Correspondence.

Mr. Berridge. Mr. H. BERRIDGE remarked that his experience of the subject was limited principally to fighting his way in and out of cars during "rush" hours on the elevated and surface car systems in Greater New York about 10 years ago. His surviving impression was one of admiration for the organization which effected the transport of such immense numbers of people at a marvellously cheap rate, coupled with a feeling of devout thankfulness that he was no longer one of the human units so transported. The Author was a past master in the art of designing those heartless New York stations where the hapless passenger, once started on a stream of traffic, had no chance of turning aside until the stream stopped, even though the "transportee" desired it never so strongly. *Nulla vestigia retrorsum* ought to be, if it were not, the motto of the Rapid Transit Railroad Commissioners of New York City. In such systems the human being was looked upon as an animated parcel—its dimensions, weight, rate of unassisted progress, air-consumption, and other characteristics were all carefully tabulated, and stations, cars, seats, and other apparatus were all calculated to fit it with no little nicety. The elusive factor was the number of parcels to be dealt with in a given time, which, in spite of every effort, seemed to defy forecasting or the provisions made to meet it during "rush" hours. The absence of regulations as to seating produced the most extraordinary crowding, which, though in the main good-natured, was by no means pleasant, especially in a company of both sexes. The New York subway referred to was under construction while Mr. Berridge was in that city, and he had noticed particularly the freedom accorded to the builders compared with that accorded in London, where he had also had some experience in this class of work. In London a shaft was sunk here and there, surrounded by an æsthetically-decorated hoarding, inside which the works progressed almost unnoticed by the general public. During the construction of the New York subway the whole of the streets affected were opened in every possible place, and large gas- and water-mains were deviated on trestles over the sidewalks in a very workmanlike but unpresentable way. He had a vivid recollection of being prevented just in time from stepping off a surface car into a subway excavation 20 feet deep, alongside which the car had stopped, and which was absolutely unprotected. The

Londoner was apt to grumble at much smaller inconveniences, and it would do him good to learn from the New Yorker how to join in the spirit of the thing and to realize that such discomfort was only temporary and would benefit him in the long run. A point in design which impressed Mr. Berridge was the trouble taken to put in transition-curves, compensation on gradients, and vertical curves to connect gradients; in fact, every device to get the traffic along as fast as possible with safety. Rail-joints also generally broke joint, as on all American tracks, which did away with the uncomfortable rhythm of the wheels passing over rail-joints, so noticeable in London tubes. As far as New York was concerned, he considered that if more attention were given to street-surfaces, so that motor-traffic could be employed, much relief would be afforded to the railways, which still appeared to be badly congested during "rush" hours. There used also to be much difficulty in making cross-country journeys, say, from Brooklyn terminus to steamer-quays on the west side. The cross-town cars used to be few and slow, and the consequence was that the only thing to do in such cases was to take the elevated to the nearest station and walk—often considerable distances. This meant that the elevated had to carry a deal of traffic which did not really belong to it. However, the Americans had so far pinned their faith to railways, and as long as the track was workable the rest of the street generally got little attention. The streets along the water front were in a parlous state in his time. Personally he could not endorse the Author's recommendation to small towns to go in for elevated railways. The noise, unsightly appearance, and loss of amenity depreciated property greatly, and in Europe, at all events, the compensation due to abutting owners would certainly be a large set-off against any economy obtained by their construction compared with a subway. Only exceptional conditions, such as those at the Liverpool docks, could justify the construction of such a general nuisance. Mr. Berridge.

Mr. LIONEL CALISCH observed that on comparing London traffic facilities with those of America, it would be seen that in New York the number of rides per head of population in 1910 were 322, while in London in 1911 they were 228·8. According to the Tables given in the Paper, the population of New York between 1900 and 1910 increased by 38·8 per cent., the number of passengers carried by 81 per cent., and the number of rides per head of population by 30 per cent.; while in London from 1901 to 1911, according to the London Traffic Report for 1912, the population increased by 9·2 per cent., the passenger-traffic 89 per cent., and the number of rides per head of population 72 per cent. It Mr. Calisch.

