by having suitable switching arrangements in the exchange, subscribers could send in their messages direct to any required circuit or receive them direct from any circuit in the same way. The advantage of this arrangement would be that there would be a printed record of the message in the office of the sender and also in the head telegraph office, and it is probable that there would be less liability to mis-

takes than in the case of the telephone. These little machines, however, are more expensive and complicated and slower than telephones, and in the nature of things can only come into very limited competition with the telephone. The same remarks apply to the telewriter. This will also, no doubt, prove useful in collecting and distributing telegrams locally, but it is the telephone that will do the bulk of the collection and distribution of messages sent over telegraph lines.

Meanwhile we have to see what steps we can take to reduce labor cost of telegrams under present conditions. The line cost also is important, but nothing like so important as in the case of the telephone, and, except in the case of very long lines, it is not so important as the labor cost. On the other hand, we have the letter post, by which we may send 5,000 or more words for one penny. The time of transmission

is a good deal greater than in telegraphing over long distances, but there the advantage of the telegraph ends. Why spend sixpence on a telegram when you can telephone for twopence or send a letter for a penny or a postcard for a halfpenny? The answer is, that you cannot telephone for twopence except over short distances, and that letters take a long time to go long distances and telegrams do not. The telegram is the cheapest quick method of communication over considerable distances. The subject is very complicated, and there are many obstacles, but three-penny telegrams and quick service would lead to a wonderful growth of telegraph traffic. Three-penny telegrams and quick service depend on rational co-operation between the telegraph and telephone, upon the extension of the telephone to practically every office and home, and last, but not least, upon efficient

printing telegraphs. It is a more or less instinctive appreciation of these facts that has led the British and other telegraph administrations to experiment so extensively during the past few years with various new printing telegraph systems. Much yet remains to be done, but it is practically certain that in the course of the next ten or fifteen years the British Postoffice alone, to say nothing of other administrations, will have to spend not less than a quarter of a million sterling on printing and other telegraph machinery in telegraph offices—that is to say, on “office equipment.” There are, of course, many other relative advantages and disadvantages of the telephone, telegraph, and letter post, but it is not necessary to discuss them here, as they have no special bearing on printing telegraphs.

(To be continued.)

New Physical Apparatus*

Interesting Devices from European Laboratories

RAPID PRECISION BALANCE.

In commercial and industrial laboratories it is often necessary to make a series of weighings of equal quantities of material. For this purpose it is customary to employ a small nickel measure similar to those used by grocers, which is “tared” once for all, and is cleaned with a brush after each weighing. The weight of the measure, however, may be altered, by contact with the hand and other causes, in the course of the series of weighings, and some of the substance weighed may be retained by the brush. For precise determinations of weight, the tare of the container must be determined each time, immediately before it is filled. In order to shorten the time required to make a series of weighings in this manner, Dr. Gerber has devised a balance in which one pan consists of a disk suspended from the beam by a central vertical rod, about which it can be rotated. Several containers are arranged in a circle on the disk and attached to it, and the disk is balanced by a tare weight on the other arm of the balance. Another weight, representing the quantity of substance required, is then attached to the other arm and balanced by filling the nearest container. The weight is then doubled, the disk is turned to bring the next container into a convenient

RAPID PRECISION BALANCE

position and the balance is restored by filling this container. In this way all of the containers are filled, the weight being increased by a constant amount each time.

VELOCITY OF ROENTGEN RAYS.

In 1905 Marx completed an extensive series of measurements, made by a zero method, which appeared to prove that Roentgen rays are propagated with the velocity of light, that is, 300,000 kilometers, or 186,000 miles, per second. Although there was no inherent improbability in this result, many physicists were unwilling to accept it, because the method of measurement appeared involved and open to ambiguity.

According to the hypothesis of Wiechert and Stokes, the Roentgen rays are caused by unharmonic or aperiodic disturbances in the ether, and are consequently propagated with the velocity of light. Bragg, on the contrary, regards the Roentgen rays as very rapid secondary cathode rays, composed of neutral pairs of oppositely electrified particles, analogous to binary stars.

Marx has recently repeated the measurements by an improved method. He still finds the velocity of Roentgen rays equal to that of light, within 3 per cent, which is the probability of error of the measurement. The accompanying diagram shows the apparatus and the principle of the method. The Roentgen rays are produced by a small vacuum tube A, at a variable distance from which is placed a second vacuum tube B, containing an aluminium plate P. Roentgen rays striking this plate will promote the

loss of any negative charge, or resist the loss of any positive charge, which it may possess. The discharge can be measured by a quadrant electrometer connected with the little Faraday's cage K, which is arranged to catch the electrons projected from the aluminium plate P.

