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All matter intended for publication must be received at our office not later than Tuesday morning of each week, in order to secure insertion in the current issue.

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Our Twentieth Anniversary

With this issue the Street Railway Journal is twenty years old. Our first number was published in November, 1884, at the dawn of the electric railway industry, and the paper has grown in size and importance continually since that time with the motive power whose development it has so faithfully chronicled. We may perhaps be pardoned if, at the outset of this, the largest number ever published of any technical or trade paper, we refer to the differences between this publication now and twenty years ago. The change from less than 500 annual pages to nearly 7000 was not made suddenly, but like that of the electric railway industry, was a gradual development, accompanied by a painstaking effort to serve the street railway companies of the country to the best of our ability.

Although many of our very early numbers were devoted largely to the subject of the horse, we tolerated horse railroading only for lack of better things. It has always been a source of pride with us that we were among the first to recognize the importance to both the railway companies and the general public of the introduction of improved motive power, and that we strenuously advocated first the cable and then electricity when the first was used only in a few cities in the far West and the latter was still in the experimental stage. The work of Sprague, Van Depoele and other pioneers soon raised the electric railway to a predominant position in the field. Nevertheless, the general acceptance of the overhead system by city councils and the general public in the early days was reached only after a long and arduous educational campaign in which this paper played no small part. Then followed the various problems of operation, and as each has arisen this paper has attempted to assist in their solution by presenting the testimony of different experts upon the topics under discussion and describing the practice on various roads. We have been able to do this only through the uniform courtesy and generosity with which street railway managers have met our requests for information. And we wish on this occasion to express our appreciation of the great assistance which we have always received from them and our readers in general, of their leniency toward our shortcomings, and the broad policy which has always characterized them in their dealings with the technical press.

This Number and Its Contributors

No more fitting way, it has seemed to us, was possible to commemorate the twentieth anniversary of this paper than by the publication of a series of articles on the achievements of those early workers who have made the electric railway what it is to-day. During the past twenty years history has been made rapidly and our columns have been taxed to record the progress of events. During this time both the publishers of the paper and its readers have lead a strenuous life. Neither has taken much time—we certainly have not—to cast a look backward and consider, even as briefly as has been necessary in this issue, the services of those who gave to the field during the early years their best thought and efforts. Yet what a glorious record it is! And how greatly has the structure of the modern industry depended for its stability upon the firm foundations of corporation law and electrical science laid by those pioneers in both horse and electric traction of the early days. It is true failures were encountered, at times progress was along wrong lines and steps had to be retraced, but as a whole the development has been so rapid that the practice of twenty or even ten years ago seems now most antiquated.

In view of the extent to which the Louisiana Purchase Exposition has been described and illustrated in previous issues of this paper, as well as in the outside press, we have not thought that it was necessary to devote any additional space in this issue to it. To obtain even a superficial idea of its important features, a visit to St. Louis is necessary, and we strongly recommend such a trip to all who can possibly arrange it, as one of the best educational helps which this country affords. Our own previous articles on the street railway exhibits at the Fair have called attention to the most important objects of railway interest at St. Louis. We have also described at considerable length, earlier in the year, the street railway systems of St. Louis, so that in the article on them in this issue no attempt has been made to do more than describe the general situation in St. Louis and mention briefly some of the most interesting features of the system.

The Development of the Industry

The list of contributors to this number is so large and each is so prominent in the field discussed by him that no attempt will be made in this editorial to refer individually to any of the several articles. Nevertheless, it might be appropriate to point out briefly the principal directions in which the street railway of to-day differs from that of even a decade ago, when electric traction had won a predominant position in the transportation field, but when the methods of operation varied but little from those of the preceding horse car days.

In the first place, we see a most striking difference in the form of street railway corporation. Consolidation has been the order of the day, and the cities in which there is more than one organization supplying local street railway transportation are now extremely rare.

With the increase in size of the street railway corporations, there has been an increase rather than a decrease in the attention given to the employee and the opportunities afforded for individuality and recognition of meritorious work. The discipline, or, to use a better word, the government of the men, is based now in all progressive companies upon scientific principles. Instead of being one of a large number from whom a mediocre or passable performance is expected, the modern manager gives every opportunity to each employee to distinguish himself by meritorious service, and recognition of this kind is often stimulated by prizes for the economical use of current, freedom from accidents and in other ways. The result has been to create, as one writer in this issue has happily put it, a new guild or craft of intelligent, ambitious workmen, which cannot but have a most important and beneficial effect on the body politic.

Great as have been the changes in the human side of the electric railway, the improvement in the mechanical and electrical departments has advanced with equal steps. The cars have grown longer and heavier, and the semi-convertible type has been introduced to supply the demand for a car which would be suitable for both summer and winter service. The changes in motors have been principally in the direction of improving their mechanical construction. The track has also been made more substantial, although the principal improvement in the permanent way department during the last ten years has been in the development of durable special work. Power station design has been greatly modified, and promises to undergo still further changes during the next few succeeding years. The modern power station dates practically from the "Intramural" power house of 1893, at which the first large direct-connected direct-current unit ever installed was put in operation. The evolution of the turbine during the past year has given an enormous incentive to the manufacturers of reciprocating engines to supply the most economical machine which they can build, while the gas engine looms up in the background as a possibly formidable, although as yet comparatively untried, competitor to the reciprocating and rotary engine.

One can hardly realize that it is less than eight years since any serious attempt was made to establish a uniform system of accounting, but no review of the development of the industry would be complete without a reference at least to this important achievement. Not only have the methods of accounting been placed on a scientific basis, but by the introduction of the car-hour unit as well as the car-mile, the street railway manager has been afforded a double basis for comparison, which experience has shown to be extremely useful.

Operating Voltage

In possibly only one important respect has there been no radical change in electric railway work during the past twenty years. Electric railways have steadily been, and still are, the slaves of a low-working voltage. In fifteen years of enormously rapid physical growth, during which the electric motor has revolutionized rapid transit completely, the customary voltage of operation has risen by hardly more than 10 per cent or 15 per cent, unless one takes into account the very early and quickly abandoned trial of 400 volts. There is, of course, reason for this moderation, in that 500 volts, the nominal standard, was for some years assumed to be safe so far as danger to human life was concerned. But while not highly dangerous, this pressure is certainly capable, as unfortunate chances have shown, of causing fatal results, although custom and the standardization of motor equipments tend to preserve it even up to the present. This moderate voltage has been thus retained, and it constitutes at once a serious limitation and an incentive for improved methods of distribution. It is the old struggle of the electric lighting industry over again, with somewhat similar results.

