HIGH SPEED TELEGRAPH TRANSMISSION BY MEANS OF ALTERNATORS.

ALTHOUGH, at the present day, high speed transmission is much more limited in its application than at an earlier period in the history of telegraphy, owing to the commercial aspects of the question having been unavoidably altered, attempts have been made from time to time to produce improvements in this direction; but until lately the admirable system invented by the late Sir Charles Wheatstone, and considerably improved by the British Post Office Telegraph Administration, has been the best available method of automatic high speed signaling.

The speed at which a series of waves can be passed over a given line depends primarily and inversely upon the product of the total resistance into the total capacity, the form of the wave having a considerable influence on the speed where any measurable capacity is present.

In the ordinary Wheatstone automatic fast speed system of telegraphy, the letters are formed by waves of different duration, a dot being produced by a short wave, a dash by a longer one. This renders it necessary to charge the line longer for a dash than for a dot, which is a grave defect in fast speed working; but the condenser compensation, introduced and employed by the British Post Office, practically doubles the speed attainable on any given line by, in some measure, equalizing the line charges. That is to say, the condenser used is always of a capacity which admits of a full charge during the time interval of a dot, and a current of the duration of a dash does not give the condenser any higher charge. Indeed, condenser compensation has such a beneficial effect, that the defect of unequal impulses is almost overcome, inasmuch as the increase of speed obtained by this arrangement and equal impulses is only five per cent. greater than that obtained with currents of unequal duration. Again, although the signals be made equal in this system, another difficulty presents itself; that is, the waves that are sent through the line are the results of the sudden applications of the full E. M. F. used (in practice, 100 volts), and consequently a reversal means a sudden change of 200 volts, i. e., from 100 volts positive to 100 volts negative. The form of the current wave with such a system depends almost entirely on the nature and form of the circuit. It is easy to produce correspondingly sudden and complete changes in the current when the circuit possesses only resistance, but when capacity, etc., is present, the form of current wave is vastly different to the impressed E.M.F. wave; for example, take the letter "A." The actual current curve on a land line without condenser compensation is shown in Fig. 1, while Fig. 2 represents the effect of shunted condenser compensation.

FIG. 1.

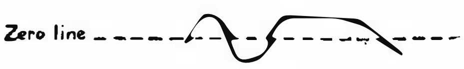

FIG. 2.

Prof. A. C. Crehore, of Dartmouth College, U. S. A., in conjunction with Lieut. G. O. Squier, of the United States Artillery, have, however, been led to make some experiments with alternators, and have suggested a mode of high speed signaling which, although presenting some mechanical difficulties, has recently been tried by the inventors of the Post Office telegraph lines in England, under the direction of Mr. Preece, and found to produce a distinct increase of speed.

Fig. 3 shows an ordinary sine wave as produced by an alternator, and it is this form of wave that Messrs. Squier and Crehore use in their so-called "synchronograph" system of fast speed telegraphy.

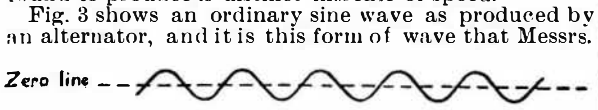

FIG. 3.

The signals are obtained by the omission of certain complete cycles or semi-cycles, the message being read by means of the blanks in the regular succession of recorded dots; or signals can be recorded on chemically prepared paper.

This system is to some extent a synchronous one, with this great advantage over the many well known synchronous systems, that the synchronism is not required between the transmitter at one end and the receiver at the other end of a line, but between the alternator and transmitter at the sending end of the line. This is easily obtained by driving the transmitter from the generator shaft. The transmitter itself is exceedingly simple, and consists of a wheel the circumference of which is one continuous conductor, presenting a smooth surface for the brushes to bear upon. If the periphery of this wheel be divided into forty equal parts, and be geared to run at one-fourth the speed of the armature of a ten-pole alternator, clearly one of these equal parts will correspond to one semi-cycle of E.M.F. produced by the alternator. Upon the surface of the wheel bear two brushes, carried by an adjustable brush-holder. One brush is joined to the generator and the other to the line, so that the current entering one brush from the generator passes across the transmitting wheel to the other brush, and thence out to the line.

Now, if a piece of paper $\frac{1}{20}$ of the circumference of the wheel be fixed thereon in such a position as to pass under one of the brushes, one semi-cycle or half wave of current will be omitted in every twenty complete waves, and by means of a suitably prepared paper ribbon, or "slip," any combination of signals can in this simple manner be transmitted. The brushes are adjusted so that the periods of disconnection and connection coincide with the zero points of E.M.F. The transmitter may, however, have only one brush joined to line, and the wheel itself may be made the connection to the generator. With this mode of signaling much higher E.M.F.'s may be used, and connections and disconnections made almost without spark at the brush contacts.

The speed of the transmitting wheel with respect to the generator shaft is immaterial, the essential being that its circumference should contain an integer number of times the arc which a point fixed with respect to the field would describe on such circumference during one semi-period of current.

