Herschel, C. Continuous Revolving Draw-Bridges. 54 p. 8°. Boston, 1875. Nineteen illustrations in text and 10 plates. The first complete theoretical discussion in the English language of drawbridges built as continuous girders. Some of the refinements are here treated for the first time.

Merriman, M. Theory and Calculation of Continuous Bridges. 130 p., 24°. New York, 1876.

Merriman, M. Roofs and Bridges. Part I. Stresses in Simple Trusses. 7+124 p. 8°. New York, 1888.

Howe, M. A. Theory of the Continuous Girder. 8+119 p. 8°. New York, 1889.

2. On Bridge Stresses—Graphic Method.

Du Bois, A. J. Elements of Graphic Statics, and their Application to Framed Structures. 51+404 p., 8°. With atlas of 32 double-page plates. 8°. New York, 1875. The first part gives the general principles, the second part the application to simple and continuous trusses, and the third part to the arch.

Cain, W. Theory of Solid and Braced Elastic Arches. 172 p. 24°. New York, 1879.

Greene, C. E. Trusses and Arches Analyzed and Discussed by Graphical Methods. Part I., Roof Trusses. 64 p. 3 pl. 1876. Part II., Bridge Trusses. 181 p. 10 pl. Part III., Arches. 13+190 p. 8 pl. 8°. New York, 1879. Part II., deals with single, continuous, and draw spans, and Part III., includes stiffened suspension bridges as well as metallic and stone arches.

Merriman, M., and Jacoby, H. S. Roofs and Bridges, Part II. Graphic Statistics. 7+124 p. 4 pl. 8°. New York, 1890. Confined to simple trusses of roofs and bridges in addition to the principles and methods of graphic statics.

Howe, M. A. Sabula Draw by Graphics. 35 p. 8°. Chicago, 1886. Comparative determination of stresses in a draw span by both analytic and graphic methods.

Hoskins, L. M. Elements of Graphic Statics. 8+191 p. 5 pl. 8°. New York, 1892. The first part relates to the theory of graphic statics, the second to simple trusses and the third to centroids and moments of inertia.

La Rue, B. F. Graphical Method for Swing Bridges. 104 p. 3 pl. 24°. New York, 1892.

3. On Stresses and Construction.

Whipple, S. Work on Bridge Building. 120 p. 10 pl. Utica, 1847. This was the pioneer work in the rational discussion of stresses and the proportioning of members in simple trusses. A later edition, published in New York, 1872, contains 6+319 p. 8°. The treatment of details of construction of wooden and iron bridges occupies more than half of this edition.

Haupt, H. General Theory of Bridge Construction. 268 p. 16 pl. 8°. New York, 1851. The first part treats of the resistance of materials, stresses in simple trusses and methods of construction. The second part gives a description of ten wooden and five iron railroad bridges, accompanied in most cases by the bills of material. One of the iron bridges is the 55-foot span plate girder bridge invented by Jas. Millholland, and erected in 1847.

Wood, DeV. Treatise on the Theory of the Construction of Bridges and Roofs. 10+249 p. 8°. New York, 1873. Almost entirely on stresses.

Bender, C. Practical Treatise on the Properties of Continuous Bridges. 150 p. 24°. New York, 1876.

Cain, W. Maximum Stresses in Framed Bridges. 192 p. 24°. New York, 1878. Also compares several American types of bridge trusses as regards weight and considers economic depth.

Ricker, N. C. Construction of Trussed Roofs. 158 p. 4 pl. 8°. New York, 1885. Two chapters are devoted to the design of a wooden and an iron roof truss and their details of construction, while the rest of the book relates principally to stresses. As most text books on bridges also treat of roof trusses this work is inserted in the list.

Burr, W. H. Stresses in Bridge and Roof Trusses, Arched Ribs and Suspension Bridges. 1st ed. 1880. 3d ed. 1 +454 p. 12 pl. 8°. New York, 1886. The discussion of stresses in bridge trusses includes also swing or drawbridges not mentioned in the title. Nearly one-third of the book treats of the details of construction and the design of a wrought iron through railroad bridge. The details of the bridge are shown on the plate.