Large amounts of current can be transmitted to motors, fixed or moving, only at great expense for copper and at great loss of energy. Hence, as traffic over electric lines grew heavier, the problem of getting the power to the motors became progressively more and more serious. But during the early stages of electric traction, while cars were yet light and speeds low, the simplest methods were reckoned the best, and additional copper was installed when it became necessary. Before long, electric roads began to expand into the second stage of their development, passing from mere tramways to the dignity of important interurban service, and thus increasing in length to an extent that greatly aggravated the difficulties of distribution.

Just as this juncture began the sensational growth of long-distance power transmission, marked by the advent of polyphase apparatus. Up to a dozen years ago, there was no feasible method available for the transmission of power for railway or any other purposes. The best that could be done in a railway plant was to raise the voltage and let it go at that, and as lines grew longer this proved to be an expensive remedy. One of the early suggestions for relief was the adoption of the three-wire distribution which had proved so successful in lighting work, with 1000 volts thus utilized for transmission, while individual motors still worked at 500 volts. The method was tempting, but proved a failure in practice. Street car traffic is so irregular in amount and distribution that proper balancing has uniformly proved impracticable for general service, and for lack of it unusual strains are imposed on the motors and the item of repairs goes up. In fact, one has regretfully to write down the three-wire system as a failure unless for some special cases.

But power transmission by polyphase alternating current was quite another matter and relieved electric traction from some very embarrassing limitations. The first uses of power transmission, however, did not come about through a deliberate effort to reduce the difficulties of distribution, but from a simple and natural desire to cut down the cost of power required by a railway system, through the substitution of transmitted hydraulic power for steam power in driving the generators. To the best of our knowledge, this was at the Taftville installation a little over ten years ago, and from it sprang the important system of polyphase distribution which has been adopted on so many roads. The rotary offered so simple and direct a means of getting current from the transmission circuit that practically no other attempt has ever been made in this country to work distribution sub-stations in any other way. On long lines the rotary offered relief from Ohm's tribute to copper and robbed the distribution of its terrors on interurban lines, and while sometimes applied without sufficient provocation, has had a highly stimulating effect on the long-distance railway.

The Single-Phase System

We do not intend to discuss in this issue whether the rotary converter is to be relegated to the scrap pile or is still to constitute an important feature of our power distribution systems. This subject was treated extensively at the meeting last month of the International Electrical Congress, a report of which was published in our last issue, and was discussed editorially in that and the preceding number. Independent of its desirability or non-desirability on city systems or on heavy trunk lines running a frequent service, it certainly can be figured out that a single-phase motor system presents many advantages in distribution and can be installed on long lines with admirable results in economy. This fact, combined with the ability of the alternating equipments to work over direct-current distributing systems, will give the system, in our opinion, a wide field in electric traction work. Of course, there is a natural disposition to wait until the roads first installed have made a definite showing of some sort, but this fact only quickens one's interest in results. One of the strong points claimed for the alternating system is its very ready applicability to roads already having transmission plants, and we believe that the temptation to try the experiment will be very strong. Street railway men have heretofore always displayed a very keen interest in improvements, and have been by no means slow to try them. We shall hope ere long to be able to present to our readers actual results from the single-phase railway motors, and await them anxiously.

Very heavy traction service, with short train intervals, as we have already intimated, is governed by somewhat different conditions. There is less objection to the third rail and to the cost of labor of attendants at sub-stations and other circumstances which are favorable to d. c. operation. Fortunately, in the New York Central installation the adaptability of d. c. equipments to a service of this kind will be thoroughly determined, and we believe with eminently satisfactory results. It is therefore with a feeling of confidence that the glorious record of electric railway development which we have seen in the past will be continued in the future that we look forward to the events of the next few years.

In this cursory review of the present, we have dwelt perhaps more strongly on the present status of the a. c. motor and the opportunities afforded by it for an increase in operating voltage than on any other branch of railway work, but it has been simply because this feature is of paramount railway interest at present. We do not depreciate the efforts which are being successfully made in other fields of endeavor, notably in power station design and car construction; each will add its quota to the successful road of the future. Nor do we believe that the single-phase system is the panacea for all of the electrical ills of the railway industry. Nevertheless, we feel confident that it will ultimately furnish the solution for many of the difficulties in electrical distribution which we are experiencing to-day.

The Subway

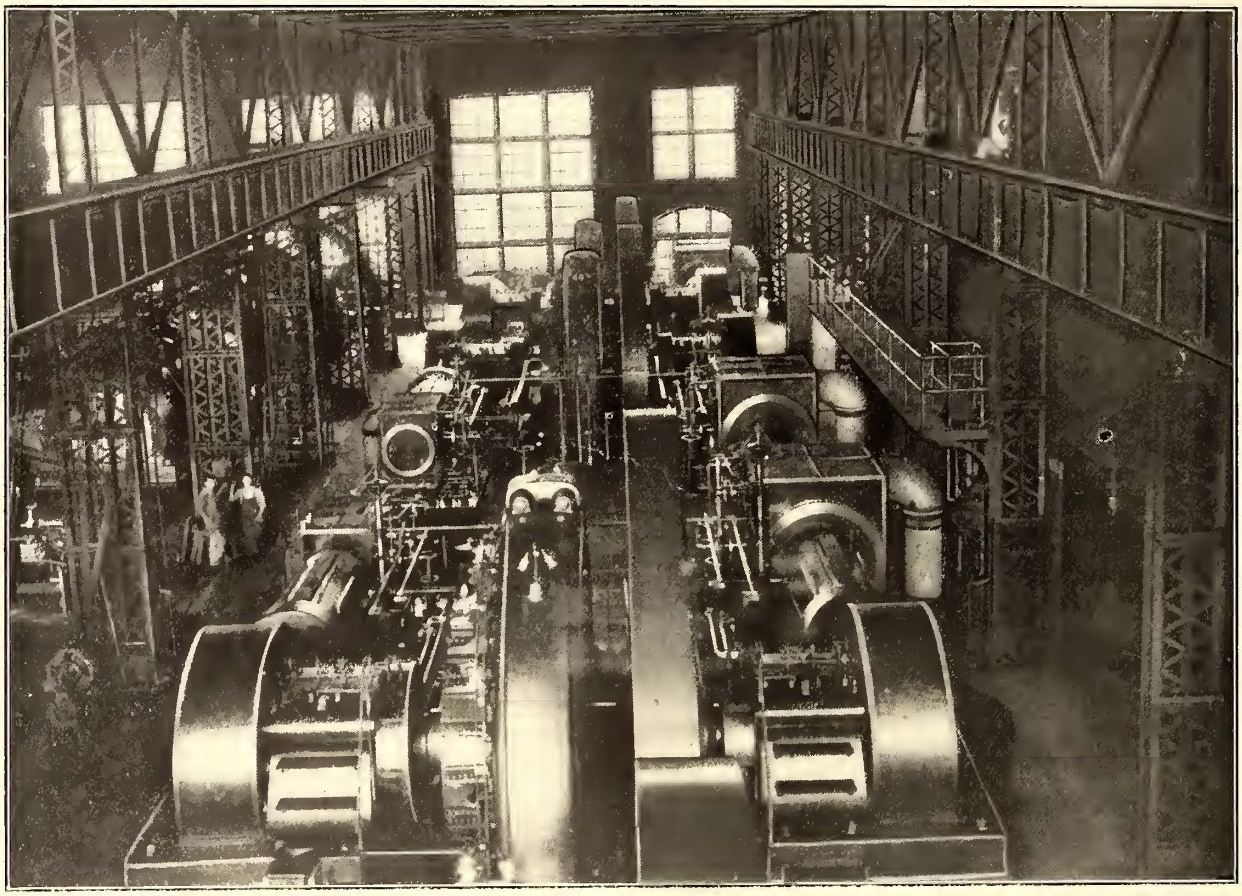
As the early part of this volume is devoted to a record of the early days, it seems quite appropriate that the later pages should treat of the present. No more striking example of the ability of electric power to cope with city transportation exists in this country than in the magnificent underground transit system which is now being completed in New York City. The publishers of this paper have been fortunate in being able to secure for this issue an account of the four principal features of the subway construction which are interesting from a transportation standpoint. The articles by Messrs. Van Vleck and Stillwell, respectively, on the power station and electrical features of the system, and the two articles on cars and the block-signal system which have been built and installed under the direction of George Gibbs will, we are confident, prove of the greatest engineering value to the street railway industry.