Mr. Calisch. would be interesting to know if the Author could give any information in regard to the financial results obtained on the underground and elevated railways in New York and other States. In London it did not appear that any of the tubes or underground railways paid a satisfactory dividend upon the capital expended. According to the London Traffic Report of 1912, the London underground railways and tubes would have to carry another 209·5 million passengers annually before they could pay 4 per cent. upon their ordinary shares. A long time would elapse before they carried this number. There was no doubt that the number of passengers carried per mile of track in New York was very high. He understood that the Author referred to "miles of single track," and not to "route" miles. In London the densest traffic was carried on the Central London Railway, on which the number of passengers per route mile averaged 5·51 millions per annum, or 2·75 millions per mile of single track, which, of course, was a much lower figure than that obtained in New York. The increase in the capacity of lines that had been electrified was a well-known advantage of electric traction, but it would appear that sixty trains per hour was the utmost limit of the present capacity of tube railways. It appeared, therefore, that some other means of transportation would have to be adopted if a tube railway was to be utilized to its fullest extent; that was, some means that would ensure an absolutely continuous succession of trains. Mr. Wellman's suggestion in regard to increasing the distances between stops was, to Mr. Calisch's mind, very applicable to London tubes. Some of the present stations could very well be cut out altogether, which would have the effect of increasing the scheduled time and decreasing the power-consumption. On most of the London underground railways the average distance between stops was about 0·4 to 0·5 mile, and the scheduled speed about 15·5 miles per hour. The Author mentioned that several improvements were made in the train-equipment when the number of cars per train was increased from eight to ten. Mr. Calisch understood, however, that these improvements had to be carried out on account of several failures of the train-equipment. He would like to know whether trouble had not been experienced with the "shoe" fuses on the front and rear motor-cars, which fused continually. Was it true that the trouble was due to the fact that the bus-line resistance was less than that of the third rail in parallel with it, and that consequently a large portion of the current in the third rail was passed through the bus-line and the fuses? Did a resistance in series with the bus-line overcome the difficulty? Most automatic signalling in New York appeared to be done by alternating-current track-circuiting, and the system was being introduced into England. The first installation had been made on the Central London Railway. He would like to know whether the train-stops in America were found to be satisfactory. Judging from the fact that the New York, New Haven, and Hartford Railway had recently offered a large money prize for a satisfactory design, it would appear that there was still some room for improvement, and he would like to know what were the defects of the present train-stop. Of course, the blow received by a stop striking a projection on a train moving at the rate of 20 to 30 miles an hour was considerable. Failures of train-stops had occurred in England, the most recent happening on the Great Northern and Piccadilly Railway and resulting in a collision. The Board of Trade, however, considered the stops satisfactory, although admitting that they could be improved, and experiments were now being carried out with a view to make them absolutely safe. The lifts on London tubes certainly wasted a great deal of the public's time, as there seemed to be no relation whatever between the arrival of a lift and the arrival of a train, and it often happened that passengers reached a platform just as their train was disappearing. A wait of 5 minutes or so resulted sometimes, when the next train happened to be a non-stop one. Escalators were far superior to lifts, and it was to be hoped that the tube railways would install them generally. Mr. Calisch.

Mr. A. J. COUNTY, of Philadelphia, pointed out that the reason why the City of New York received no tenders, as mentioned on p. 175, was that the distinction became clearly recognized between a rapid-transit system—serving but one general territory, running trains on close headway, with a uniform fare of 5 cents, and without luggage or other parcel-traffic to carry and handle at the stations—and the main-line railways, having graded fares and trains of varied composition, serving many different districts, and carrying not only passengers but also luggage, parcels, express, milk and other light traffic, and with many causes to interfere with preserving an exact time-table with trains from outlying points. In short, it would not have paid the main-line railways to incur this heavy cost of subway-construction for passengers paying only 5 cents fare, and, what would have been more serious, it would have meant disruption of the city's rapid-transit service and outlay on larger tunnel-sections and rolling stock. The vertical clearance was therefore reduced to 13 feet 2 inches, and the lines were restricted to city rapid-transit purposes; but the new subways were being constructed to enable a longer and wider car to be used. With regard to franchise conditions in the United States, so far Mr. County.