Du Bois, A. J. Strains in Framed Structures. 1st ed. 1883. 7th ed. 228+540 p. 28 pl. sq 4°. New York. The first part (three-fifths of the whole) is devoted to the determination of stresses, the discussion relating to suspension systems and continuous girders being quite extended, while that on elastic arches is very brief. In the seventh edition the theory of the cantilever truss was added. In the second part 124 pages are devoted to describing the forms of bridge members and their details and the methods of dimensioning them, illustrated by numerous independent examples, and following this are chapters on the derivation of formulas for dead weight and economic depth, on the design of an iron railroad bridge, on shop drawings, on ordering, shipping and inspecting bridge material, and on bridge erection. The plates include detail drawings of the wrought iron truss and of a number of travelers and false works used in erection.

Johnson, J. B., Bryan, C. W., and Turneaure, F. E. Theory and Practice of Modern Framed Structures. 11+527 p. 39 pl. sq. 4°. New York, 1893. The first part (230 p.) contains the discussion of stresses in simple, continuous and cantilever trusses, suspension and drawbridges and arches. The second part opens with details of construction, followed by designs of a plate girder, an iron roof truss, a pin-connected railroad bridge, and a highway bridge, and two standard plans for Howe trusses. Succeeding chapters deal with swing bridges, trestles, elevated railroad structures, stand-pipes, tall building and mill building construction. The chapter on the aesthetic design of bridges is illustrated by numerous diagrams and half-tone views of bridges. The appendix contains articles on structural steel, general specifications, manufacture and inspection, and American methods of erection. All designs are accompanied by general detail drawings.

Bovey, H. T. Theory of Structures and Strength of Materials. 15+817 p. 8°. New York, 1893. A portion of this work is on stresses in roof and bridge trusses, including arched ribs, draw, cantilever and suspension bridges; and the details of construction also occupy a small space. The larger part is on the mechanics of engineering.

The subject of stresses in trusses is also treated in several other works on mechanics, such as those by Church and Lanza.

(TO BE CONTINUED.)

A Historical Sketch of Railroad Signaling*

The commencement of railway signaling may be said to have been contemporary with the introduction of the locomotive. Railway engineers at once recognized the importance of securing immunity from collision, and from that time to the present, a remarkable amount of ingenuity has been brought to bear upon the art. Notwithstanding this, the best practical applications have fallen short of securing the desired degree of safety. The ever varying contingencies of railway traffic, and the seeming impossibility of reducing the human factor beyond a certain point, are two of the many difficulties which have faced the signal engineer. One of the greatest difficulties in the way of efficient signaling in this country, is the lack of sufficient side track siding accommodation, and the attendant inferior arrangement of switches. This matter of proper switch arrangements greatly affects the safety of the line, and it is almost impossible to properly signal a badly arranged system of tracks. A great number of fatal accidents have been caused by using the main tracks for passing or shifting purposes. The danger in railway travel arises from the irregular movements. If all train movements could be made as laid down by the time tables, we should have few collisions. Owing to the rapid increase of railway traffic in England after the introduction of the locomotive, the need of proper signaling appliances was much sooner felt in that country than elsewhere, and we therefore turn to England for the early history of signaling.

I cannot give a better idea of the first steps in signaling, than by reading the following extracts from the *Railway Engineer* (London) of February, 1881.

"The importance of means and apparatus, for communicating intelligence, by signs or signals, between distant places, was recognized at a very early date, and amongst the earliest appliances for effecting this end, we read of the semaphore or its equivalent, which form is still chiefly preserved on almost every railway, whether home or abroad. Probably the first record of a semaphoric system is that described by Polybius in ancient Grecian history, for transmitting messages by its combinations spelling out words. In 1700, semaphores were exhibited in France, and we learn of their application again during the French Republic. A Prussian semaphore was then invented with three arms, capable of indicating 4,000 different signals. We next hear of its introduction into Russia in a more expensive and elaborate form, during the days of Emperor Ncholas I., with a view to transmitting both civil and military intelligence. But Dr. Hooke was about the first to associate his name with semaphores in this country, and in 1814 the Admiralty adopted Macdonald's system, which was subsequently improved upon by Admiral Popham and Lieutenant Colonel Pasley.

At the commencement of railway engineering, as previousy stated, it was obviously necessary that some scheme would have to be devised to conduct and regulate the transit of trains with safety and reliability. But although our engineers thus early recognized the value of the semaphore signal, each preferred to supply his own contrivances for the railways under his command. Therefore there was very little similitude in design or action, but signals were variously modified according to individual fancies, and in some instances even carried to such extremes that similar signals on different railways had opposite significations.