The construction of the power station for the operation of the subway involves many triumphs, both in steam and electric engineering. The plant is notable for the interesting arrangement of coal bunkers and economizers, and the provisions which have been made for the use of superheated steam. An interesting construction feature is also the location of each of the six 225-ft. brick stacks upon the structural-steel frame work of the building so as to save space in the boiler room below. The engines, which are of the Manhattan type, have the unusually large ultimate capacity of 11,000 hp. and are direct coupled to alternating-current generators of 7500-kw capacity. The high-tension alternating-current distribution system, involving the use of rotary converter sub-stations, is used, and many unusual provisions have been made to provide absolute reliability of operation. An extreme refinement is to be noted in the provision of an automatic signaling system for instantly turning off power from the third rail in case of accident. A repetition of the Paris subway disaster is rendered impossible, both on account of the use of the steel cars and also the provision for lighting the subway independent of the power-feeder circuits.

The construction of the new steel cars is worthy of careful study by those interested in rolling stock, on account of the novel method of supporting the floor load of the car from the side framing—a radical departure from previous methods of car construction. In this way the weight of the car has been kept down to that of equivalent wooden construction. In other details also, such as the arrangement of the motorman's cab, car wiring, etc., these cars are improvements over anything that has heretofore been built. The block-signal system installation is one of the most complete that has ever been installed, and introduces the use of many novel and interesting features. A study of this great installation, embracing the perfection of skill in both the electrical and mechanical fields, will prove both interesting and profitable.

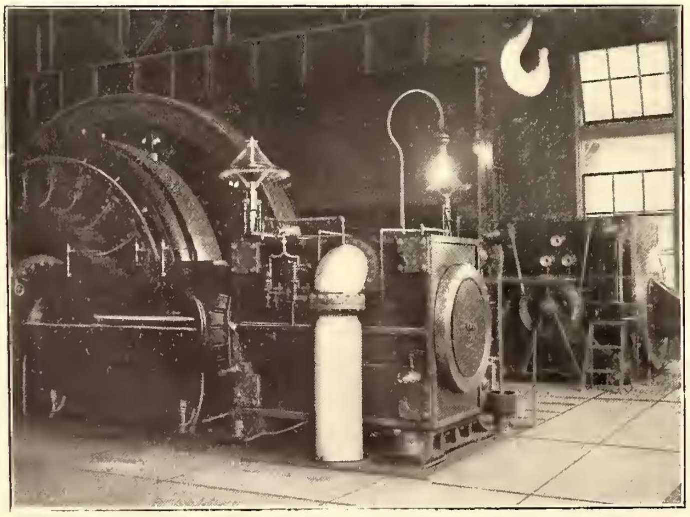
THE ELECTRIC RAILWAYS OF ST. LOUIS

So much attention has been given to the electric railways of St. Louis in these columns the past two years that it is not now necessary to go into any extended discussion of them, but rather to give a brief summary of the situation, enlarging on a few things not before described. Since the American Street Railway Association met in St. Louis in 1896 great changes have been made, both in the organization and physical equipment of the street railway properties. In 1896 there were no less than six important street railway companies operating in the city. These were the Lindell Railway Company, the Union Depot Railroad Company, the National Railway Company, Missouri Railroad Company, the Southern Electric Railroad Company, and the St. Louis & Suburban Railway Company. Since then the long-talked-of consolidation has taken place, and the St. Louis Transit Company controls all the lines in the city of St. Louis save those of the St. Louis & Suburban Railway Company. A map of the lines of the St. Louis Transit Company is published on the opposite page. In addition to the lines shown on the map, the company owns an interurban line to Creve Coeur Lakes, which lie to the west of the city.