Complete control of every semi-cycle of current thus permits the maximum speed of transmission of signals with a given frequency. If the transmitter does not act in synchronism with the generator, the "make" and "break" of the circuit occurs when the current is not naturally zero, and considerable interference results; care is, therefore, taken to insure that the "slip" admits of the line connections being made at the proper times only.

Although the received signals were originally intended by Messrs. Squier and Crehore to be recorded on chemically prepared paper, they have also devised a very ingenious massless receiver, although at present it is not in a practical form. It is based on the well known discovery of Faraday that a beam of polarized light may be rotated by means of a magnetic field, the direction of rotation of the ray being the same as the direction of the current producing the field; the rotary power depends upon the intensity of the magnetic field, and the total amount of rotation upon the length of the rotary medium in which this magnetic field exists and through which the ray passes.

The method adopted is to pass a beam of light through a Nicol's prism, thence through a long tube with plane glass ends containing liquid carbon bisulphide, and afterward through a second Nicol's prism. The ray of light is received on a screen having a sensitized surface, which is carried forward at a uniform speed; a long coil is wound round the tube containing the carbon bisulphide, the prisms being adjusted so that no light passes through the tube when no current is flowing through the coil, the source of light being an arc lamp.

The passage of a current rotates the polarized ray within the tube, and the light then falls on the sensitized screen, and is thereby recorded.

As neither of these methods of reception is suitable for everyday use, the British Post Office undertook, in conjunction with the inventors, a series of valuable and interesting experiments over the departmental lines under more practical conditions. The existing departmental records of capacity, resistance, and mileage, compiled for the whole country, proved invaluable by supplying exact data for each of the experiments performed, and enabled reliable tables and curves to be constructed. The experiments consisted of determinations of the highest limits of speed for the Wheatstone automatic, as well as the synchronograph system on various lines, the following combinations being specially compared:

1. Ordinary Wheatstone automatic with condenser compensation as is used at present.
2. The synchronograph sine wave transmission system with chemical receivers.
3. A combination of the synchronograph sine wave transmission with Wheatstone receivers.

The alternator used for these experiments consisted practically of several separate alternators on one shaft, each being independent of the remainder, and so constructed that, with the same speed of revolution, different frequencies or wave speeds could be obtained, transformers being used in those cases where it was desirable to maintain the E.M.F. unaltered.

Careful estimations were made not only of the force employed, which is about 50 per cent. higher than that ordinarily used on Wheatstone circuits, but also of the wave speed, and its equivalent value in "words per minute" in each case.

On a line from London to York and back, mainly composed of copper, having a total mileage of 431½, and a K.R. equal to 33,000, a speed of 540 words per minute was attained with Wheatstone receiver and Crehore-Squier transmitter (synchronograph), although the maximum limit was not reached. The speed obtainable with this K.R. being only 360 when ordinary Wheatstone automatic was used.

From London to Aberdeen and back, with a total mileage of 1097¼ and a K.R. of 261,000, a speed of 135 words per minute was obtained by the Crehore-Squier Wheatstone combination, as compared with 46 words per minute on the ordinary Wheatstone automatic with the best compensating arrangements.

These two cases are typical of the whole series of observations, which enabled the comparative wave speeds of the different systems to be estimated as follows:

Wheatstone automatic alone	1
Crehore-Squier transmission and Wheatstone receiver	2·9
Crehore-Squier transmission and chemical receiving	2·9

In the first two cases the number of waves necessary for each word is of course the same, but in the last named case, where chemical receiving is employed, a further gain is obtained by using fewer waves for each word, making the word speed in the three cases bear the ratio 1, 2·9 and 7.

Chemical receiving is by no means so convenient as ordinary Wheatstone, and the most pressing practical requirement at the present day is not higher speeds for short distances, but higher direct working speeds over long lines where at present intermediate "repeaters" are necessary.

It is satisfactory to note that the maximum wave speed attainable by synchronograph transmission with the chemical receiver or with the Wheatstone receiver is exactly the same on any circuit where the speed is limited by the line itself and not by the receiving apparatus.

On the Wheatstone system shunted condensers are necessary to compensate for two distinct effects—the unequal duration of the signals and the inductance of the receiver. Where the synchronograph transmission is employed on short cables or open lines, no line compensation is required, and a fixed condenser can be shunted across the receiver coils so as to compensate for the inductance of the receiver for any given speed. In connection with this question the inductance of the Post Office receiver was carefully verified, and was found to be 3·46 henries, the necessary condenser compensation depending solely on the speed of transmission (or wave-frequency) and the arrangement of the receiver coils, and in no instance having any direct or complicated relation to the line capacity.

On an artificial cable, equal to about 200 miles of ordinary submarine cable, where condenser compensation is used at both ends, the increase of wave speed obtained by the synchronograph was only 50 per cent., instead of 190 per cent., as in the case of open wires. It would therefore appear that with further experiment some line compensation might be found to be necessary for cable working.