On the first railway opened, the Liverpool & Manchester, in 1830, the signals were given by square or circular boards fixed at the top of poles, of sufficient height to insure their being easily seen. Figure 1, plate 73, represents a front and end elevation of such signal, in which the boards and the post, are capable of being turned practically round on a vertical axis. One side of the board was painted red implying danger, and was to be considered 'on' when placeed transversely, or at right angles, to the road, and 'off' or 'line clear' when turned half round, or parallel to the rails, presenting an end view to the driver of an approaching train The lamps for night signals were fixed to the board or post, receiving the same relative motion, and presenting respectively a red or white light. The signals were located on the left of the train.

On some lines no fixed signals were originally used, the traffic being entirely conducted by hand signals, but from the first, uniformity of color was observed. For example: on the Greenwich line only hand lamps and flags were employed, the signls being given by men situated at different parts of the road; which method proved as inefficient as expensive, and in 1845 the system was condemned as utterly useless. In windy weather when the flags were blowing in the direction of the train, the signals could not be seen at all.

But after this date flag signals combined with mechanical ones were considerably used, and often resulted in conveying conflicting intelligence, and causing many sad accidents.

The Great Western line employed partially rotating perforated disks, with a rectangular board below, fixed on the post at right angles to the disk. This arrangement is shown in fig. 2. The Lancashire & Yorkshire railway used signals consisting of two disks, situated on arms at right angles to the post, commonly termed "spectacle signals," and shown at Fig. 3.

In the meantime some of the Irish railways adopted a rotating pennant-shaped signal as represented at Fig. 4.

Figures 5 and 6 represent respectively the early signals used on the Black Wall and Grand Junction Railway. Figure 7 shows the class of day signal employed by the Southwestern Railway in 1840, in which the disks are capable of turning on an independent horizontal axis, besides turning bodily with the post on a vertical axis. In this case one signal controls both the "up" and the "down" line by the various positions of the perforated disk, the movments of the same being affected by a cord passing over a pulley. The respective signals given by the relative positions of the solid segment in the disk, will be readily understood by reference to the sketch. When the disk is turned round bodily with the post so as to present an end view, it signifies both roads are "clear." This kind of visible day signal is still retained on some parts of the line.

Somewhat similar signals were used on the Brighton Railway for governing the branch and shunting traffic. They are shown at Fig. 8. But the disks were not provided with an independent rotary moton as in the above case.

In the meanwhle a modified "spectacle" signal became much in vogue on the southern railways, and is represented at Fig. 9. The general design is exactly similar to those used on the Lancashire & Yorkshire, but on the Southern railways the posts were fixed, while the arms and disks at their extremities were capable of partial vertical rotation about a clear horizontal axis, through the intervention of ropes or chains passing over pulleys and actuated by levers.

Balance cross bar signals were next tried on the northern railways as shown at Fig. 10. And in 1841, the semaphore signal was introduced on our railways by Mr. C. H. Gregory. It rapidly superseded all other kinds of visible day signals, and maintains its superiority to the present day. Figure 11 represents the early semaphore signal, which consisted of two arms, capable of being radially raised or lowered through an arc of about 90 degrees; the left hand arm only concerned the driver of an approaching train, and when at right angles to the post signified stop or danger, when at an angle of about 45 degrees or half lowered, caution, and when almost parallel with the post, go ahead or line clear. The night visible signals were worked in concert with the arms by imparting radial reciprocating motion to a pivoted frame provided with bi or tri-colored glasses. The glasses were thus moved over the face of a fixed lamp presenting a red, green or white light, in accordance with the previously mentioned respective day signals.

These different positions of the arms for transmitting signals of intelligence were seen at a greater distance than any other previous signal. The arms were worked by stirrups, located in cabins, and the point switches were independently shifted. Semaphore signals actuated by passing trains, were tried on the North London Railway, but proved unreliable.