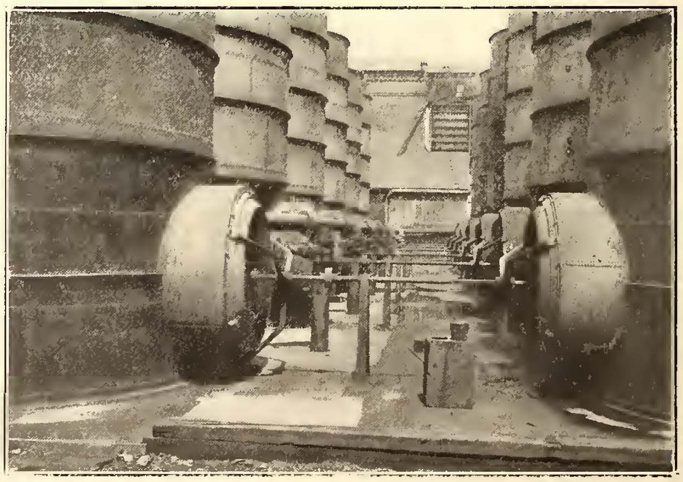


INTERIOR OF THE PARK AND VANDEVENTER STATION OF THE ST. LOUIS TRANSIT COMPANY

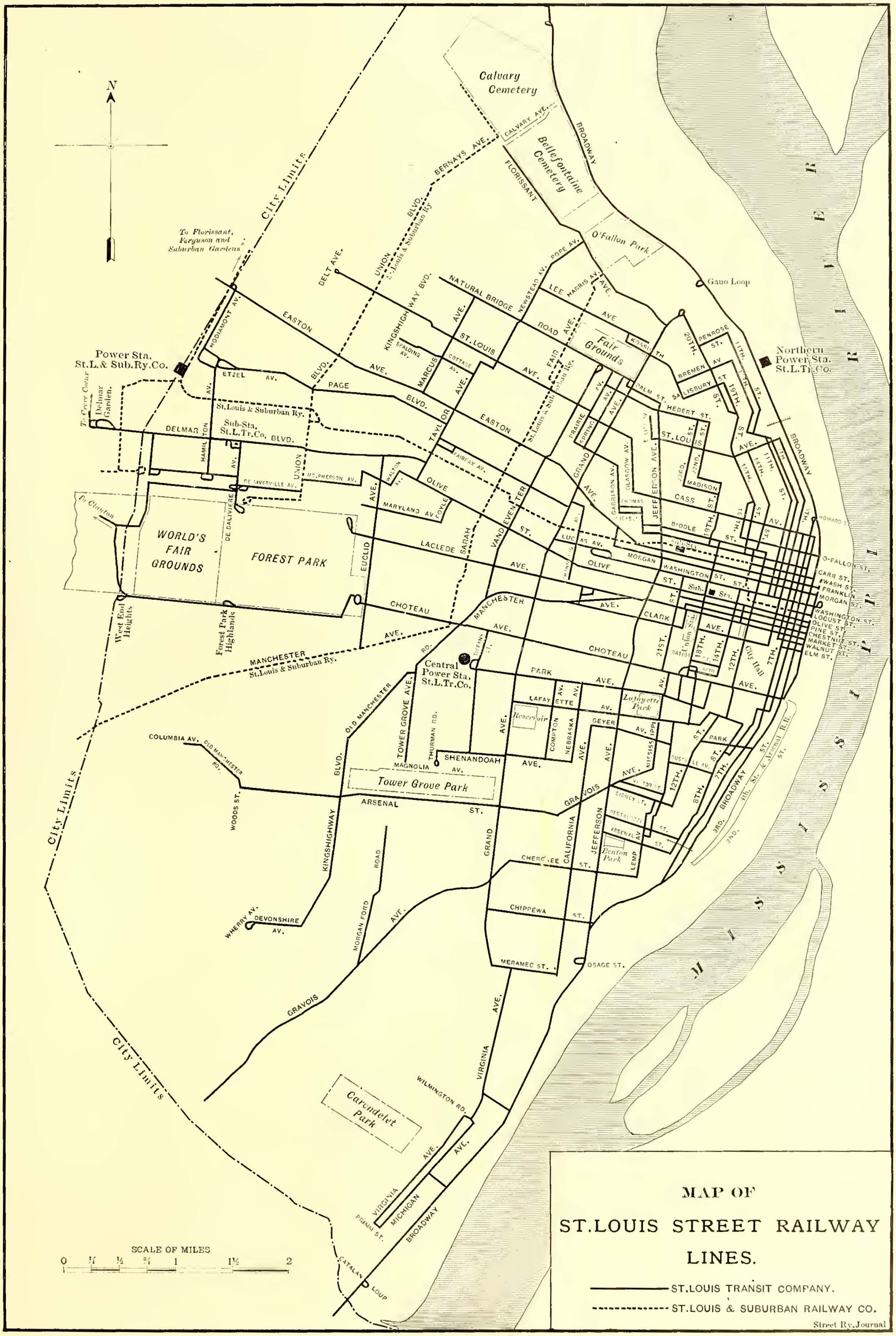
Of the suburban or interurban electric lines outside of the



A 36-IN. AND 70-IN. X 60-IN. ENGINE AND GENERATOR IN THE STATION OF THE ST. LOUIS TRANSIT COMPANY



COOLING TOWERS OF THE CENTRAL STATION—ST. LOUIS TRANSIT COMPANY


MAP OF
ST. LOUIS STREET RAILWAY
LINES.
ST. LOUIS TRANSIT COMPANY.
ST. LOUIS & SUBURBAN RAILWAY CO.
SCALE OF MILES
WORLD'S FAIR GROUNDS
FOREST PARK
Tower Grove Park
Carondelet Park
Calvary Cemetery
Bellefontaine Cemetery
O'Fallon Park
Fair Grounds
Lafayette Park
Benton Park
Central Power Sta. St.L.Tr.Co.
Northern Power Sta. St.L.Tr.Co.
Power Sta. St.L.& Sub.Ry.Co.
Sub-Sta. St.L.Tr.Co.
City Limits
MISSISSIPPI RIVER
Street Ry. Journal

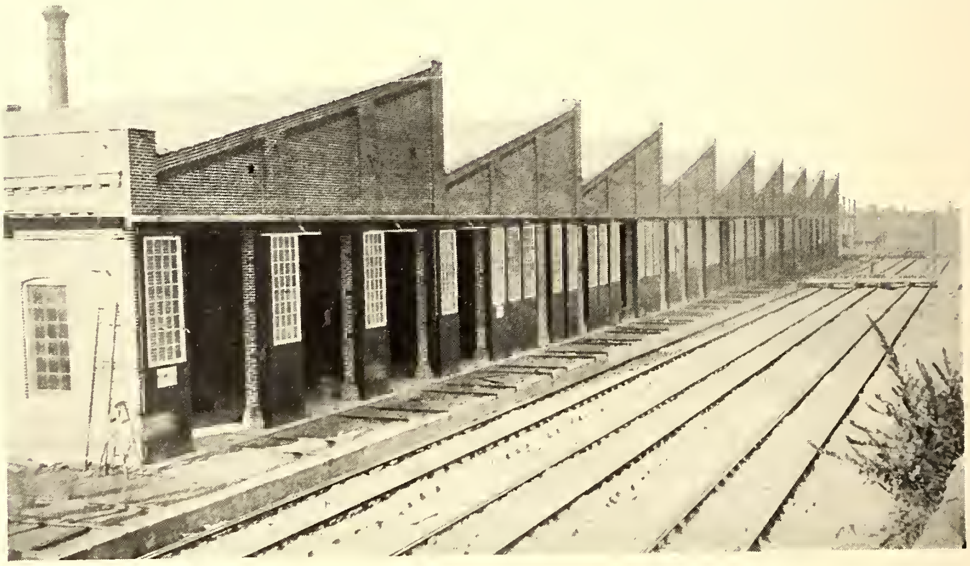
CAR HOISTS IN ST. LOUIS TRANSIT COMPANY'S SHOPS

city limits, the St. Louis & Suburban Railway Company controls the greatest mileage, the St. Louis Transit Company coming next. The St. Louis, St. Charles & Western Railroad Company is the only remaining company in the field, and this company does not control its entrance to the city, but transfers passengers to the Easton Avenue line of the St. Louis Transit Company, and to the St. Louis & Suburban Railway Company at the city limits.