Mr. County. as subways were concerned, their heavy first cost, the risk of the construction of competitive lines by the city, if not by other capitalists, and the heavy traffic required to render them remunerative, with constantly increasing taxation assessments, had caused private companies to look to the municipalities to construct them, because of the advantages which such public bodies possessed over a private company in the following respects: (1) general ability to raise capital at lower rates of interest; (2) if a deficit occurred, it was paid by the city under its taxation plans; (3) the lines opened up new areas and increased the taxable value of property, and some cities could afford to build lines for the sake of profits to be obtained in this way, although these lines might not be directly profitable; (4) a city or municipality could determine in the general public interest to construct some rapid-transit lines irrespective of the question of profits, either for the sake of this increase in the taxable value of property, or to relieve congested residential areas, or to encourage greater population. Real rapid transit required the construction of underground or elevated lines, and New York had given a demonstration of the desirability of first constructing elevated lines and supplementing them later by subways. With later improvements, both in construction and in working, a much superior type of elevated railway, with less objectionable features, could be constructed and worked. Boston, by its successive steps in handling the rapid-transit problem under conditions that would obtain in an average-sized city, had established a rapid-transit scheme more within the power of the ordinary city, namely, first, concentration of the surface lines in subways under the congested parts of the city; secondly, the construction of partial subways and elevated lines—the latter plan also obtaining somewhat in New York. In Mr. County's opinion these steps ought to be taken by almost every city before sufficient justification was found for the construction of subway lines. It would pay the larger municipalities, in order to extend their residential sections and provide cheap homes for the working classes, and for recreational purposes, to construct elevated railways where required, and, when they had been in operation for about 30 years, replace them by subways, if overcrowded or obsolete.

Mr. Gibbs. Mr. GEORGE GIBBS observed that the Paper could not fail to be of great interest and value to students of rapid transit in cities. It so admirably summed up a variety of topics that detailed criticism seemed somewhat out of place. With regard to elevated railways, this American invention for transit through city streets had been much criticized in respect of unsightliness and noise from moving trains. Elevated railways were adopted in New York as a relatively cheap means of transit in a long narrow city in which the distance between the business and residential districts was necessarily great. They were at first looked upon as an experiment, and were not popular, being even regarded, though wrongly, as unsafe; but the need of rapid communication, in a city which could extend its area in one direction only, forced people to use them, and they soon became both popular and profitable. At present they were regarded as too useful to permit of their removal, notwithstanding the presence of an extensive subway system which ran parallel to them; but it was improbable that any more elevated lines would be authorized in the central districts of the very large American cities. In order, however, that a subway should be profitable, the density of traffic must be very great, and this was only possible in the thickly-populated districts of the large cities. Therefore future rapid transit would be by subways in the centres of the great cities and by elevated roads in the outlying districts. The Author referred to two types of stations, the "stub-end" and the "loop." Mr. Gibbs considered that the construction of loop stations was seldom warranted, except to avoid crossover movements into a storage-yard. A dead-end station having multiple tracks and platforms was simple and compact, occupied the minimum of space, and could be operated with as close a main-track train-headway as could a loop-track station. The first New York subway, which was completed in 1905, dealt with probably the heaviest service and most exacting conditions of any attempted at that time in urban transit. It was a four-track railway in a tunnel, with a large amount of curvature and limited clearances. The express service especially was very exacting, requiring an average speed of 25 miles per hour, with stops 1½ mile apart, involving a maximum speed of at least 45 miles per hour between stations. In its equipment this subway might claim to be the pioneer in at least two important innovations tending to safety in the working of rapid-transit railways, namely, an improved signalling-system and the introduction of steel passenger-cars. The Author had described the block-signal system adopted, which, on the express tracks, included a complete overlapping system, in which the overlaps were of sufficient length to bring a train—which might be running at the maximum possible speed at the point in question—to a stop by an emergency application of the brakes before it reached the end of the overlap, where another train might be standing, and provided, in addition to the signals, automatic tripping devices which would cut off the power and apply the brakes on a train which passed a danger indication. This arrangement of adjusting the length of the over- Mr. Gibbs.