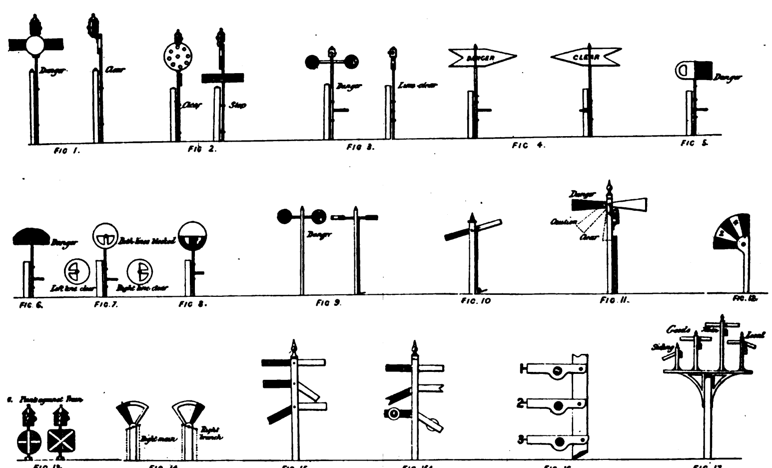
In 1842 a novel signal, invented by Mr. C. Hall, was introduced on the Eastern counties railway. It consisted of five leaves of fillets, each of different color, put together like a fan, each colored sector representing a different elapse of time, thus enabling the driver to know how long ago the previous train had passed that point. The arrangement is shown at Fig 1.

These visible mechanical time indicators were not found to answer long. A scheme for the same object had been devised and tried elsewhere, but was never successfully adopted. It consisted of a copper ball, which when placed at the top of a vertical guide post occupied about ten minutes in its descent, thus indicating by its relative height how long since a train had passed.

Mr. Whitworth, the well known mechanical engineer, provided the Lancashire & Yorkshire with a mechanical disk and gong signal for protecting trains during their transit through tunnels. By combining both visible and audible signals, the driver could not make a mistake.

Auxiliary or distant semaphore signals were next adopted for indicating, at intermediate positions of the road, how the home signals stood before sighting them, which signals were worked from the home cabins by levers and wires.

The early signals for indicating to the driver the position of the switches, were in most cases similar to those signals already described, with the exception of size, as shown in Fig. 13. Figure 14 shows a rather different switch indcator, used by the Southeastern Railway Co., for governing branch switches, in which a vertical radial arm was worked to the right or left by rods or chains.



History of Railroad Signals.

"Plate 73;" with paper by Mr. A. H. Johnson.

*From a lecture by Mr. Arthur H. Johnson delivered before Lawrence Scientific School, Harvard University, Cambridge, May, 1894.

It will be necessary here to break off from the elements of early "out-door" signals to briefly review what had been going on in the cabins or "indoor" department.

Electricity having been so successfully introduced for commercial purposes, its utility and applicability to railway signaling was very soon obvious, and Messrs. Cooke and Wheatstone were the first to show us how to apply it, and obtained a patent in connection therewith in 1837. Their "indoor" electrical signaling instrument was really nothing more than what we now know as a galvanometer; it had five deflecting needles which served to indicate any required signals by a code of signs.

These gentlemen spent some time in trying to introduce it to the Liverpool & Manchester, and it was subsequently adopted by the Eastern Counties between Norwich and Yarmouth and afterwards by the Great Western line.

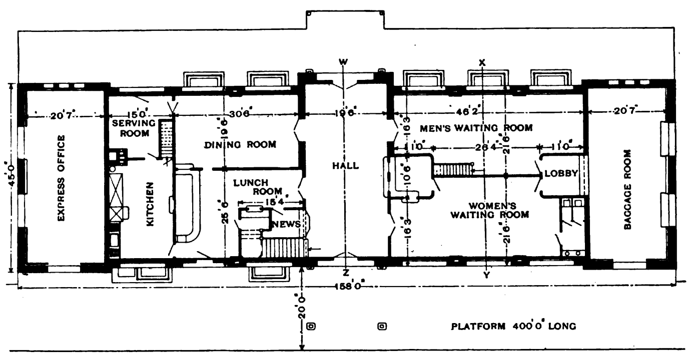
Until 1840, the line wires for connecting these and other similar electrical transmitting and receiving instruments, were insulated by a covering and placed in pipes under the ground, but it was subsequently discovered that the bare wires might be supported on poles in the open air, with glass or earthenware insulators, to prevent them communicating with the earth, through the poles, to which show how far the train had traveled unimpeded in the time, and, therefore, there was always the risk of being caught up by a succeeding train and run into.

Not long after, Mr. Edwin Clark improved upon this very imperfect mode, and introduced to the London & North Western Railway the now well-known "block signaling system," meaning the maintenance of a definite and unvarying interval of "space" between trains, instead of time.