The experiments show that where the capacity of the line is not great, as in the case of aerial lines, the transmission of the current in sine waves produces the best results, and leaves the factor of the inductance of the receiving instrument to be dealt with separately, and consequently in a more exact manner.

The principal difficulty in the application of the system is the necessity for the use of a new code of signals, or a reduction in the speed value to admit of conformity with existing codes. The existing Wheatstone automatic instruments are also light, portable, and adapted for use in outlying districts at short notice, where the synchronograph would probably be found to be less suitable. The perforator at present in use for the preparation of the transmitting "slip" has also, by a process of evolution, become extremely convenient and equally suitable for hand working in confined spaces or where power is available.

A suitable and easily manipulated perforator for the synchronograph has yet to be devised. Messrs. Squier and Crehore, however, deserve great credit for the discovery, with limited means of experiment, of an improved and promising system of high speed transmission.—Nature.

A MIRROR PSEUDOSCOPE AND THE LIMIT OF VISIBLE DEPTH.

By Prof. G. M. STRATTON, University of California.

IN the course of an interesting review of recent work on the visual perception of depth,* M. Bourdon comes to the question why the heavens seem the particular distance above us that they do. In substantial agreement with Lipps, he explains the matter as arising from the limitations of binocular vision. There is a limit beyond which all objects appear equally distant, so far as immediate stereoscopic appreciation of their positions is concerned; so that the stars cannot be directly felt as farther than the maximal range of binocular effectiveness. This maximum, therefore, whatever it may be, fixes for us the distance of the vault overhead. Taking an angle of 60″ as the threshold for the perception of spatial differences in the visual field and 65 mm. as the average interocular distance, he computes the range to be about 220 meters, and believes that this agrees fairly well with the apparent distance of the sky.

By a similar computation, after experiments in discriminating the distances of objects less than a meter from the eye, Helmholtz† gives "240 meters or more," as an estimate of the extreme distance at which an object might still appear in stereoscopic relief against a background infinitely remote.

These numbers were doubtless intended only as rough approximations of the actual limit. But a more direct examination of the fact inclines me to believe that they can hardly be accepted even in this spirit, and that the method by which they were made must in some way be open to objection.‡

The problem, it seems to me, can be attacked by means of the pseudoscope, and perhaps most conveniently and successfully when in the form shown diagrammatically in the accompanying figures. A box provided with two eye holes (near *L* and *R* in Fig. 1) is open on the side opposite these holes. In the box are two perpendicular mirrors (*M* and *N*) inclined at a horizontal angle of 45° to the line of sight. Each of these mirrors is rigidly held in a small frame (for simplicity's sake, not indicated in the figure) which can be slipped to the right or left in the box and, if need be, turned slightly so as to vary the inclination of the mirrors. In a well constructed instrument the entire movement of the mirrors would be delicately controlled by thumb screws. The mirror, *M*, faces outward and to the right; the mirror, *N*, inward and to the left.

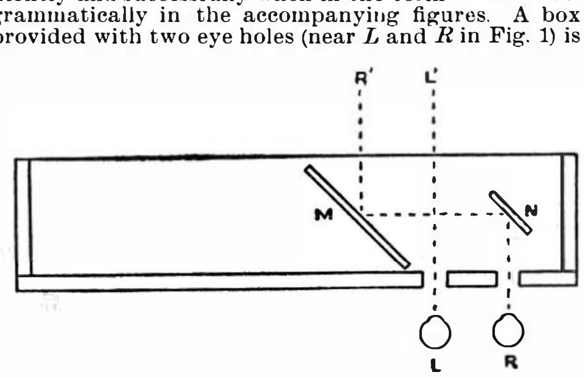

FIG. 1.—NORMAL PSEUDOSCOPIC VISION.

It is apparent that when the mirrors are in the position shown in Fig. 1, the left eye is in direct view of the scene along the line, *LL'*, while the right eye receives its light along the doubly reflected line, *RR'*, so that its view of the scene is practically from a point to the left of the left eye. The relative points of view of the two eyes are thus interchanged and a vivid pseudoscopic effect results. With a little care in adjustment the distance between *R'* and *L'* can be made equal to the interocular distance, and the difference in parallax for different objects remains the same as in normal vision. But the instrument also permits a wider separation of the lines, *R'* and *L'*, by carrying the larger mirror farther to the left (as in Fig. 2). This arrangement increases

* Les résultats des travaux récent sur la perception visuelle de la profondeur. L'année psychologique, iv, 390.

† Physiologische Optik, 2d ed., pp. 790, 791.

‡ Prof. Le Conte, in putting the limit at "perhaps a quarter of a mile" (Sight, 2d ed., p. 163), comes nearer the mark, although I believe that this, too, is short of the true figure. He does not state the method by which he reached his result.