Mr. Gibbs. laps to conform with the motive-power capabilities of the trains at all points over the line was believed by Mr. Gibbs, who was consulting engineer for the equipment of the subway, to have been novel at that time. The first steel passenger-cars put in practical use anywhere were also part of the equipment of this subway and were the result of considerable experimental work in the years 1903 and 1904, when orders were finally placed for 300 all-steel cars. To-day, of course, none but steel cars were built for city rapid transit in subways, and, in fact, steel passenger-cars were becoming the standard of all railways in the United States. It might be interesting to state that the late Mr. Yerkes became interested in the development of the steel car, and early in the year 1905 ordered 112 cars for the Baker Street and Waterloo railway. These cars were built at Manchester by the American Car and Foundry Company. In 1907, 150 cars of the same kind were put in service on the Charing Cross, Euston and Hampstead railway.

Mr. Seaman. Mr. H. B. SEAMAN, of New York, observed that the Author had presented very interesting data, both historical and constructional, upon city passenger-transportation in the United States. The subject might be extended indefinitely, but the presentation practically covered the progress in "rapid-transit" development. The relative cost of elevated and underground railways was stated to be 1 : 5; but the ratio would vary greatly with the character of the construction of either system. An elevated railway would vary in cost about 50 per cent., according to whether it was designed with an open floor or with a ballasted track. The underground railway would also vary, perhaps 75 per cent., according to whether it was constructed in outlying districts or through a district of congested city traffic, and whether it was constructed above or below water-level. Since elevated railways were usually designed for outlying districts, their cost should be compared with that of underground railways in the same district, and in such case the relation would be nearer 1 : 3, or, in extreme cases, 1 : 2; while, if elevated railways in outlying districts were compared with underground railways through congested districts, and possibly below water, the comparison might be 1 : 8. It should be remembered also that the damage to abutting property must be added to the cost of elevated railways: in most cases this fully equalled the cost of the structure, and might greatly exceed it. On the other hand, an elevated railway, worked without block signals, was of greater traffic-capacity than an underground railway where block signals might be required. The comparison of the typical subway-sections shown on p. 187 was

Mr. Seaman.

of interest as indicating the gradual increase in size with the more recent designs. Probably the best designed and most conveniently worked underground railway in use at present in the United States was the one recently completed under Main Street in the city of Cambridge, Mass., and it would be noticed that this had the largest clearance (15 feet 4 inches) above the base of the rails. This larger size not only facilitated ventilation, but also offered less train-resistance in working. The additional cost of increasing the clearance from 14 feet 10 inches to 15 feet 4 inches had been stated by the late Mr. Geo. A. Kimball, Chief Engineer, to be about $1\frac{1}{4}$ per cent. The greater height and width permitted the use of larger cars, with resulting economy in operation. It should be noted that these larger cars of the Cambridge subway, which were 69 feet long, weighed less per lineal foot than the shorter cars, 51 feet in length, which had been in service in the New York subway. On p. 187 the Author called attention to the increase in the height of the Fourth Avenue (Brooklyn) subway to 15 feet above the base of the rails. When, as Chief Engineer of the Public Service Commission of New York City, Mr. Seaman took charge of this work, he found that the predecessors of the Public Service Commission—the Rapid Transit Commission—had considered that the height (13 feet) of their first subway was insufficient, and had increased their new work to 14 feet above the rail-base. Upon investigation he learned that to increase this height further to 15 feet would cost only about 3 per cent. more than their new design. The tenders for construction, from a number of contractors, would vary by 25 per cent. or more, according to the number of bidders and their anxiety to obtain the contract. By encouraging strenuous competition in bidding, therefore, the 3 per cent. increase for the better design would fade into insignificance. Further, it was important that the subway should be constructed so as to invite competition for the operating contract. There were two large companies operating in the city, the Interborough Rapid Transit Company and the Brooklyn Rapid Transit Company. The former was the only company using cars small enough for the smaller section. The latter company, and the suburban service of other railways, required at least 15 feet for their rolling stock. The importance of opening competition to all the operating companies was even greater than was the necessity of competition for construction, and with this as the controlling factor, the height of 15 feet was adopted. The value of this decision had been well illustrated in the subsequent developments. The city received no bids to its original advertisement for operators, because of the financial stipulations contained in the offer; but later, when these financial