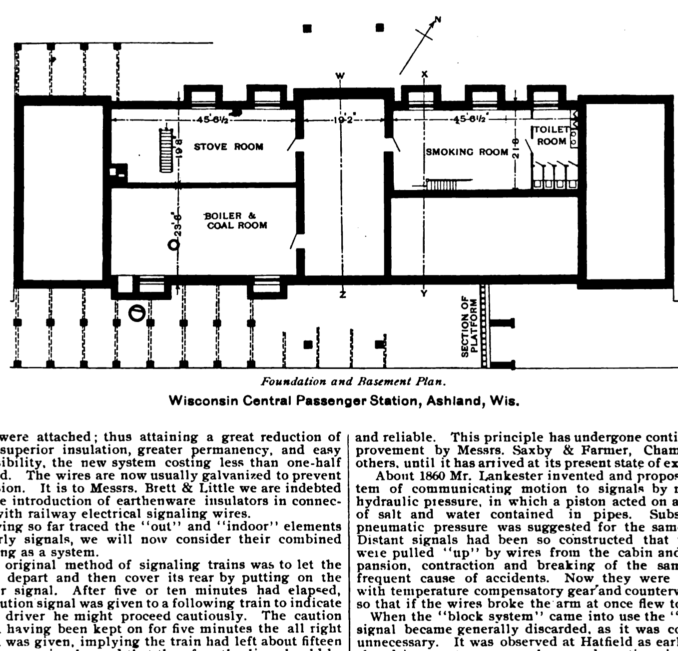
In 1852 Mr. E. Tyer made several improvements in this system, which were rapidly adopted by the London & Brighton, and subsequently by the South Eastern. This gentleman, with such other eminent electricians as Mr. Preece and Mr. Walker, have continued the work of improvement until we recognize the instrument of to-day.

It was not until 1856 that conflicting signals, or contrary positions of switches and signals, were prevented by the introduction of Mr. Saxby's now well known "interlocking system" in which an arrangement of mechanical obstacles rendered improper relative positions of the switches and signals impossible. Thus, by an ingenious arrangement of pins, working in slots, the position of the switches and signals of the most complicated junction were rendered safe


North Elevation.



First Floor Plan.



Foundation and Basement Plan.

Wisconsin Central Passenger Station, Ashland, Wis.

they were attached; thus attaining a great reduction of cost, superior insulation, greater permanency, and easy accessibility, the new system costing less than one-half the old. The wires are now usually galvanized to prevent corrosion. It is to Messrs. Brett & Little we are indebted for the introduction of earthenware insulators in connection with railway electrical signaling wires.

Having so far traced the "out" and "indoor" elements of early signals, we will now consider their combined working as a system.

The original method of signaling trains was to let the trains depart and then cover its rear by putting on the danger signal. After five or ten minutes had elapsed, the caution signal was given to a following train to indicate to the driver he might proceed cautiously. The caution signal having been kept on for five minutes the all right signal was given, implying the train had left about fifteen minutes previously, and that therefore the line should be clear. On the Liverpool & Manchester, the red light, or board, was kept on for three minutes after the train had departed, then the green light, or half-turned board for five minutes, thus giving a line-clear singal after the lapse of eight minutes.

It is obvious that this system could not guarantee at any time the line to be really clear, for although it could indicate how long a train had been gone, it could not and reliable. This principle has undergone continued improvement by Messrs. Saxby & Farmer, Chambers and others, until it has arrived at its present state of excellence.

About 1860 Mr. Lankester invented and proposed a system of communicating motion to signals by means of hydraulic pressure, in which a piston acted on a solution of salt and water contained in pipes. Subsequently pneumatic pressure was suggested for the same object. Distant signals had been so constructed that the arms were pulled "up" by wires from the cabin and the expansion, contraction and breaking of the same was a frequent cause of accidents. Now they were provided with temperature compensatory gear and counterweighted, so that if the wires broke the arm at once flew to danger.