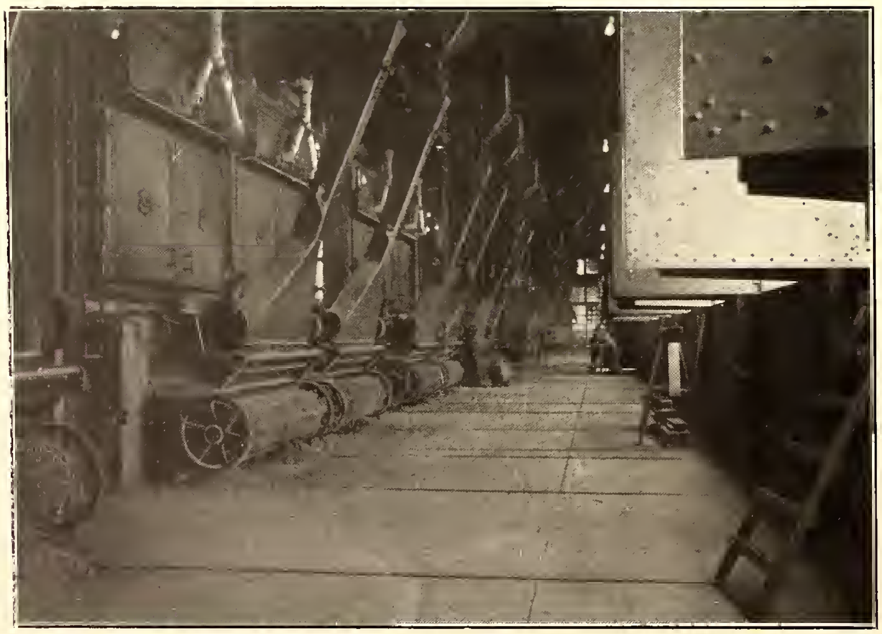
As all of these systems have been quite fully discussed in these columns during the past twelve months, it has not been considered necessary to follow the usual custom in this issue of publishing extended descriptions of them. Instead, a few particulars will be given of the Transit Company's system only, especially of those features which will attract the most attention from the visiting street railway manager.

ST. LOUIS TRANSIT COMPANY

The St. Louis Transit Company, which controls all the street railway lines of the city of St. Louis except those owned by the St. Louis & Suburban Railway Company, operates 358.65 miles of single track, occupying 176.41 miles of street. The St. Louis Transit Company is the lessee of the street railway properties controlled by the United Railways Company of St. Louis. The United Railways Company of St. Louis is a corporation formed in 1898 for taking over numerous small companies which make up the consolidation. The St. Louis Transit Company was formed about a year later, in March, 1899, to lease all the lines controlled by the United Railways Company. The St. Louis Transit Company, under this lease, is obliged to pay the United Railways Company interest on the outstanding bonds of the United Railways Company. The St. Louis Transit Company is to make all extensions and improvements, receiving in payment securities of the United Railways Company. It is unnecessary to go into details as to the amount of bonds and stock outstanding, as the situation can be summed up by the statement that for 1903 the St. Louis Transit Company paid in the shape of interest and rentals $2,844,119, which is approximately $7,800 per mile of track. The operations of the company for the past three years show a deficit, although for 1903 the deficit was a nominal amount compared with previous years. The total rolling stock of the company is figured at 1500 cars. This includes the old equipment and 450 new cars purchased to take



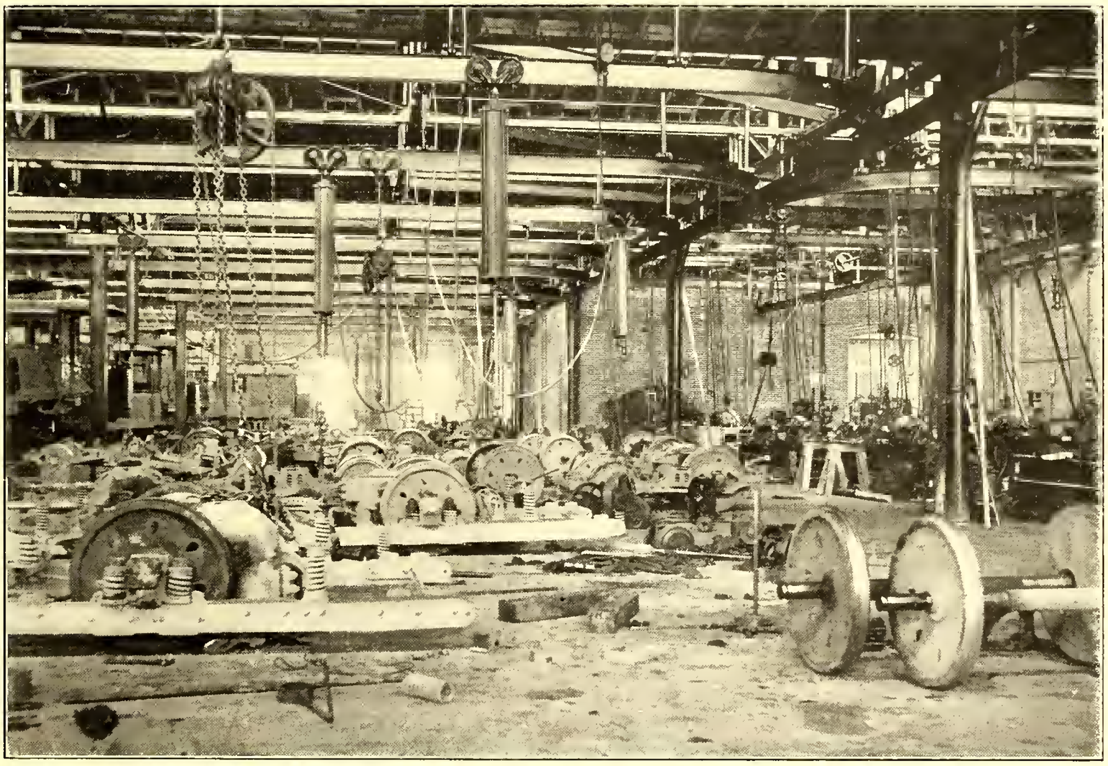
EXTERIOR OF ST. LOUIS TRANSIT COMPANY'S SHOPS