The tube A is traversed by an alternating current

APPARATUS FOR MEASURING THE VELOCITY OF ROENTGEN RAYS

of high frequency, and therefore emits Roentgen rays, not continuously, but periodically at very short intervals. Similarly, the negative charge of the plate P, which is favorable to the detection of Roentgen rays, is not maintained continuously, but is produced periodically by a high frequency current. In order to cause a deflection of the electrometer the Roentgen rays must strike the plate P at the exact moment when it is negatively electrified. The two high frequency currents were generated by the same oscillator, and were consequently of the same period. The plate P was connected with the oscillator by a wire of variable length D, along which the electric waves travel, as is known, with the velocity of light. The Roentgen rays reached the plate by traveling the distance A' through the air. The position of the detector tube B and the length of the wire D were first adjusted to produce a maximum deflection of the electrometer. The distance between the vacuum tubes A and B was then altered by a measured amount and the wire D was lengthened or shortened until a maximum deflection of the electrometer was again produced. To obtain this result it was found necessary to increase or decrease the length of the wire by an amount equal to the increase or decrease in the length of the air path followed by the Roentgen rays. Hence the experiment shows that Roentgen rays travel with the velocity of light. This result is at variance with the theory of Bragg, and confirms that of Wiechert and Stokes.

USE OF LIPPICH PRISM IN PROJECTION.

When a Nicol prism is used with an electric arc for making lantern projections by polarized light there is danger of melting the Canada balsam which cements

LIPPICH PRISM

together the two parts of the prism. This danger is greater now than it was formerly, because the increased cost of objects made of calc spar leads to the employment of small prisms, which are exposed to a very concentrated beam of light.

A Nicol prism is made by bisecting a natural rhombohedron of calc spar along a plane inclined at a certain angle to the optic axis and interposing a thin

stratum of Canada balsam between the two halves A and B (see illustration). A ray of unpolarized light, entering the film parallel to the axis at a, is divided within the doubly refracting crystal into two polarized rays, one of which, called the “ordinary” ray, is refracted to a, where it is totally reflected to the side of the prism at e and there absorbed by a coating of black pigment, while the other, called the “extraordinary” ray, passes straight through the compound prism along the line a b c. It is the suppressed “ordinary” ray that does the mischief, for its absorption by the black coating heats the prism. Moreover, in most cases it is not entirely absorbed, and therefore causes optical disturbances. It was for the latter reason that Lippich suggested polishing a portion of the side of the prism and attaching a triangular glass prism C. By this device the “ordinary” ray is conducted entirely out of the prism, along the line e f. As the production of heat by absorption is eliminated, together with the optical disturbance, Lippich's modification of the Nicol prism is especially well adapted for projection, and it has been used for that purpose with excellent results.

A NEW LINEAR BOLOMETER.

A bolometer is an instrument for measuring radiant heat by means of the increase of the electrical resistance of a conductor exposed to the radiation. This conductor, w, is inserted in one side of a Wheatstone

Fig. 1

Fig. 2

bridge (Fig. 1), and the resistances of the other three sides a b c are so adjusted that no current flows through the diagonal containing the galvanometer g. The bolometer conductor w is then exposed to radiation, which raises its temperature, and, consequently, increases its resistance, so that the balance is destroyed and the galvanometer needle is deflected.

In practice it is desirable to arrange the apparatus according to the more complex scheme of Fig. 2, in which variations in the temperature of the air have less effect, and in which the conductors, 1, 2, 3 and 4 must be of the same material. The character of these conductors is of the utmost importance. They must have as large a surface as possible, small thermal capacity and high resistance, and yet must be able to carry strong currents.

Leimbach has recently constructed a linear bolometer of extraordinary sensitiveness, in which the conductors are platinum ribbons about 1/2 inch long, 1/1,000 inch wide and 1/100,000 inch thick. These ribbons were produced by stretching and flattening platinum wire thickly plated with silver (Wollaston wire) and then dissolving the silver in nitric acid.

Roman Portraits of the First Century, A.D.

PROF. WILLIAM F. PETRIE exhibited at the recent Con-
vocation of the Royal Society some Roman portraits of the first century A. D.

These portraits are painted with colored wax upon thin panels of cedar. On some a fresh coat of paraffine has been now added for security. They were placed over the faces of the mummies and bandaged down round the edge. They are from the same cemetery, at Hawara, Egypt, as those in the National Gallery, a site now exhausted by the British School of Archaeology in Egypt.

*These brief notes are taken from our French and German contemporaries, *La Nature* and *Prometheus*.