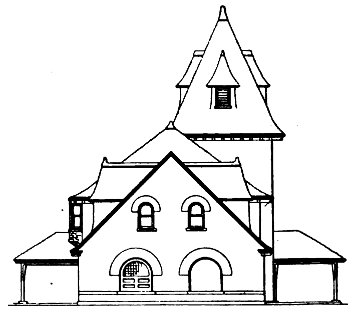
When the "block system" came into use the "caution" signal became generally discarded, as it was considered unnecessary. It was observed at Hatfield as early as 1856 that drivers not uncommonly passed caution signals at a rate of 35 miles an hour, and at Lewisham in 1862 many persons lost their lives through such negligence.

The foregoing passage from the *Railway Engineer* gives us a good idea of the early steps in signaling. Some notes on the progress in other features of the art will be given in a subsequent chapter.

[TO BE CONTINUED].

The Union Passenger Station at Ashland, Wis.

The accompanying engraving shows the general design of the Union Passenger Station recently erected at Ashland, Wis., for the Wisconsin Central Railroad Co., after the plans of Mr. S. S. Beman, Architect, Chicago. The station is used jointly by the Wisconsin Central Lines and the Northern Pacific Railroad Co. The building is constructed of Lake Superior brownstone, laid in random rubble with limestone water table and sills. The roof is of tile. The outside woodwork is painted olive. The inside woodwork is white pine, the basement and first


Ashland Station, East Elevation.

floor being finished in oil and the second floor painted. The building is heated by steam from a small boiler in the basement, and lighted by electricity; light and water being supplied by the local company.

The arrangement of the main floor is clearly shown by our engraving, the baggage room being at one end and the express office at the other, and the intervening space occupied by waiting rooms, a hall, and lunch and dining-rooms. The upper floor furnishes room for various local offices of the company. The cost of the building was about $30,000.

The Liverpool Overhead Railway.

The directors' report for the first half of the present year has just been issued. The number of persons carried during the six months reached a total of 2,861,437; 277,653 first class, 1,246,975 second class, and 1,336,809 workmen passengers at special rates. These figures, as compared with the two previous half years—that is, since the opening of the line—show a steady increase. From March 6 to June 30, 1893, the total number carried was 1,370,742 (made up of 235,487, 956,922 and 178,333,) while for the second six months of last year the numbers were 2,475,639 (made up of 260,221, 1,293,840 and 921,578). These figures show the almost stationary character of the first class travel, with an actual dimunition in the second class, and a heavy increase (50 per cent.) in what corresponds practically to the third class. This is quite in accordance with the general experience on English lines where the three classes are still in use. During the past half year 50,483 trains have been run, makng a total mileage of 265,349, as compared with 243,539 in the previous period. Punctuality has been well maintained with the automatic electric signalling system, 96 per cent. of trains being on time. Of the 7 miles 5 chains authorized, 6 miles 4 chains have been built and are operated; the rest is in hand with early expectation of being finished.

Turning now to the financial results, the gross receipts for the six months approximate to $100,000, whilst the working expenses are $74,735, giving a proportion of 74 per cent. as near as may be. This is the same as for the previous half, when the amounts were $91,710 and $63,660 respectively, so that no great saving of cost in working the line has been achieved. The proportion seems high, even for a short line with many stations. Although a greater train mileage has been made, yet the total expenditure on locomotive power is nearly 25 per cent. less than previously when the line was worked under contract at a fixed sum per train mile. The cost of fuel works out to .81 of a penny per train mile, and the total running expenses—including wages connected with the generating plant and motors, fuel, oil, tallow and other stores—do not exceed 2.73 pence per train mile, or say 5½ cents. Renewals and repairs under this head come to £157 only, say $785, making a total of £3,179, or $15,895.

By far the heaviest item in the total expenditure is put down to traffic expenses, which include all salaries and wages, station expenses, etc., and this amounts to nearly one-half of the gross expenditure. The sum named—£6,276 or $31,380—covers salaries and wages, fuel, lighting, signalling, water and stores, clothing, printing and stationery (tickets, etc.), and is 20 per cent. heaiver than for the preceding half. The net revenue—after paying interest on mortgage debentures and calls paid in advance—is sufficient with the balance brought from last half year to pay the full dividend of 5 per cent. upon the preference shares and a dividend of 1 per cent. upon the ordinary shares, with a balance of $5,000 carried forward.

The Liverpool Overhead line has thus taken a much shorter time to reach a dividend paying stage than the less fortunate City & South London underground, although for the past half year the latter has done so much better that its directors have also voted a dividend of 1 per cent. upon the ordinary shares instead of the 5/8ths of 1 per cent. hitherto divided.