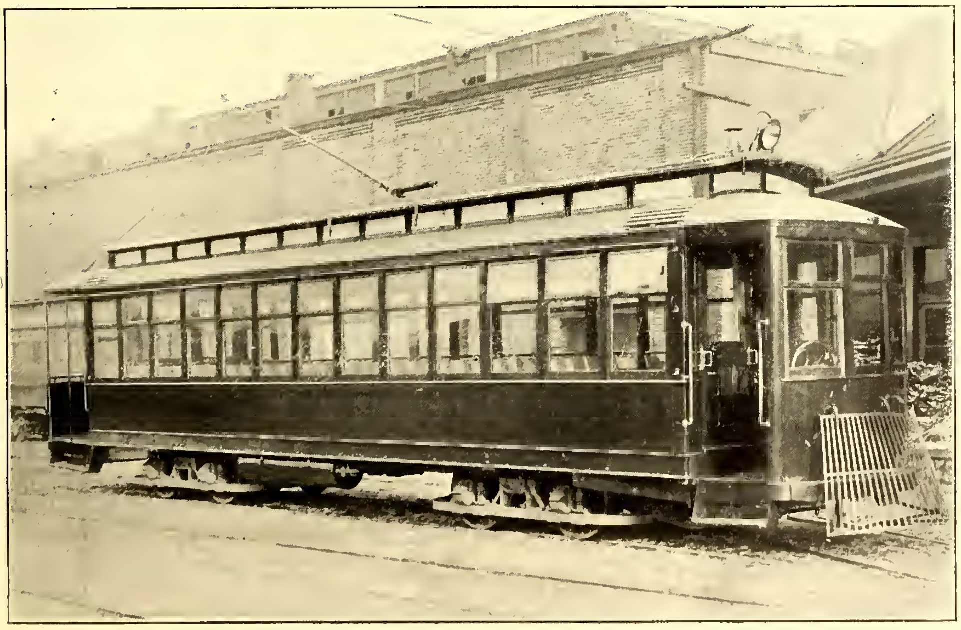
THE BOILER ROOM OF THE PARK AND VANDEVENTER POWER HOUSE OF THE ST. LOUIS TRANSIT COMPANY care of World's Fair traffic. Last winter the maximum number of cars in service on the rush-hour schedule was 893. On World's Fair opening day 1000 cars were operated. Up to the time of writing this article the World's Fair crowds, even on the days of the largest attendance, have at no time taxed heavily the regular facilities of the company for handling them.

The greater part of the power used in the operation of the St. Louis Transit Company's system is generated as direct current. Naturally, one of the first changes after the consolidation was a rearrangement of the company's power generating system. This was done by abandoning a number of direct-current power stations, enlarging very greatly the power station at Park and Vandeventer Avenues, first built by the Lindell Railway Company, and building a new combined direct and alternating-current station at Salisbury Street, near North Broadway. About a year before the opening of the Fair the plans were drawn for a large alternating-current station to be located in East St. Louis, where coal would be cheap and coal blockades unlikely. This plan was not carried out, however, as a contract was made to rent a certain amount of power during the World's Fair season from the Union Electric Light & Power Company, which was building a large alternating-current station on the river front, about one-third of a mile north of the Eads Bridge. The same company also agreed to sell a certain amount of power to the World's Fair, and feeders were installed for that purpose. The World's Fair, however, did not require as much power as expected, and the Union Light & Power Company's plant, although completed, was not in the best shape to furnish power continuously, so that the large 3500-kw Allis-Chalmers unit in the World's Fair power plant has been supplying the St. Louis Transit Company's sub-station with power up to the time that the decorative lighting is turned on at the Exposition. The largest power plant of the company is that at Park and Vandeventer Avenues, and this is also the largest direct-current railway generating station in the West. The total rated capacity of this station is 16,950 kw, all of which is taken out over an immense direct-current switchboard having recording wattmeter and other totalizing instruments of 30,000-amps. capacity. Some of the smaller units at this station have been used as boosters for feeding the long line to the Creve Coeur Lakes during exceptionally heavy summer traffic. On one occasion two generators were