Mr. Seaman. restrictions were removed, spirited competition took place for the operating contracts, from both the Interborough company and the Brooklyn company, and finally what were now termed the "dual contracts" were evolved, which would be undertaken separately by those two companies. The Brooklyn company undoubtedly would not have entered the field had not the city shown its willingness to construct a subway to meet its requirements; yet, on the other hand, when these contracts should be signed, with a provision for reversion to the city, it would remain to be seen whether that company would not prefer a smaller subway, with new rolling stock, thus fortifying themselves against competition by the suburban companies when the city attempted to resume possession. In writing the subway specifications of the Public Service Commission, from which the Author quoted, Mr. Seaman had used similar specifications to those which, as Consulting Engineer to the Department of Bridges, he had already written for the design of long-span and short-span bridges in New York City.[1] The clauses covering timber, which would be rarely used in subway work, were retained in these specifications to make them more complete.

Mr. Shaw. Mr. P. W. SHAW, referring to *Fig. 8a* (p. 184), wished to draw attention to the projections in the station-platform, to which the pathways led from left and right for the convenience of passengers boarding the cars, necessitating the trains being brought to a standstill within the very narrow limit of 11 feet, so that the door-openings in the cars should be opposite these projections. He was of opinion that the 6-inch space between the platform and the cars on each side of the projecting portion was a source of danger to the travelling public, especially during crush hours and at holiday times, when the passengers were apt to crowd the platform and get pushed beyond the ends of the guard-railings, where the width was only 12 inches for standing on, and the open space was wide enough for anyone to get one foot between the platform and the car; also that the fixed positions of these landing-places restricted the length of all future rolling stock to the one length at present in use, which might not be found to be the most suitable or convenient later on. When in New York during the construction of the underground railway, he had been much interested in the methods adopted for carrying the vehicular and electric-tramway traffic temporarily on timber flooring laid on beams and props, over the open cut, while the work of constructing the subway was in progress below the surface. Great credit was due to those in charge of the work for

[1] Trans. Am. Soc. C.E., vol. lxxv (1912), p. 325.

the excellent way in which so bold a scheme was carried out, with little inconvenience to the public. The proximity of the subway to some of the buildings, necessitating frequent and careful underpinning of the foundations of the existing walls, must have been at times a source of great anxiety to those responsible for the work. With regard to the ventilation of subways for railway traffic, the original design of the subway in New York was not conducive to good ventilation, as was found shortly after traffic began. The open oblong section, with two or more rows of columns, only tended to displacement of the more or less foul air from one track to another by the passing trains. With each track in a single tube, or in a partitioned portion of an oblong subway, a train would act like a loose piston, forcing the existing air out in front of it, while the partial vacuum formed at the rear would be quickly replaced by fresh air from the surface, through openings at the stations and vents made for that purpose in the roof of the subway. With respect to the question whether elevated tracks or subways were preferable, he thought subways were better for populated areas, as they were inaudible from the ordinary roadway, and if they were laid well below the level of the foundations of the adjacent buildings, little or no vibration would be felt in the buildings from passing trains; while elevated railways were a source of great annoyance from the noise overhead of passing trains, the diminution of light—which might not be objectionable in a sunny climate, but was decidedly so in a cold and moist one—and the dripping of water from the elevated structures during and after a shower of rain. One of the objections to subways was their heavy cost, and unless special attention was paid to ventilation, they were liable to become hot and stuffy in warm climates where the shade temperature on the surface ranged between 95° and 110° F. The Author stated that tie-plates were placed between the rail and the sleeper, presumedly to keep the flat-bottomed rails from cutting into the soft-wood sleepers. In the early days of steam-tramways in Sydney, N.S.W., steel tie-plates, or sole-plates, as they were called, were used under the joints of the rails, both rail and sole-plate being spiked to a sleeper under the joint. As they frequently became loose through the working at the joint, and noisy, they were abandoned altogether when the tracks were relaid with heavier rails, as it was found that the Australian hardwood sleepers were little affected by the foot of the rails, and that many years elapsed before they became chair-worn. The timber was also so tough that dog-spikes seldom became loose, and screw-spikes for holding Mr. Shaw.