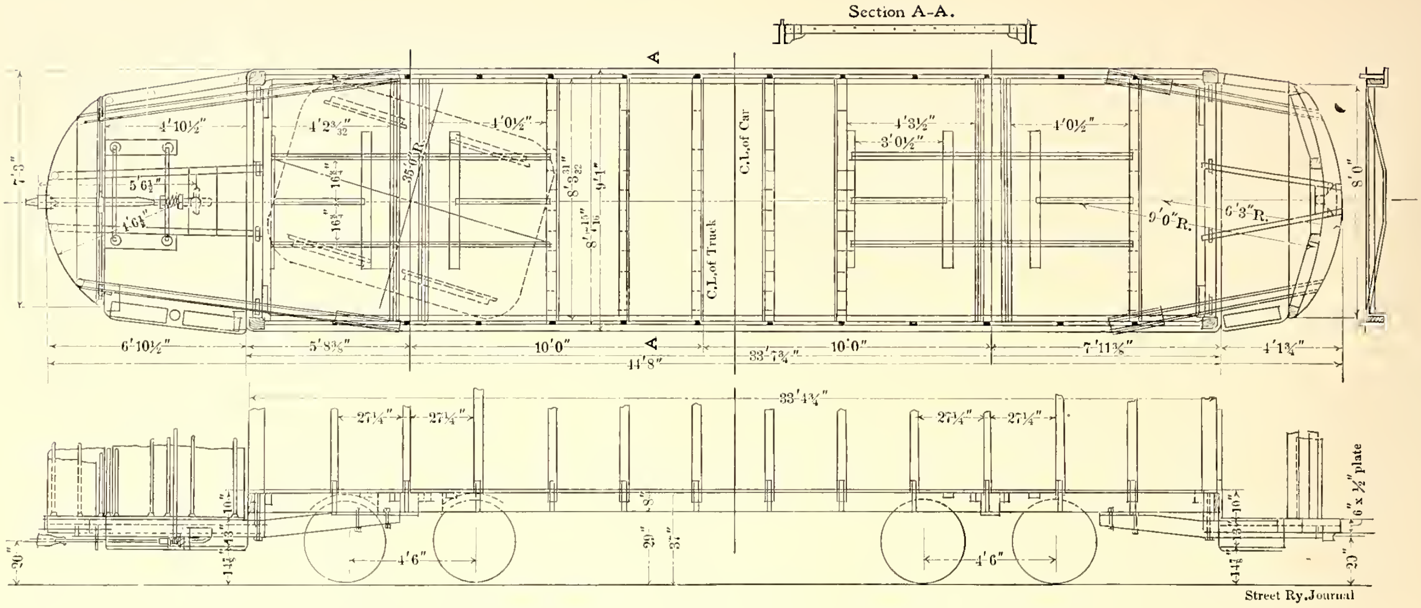
TRANSFORMER TEST OF ARMATURE



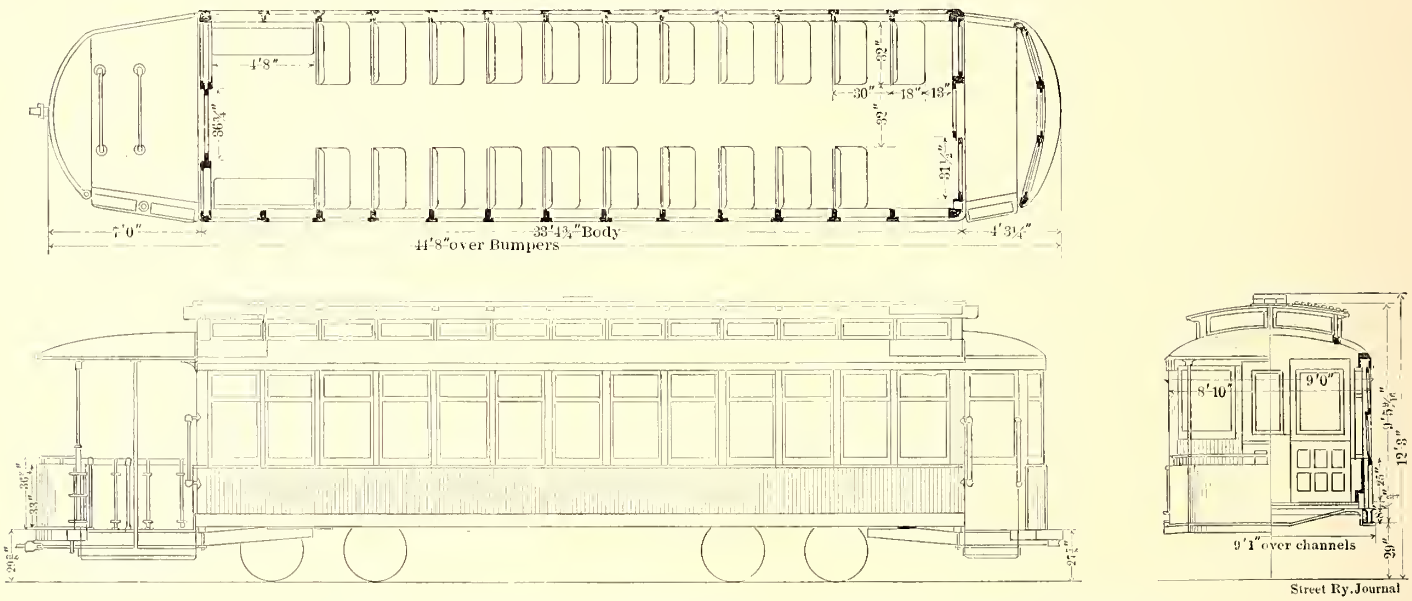
GENERAL VIEW OF INTERIOR ST. LOUIS TRANSIT COMPANY'S SHOPS



ST. LOUIS TRANSIT COMPANY'S STANDARD CAR



PLAN OF BOTTOM FRAMING OF CAR—ST. LOUIS TRANSIT COMPANY



PLAN OF STANDARD SEMI-CONVERTIBLE CAR—ST. LOUIS TRANSIT COMPANY

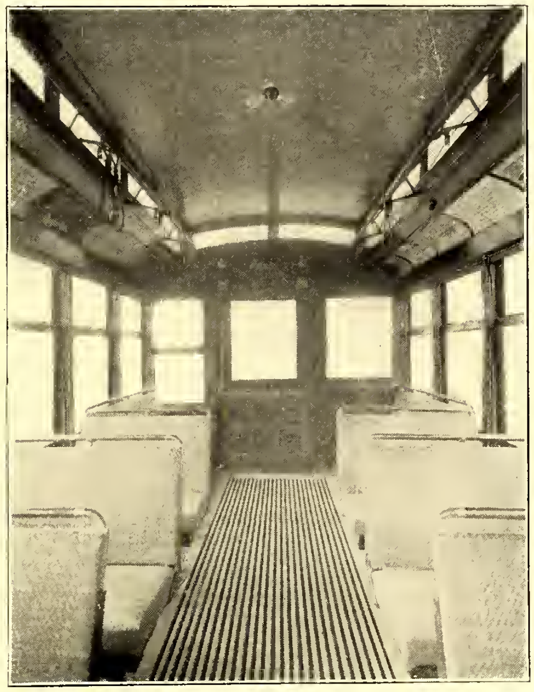
put in series as boosters, adding their voltage to the regular station voltage, giving a voltage of about 1700 on the boosted feeder at the station. This station is notable for the large cooling towers for condensing purposes, the entire station being designed to operate condensing with artificially cooled water. A large amount of coal storage was provided at this plant, but considerable difficulty has been experienced with spontaneous combustion.

The other principal station of the company, known as the Northern Station, has both alternating and direct-current generators. This station has a rated capacity of 6900 kw, of which 2400 kw is in three-phase, 6600-volt, 25-cycle current. The principal sub-stations are at Delmar and DeBalivere Avenues, near the Fair, at South Broadway, and on Locust Street, near Eighteenth Street, the latter being a new sub-station designed to use rented power. This sub-station is described more fully in another article. Besides the two principal power houses, the company has been obliged to operate part of the time a direct-current plant at Geyer and Missouri Avenues, built by the Union Depot Railroad Company, and another fairly modern direct-current plant belonging originally to the Cass Avenue & Fair Grounds Railway Company.

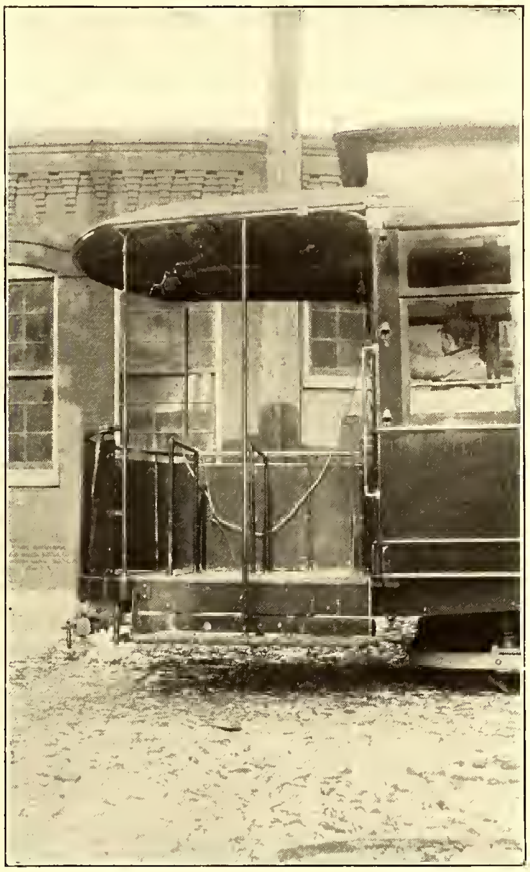
That feature of the St. Louis Transit Company's property which will probably be of most interest to the visiting street railway men is the new repair shop at Park and Vandeventer