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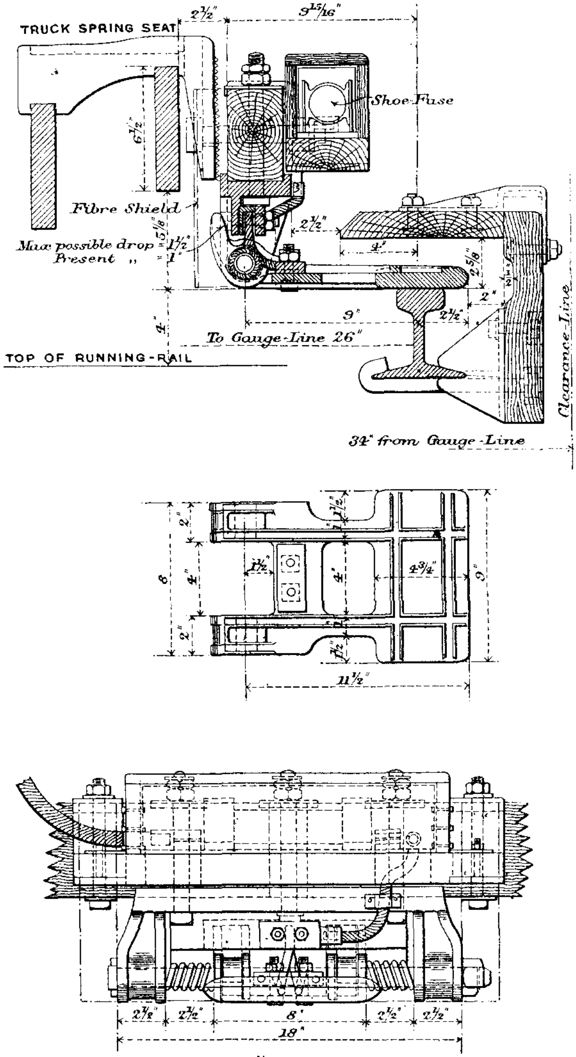
Mr. Shaw. down the rails were therefore unnecessary. The longitudinal steel box stringers under each rail for the multiple-unit trains in the Philadelphia subway appeared to be somewhat extravagant, considering they were bedded in concrete over brickwork, and although they were shown in Fig. 15, Plate 5, as being filled inside with concrete also, it was not apparent how such concrete could have been put inside between the two vertical and horizontal channels. Mr. Shaw considered that better results would have been obtained by laying and bedding the longitudinal timber stringers directly in the concrete brought up to and flush with the top of the stringers. A small spoon drain along the outer sides of the track, connected with the centre drain at convenient distances apart, with drain-holes under the rails and stringers, would have led the moisture away from the stringers and kept the subway dry. This applied also to the tramway-track in the Philadelphia subway, shown to be laid at a lower level than the multiple-unit track, and with the concrete brought up on the outsides, flush with the tread of the rails; and although this prevented moisture from collecting on the sides of the track, it would be better to connect the small spoon drains on either side of the track with the centre drain by means of small drain-pipes under the rails, so as to keep the rails dry, and prevent undue oxidation of the exposed steel surfaces. Mr. Shaw would be glad if the Author could supply some further information as to the kind of contact-shoes used on the third rail in the New York subway, as the space between the head of the contact-rail and the projecting timber covering appeared to be only about 3 inches, which seemed very small for a shoe to work in, although the system of covering and protecting the live rail was excellent. He would also be glad to have particulars of the shoes used in the Philadelphia subway for the bottom-contact system (Fig. 15), and how they were supported and kept up against the face of the contact-rail.

Dr. Zollinger. Dr. A. ZOLLINGER had followed with interest the progress made in North America in the means of transport described in the Paper. It was necessary for urban railways to adapt themselves to the increase and settlement of the population if their purpose was to be fulfilled. It was only cities with a population of upwards of a million that could bear the cost of underground or elevated lines; in others only a line at street-level could pay interest on the capital outlay. In Switzerland steam-locomotives were generally debarred from running through the streets, and the establishment of tramways was therefore delayed until the employment of electricity rendered them practicable. It was owing to the introduction of electric traction that cities were first enabled to develop rapidly outside their centres of communication. It then became possible to establish elevated and underground railways, free from the smoke nuisance, a step which greatly assisted the development of the cities. The centre—the business quarter—could be relieved, and the inhabitants could make their homes on the outskirts of the city, where they could live under healthy conditions and within easy reach of their work; and this state of things tended also to increase the influx of population to the great cities, which absorbed everything. The elevated lines, as being cheaper to establish, served for the local traffic, and the underground lines for through traffic, because, owing to the higher establishment-costs, the stations must be fewer in number, and therefore placed in the most important business centres. It was interesting to observe the increase in the number of rides per head with the increase in the population; this ratio, however, must not be taken on the entire population of the city, but on the population outside the centre of communications. On the latter basis it would be more difficult to calculate, but would afford a more correct idea of the number of rides per head of population. The valuable statistical data contained in the Paper would be useful in other undertakings. **Dr. Zollinger.**

The AUTHOR stated, in reply to Mr. Calisch's inquiry as to the financial results on underground and elevated railways, that the elevated railway in New York was leased to the Interborough Rapid Transit Company (which also operated the underground) on the basis of a guaranteed dividend of 7 per cent. on the capital stock of $60,000,000. The Interborough Rapid Transit Company had paid the following dividends in recent years: in 1911, 9 per cent. regular and 1 per cent. extra; in 1912, 10 per cent. regular and 5 per cent. extra; and in 1913, 10 per cent. regular and 2 per cent. extra. The Brooklyn Rapid Transit Company, which operated both the elevated and the tramways, paid $5\frac{1}{4}$ per cent. in 1913. The Philadelphia Rapid Transit Company, which operated the elevated and underground lines and tramways as well, had a small deficit in 1912 and a surplus of $509,582 in 1913. The Boston Electric Railway Company, which also worked the elevated, underground and tramway lines, paid 6 per cent. in 1912. The Author had not heard of any serious trouble with the "shoe" fuses on the underground in New York, due to the increase in the number of cars in a train, although the bus-line resistance had been increased beyond that originally installed. The automatic train-stops on an electrically-worked line with multiple-unit trains were considered satisfactory; but, for lines worked with steam-locomotives the train-stop had not advanced beyond the experimental stage, and it **The Author.**

The Author. was for this latter service that the New York, New Haven, and

Figs. 18.



Scale: 1½ Inch = 1 Foot.

INCHES 6 5 4 3 2 1 0 FOOT

INTERBOROUGH RAPID TRANSIT COMPANY'S NEW TYPE OF THIRD-RAIL COLLECTING-SHOE.

Hartford Railway had offered a prize for a satisfactory device.

While, as stated by Mr. Gibbs, the New York subway was a pioneer in the use of steel passenger-cars, the first 500 cars used on this line were of wood sheathed with metal. These were ordered in 1902, and while experiments in steel-car construction were made, it was probably the disastrous fire on the Metropolitan line in Paris, on the 10th August, 1903, that hastened the decision to use steel cars. Referring to Mr. Seaman's comments, the financial stipulations might have prevented the City from receiving tenders on its original invitation for operators, but apart from this, the working of these lines was not attractive to the main-line railways, for the reasons stated by Mr. County; and in view of the fact that new steel rolling stock would have to be obtained by any operating company, the wisdom of the increase in the internal dimensions of the subway was doubtful. In reply to Mr. Shaw's inquiry as to how the concrete was placed inside the longitudinal steel box stringers used in the permanent way in the Philadelphia subway, these stringers were not covered, but the tops of the side channels were held in position by an occasional steel strap, and the concrete could therefore be placed in the intervals between the wooden blocks supporting the rails. The contact-shoe used in the New York subway was shown in *Figs. 18*. **The Author.**

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18 March, 1913.

ROBERT ELLIOTT-COOPER, President,
in the Chair.

The discussion upon Mr. G. D. Snyder's Paper, "Notes on City Passenger-Transportation in the United States," was continued and concluded.