ST. LOUIS TRANSIT COMPANY'S MOONLIGHT CAR

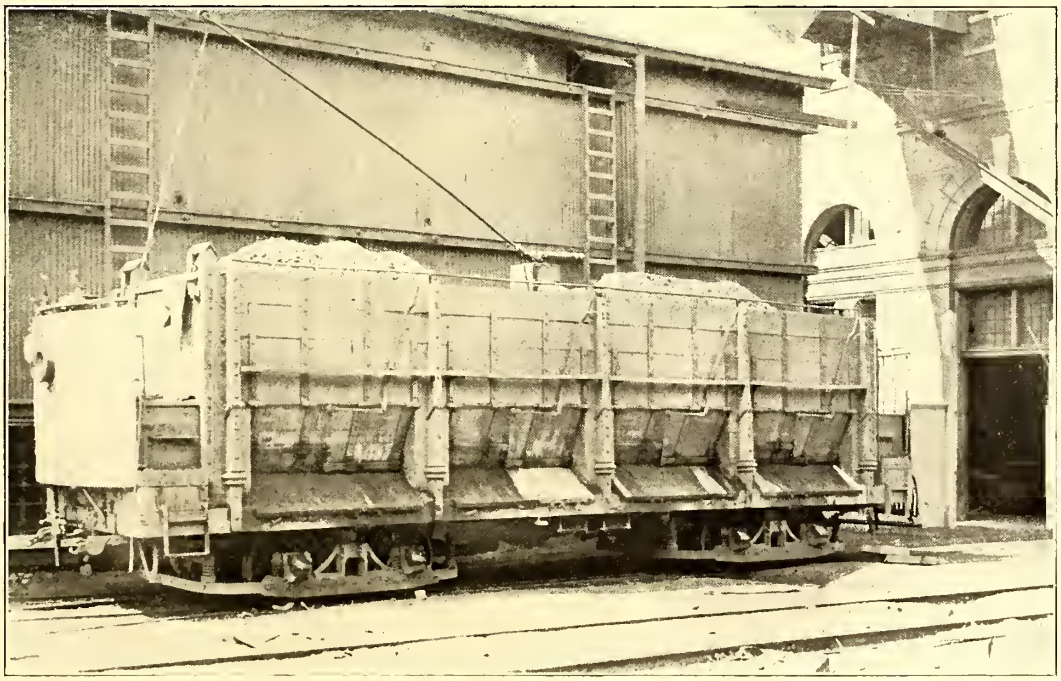
Avenues. This shop was built with the idea of centralizing at one place the entire repair work of the system. Whatever opinions various managers may hold as to the advisability of the centralizing of repair work in one shop, it must be admitted that, for centralized repair work, this shop stands as one of the best, if not the best, in the country in its equipment for doing the work for which it is designed. The principal strong points about this shop are the car hoists with which all the repair tracks are equipped, the facilities for handling material by means of overhead travelers, and the uniform lighting of the whole shop. The company made all of its own trucks for the 450 new cars recently purchased, and its facilities for truck manufacture are very complete. The repair shop has twenty-seven repair tracks. The entrance to all of these tracks is gained by a transfer table running along one side of the building. Each repair track is designed to accommodate one car. Part of the repair tracks have pits and part have not, as all the more recent equipment of the company's design is to be handled from above entirely, without pit work. The car hoists consist of motor operated screw jacks, the four screw jacks being worked simultaneously by a sprocket chain driven by a motor. All the hoisting mechanism is underneath the floor. The entire shop is served by an overhead traveler system for carrying motors and heavy material. The hoisting in connection with the overhead traveler system is done by compressed air hoists, which raise the material and deliver it to the chain hoists. The latter require no hose connection and can be moved to any point in the shop. Air hoists are placed at all points where lifting or lowering is to be accomplished. The accompanying engravings from photographs give a good idea of these shops, which are well worth careful study on the part of visiting street railway men because of the care with which many details have been worked out.



INTERIOR OF ST. LOUIS TRANSIT COMPANY'S STANDARD CAR



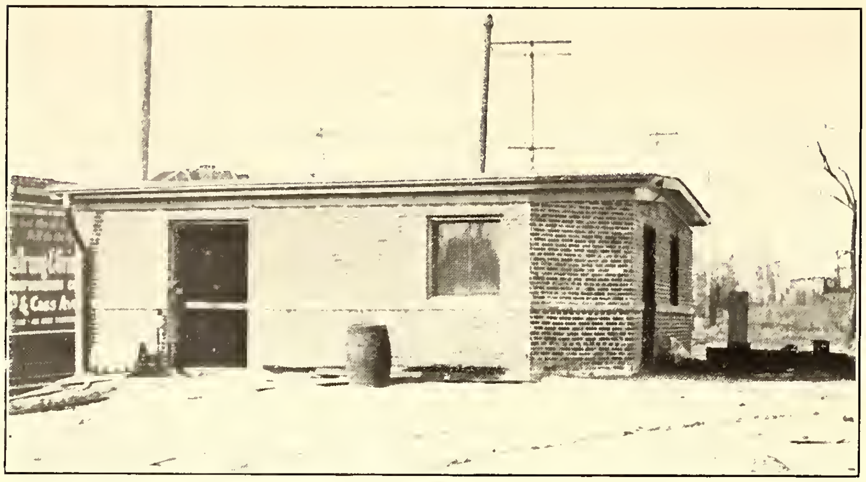
ST. LOUIS TRANSIT COMPANY'S STANDARD REAR PLATFORM



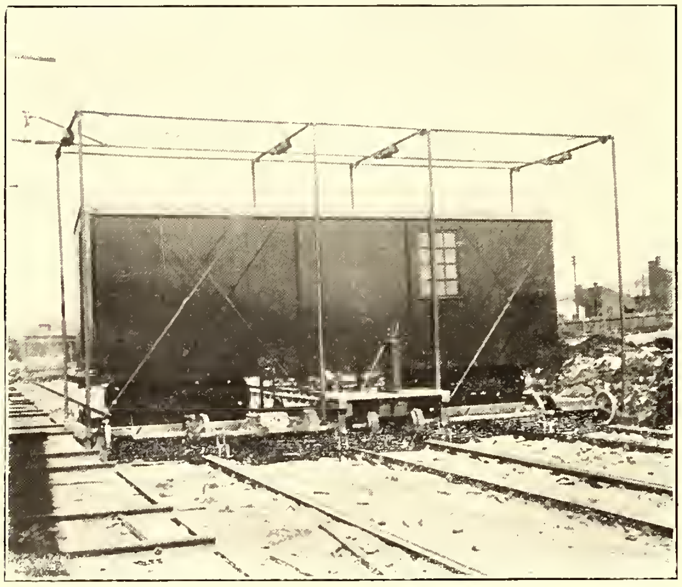
ST. LOUIS TRANSIT COMPANY'S CINDER CAR

The rolling stock consists mainly of double-truck cars, as the St. Louis street railways were among the first to adopt the double-truck car extensively for city service. Many peculiar styles of early double-truck cars can be found.

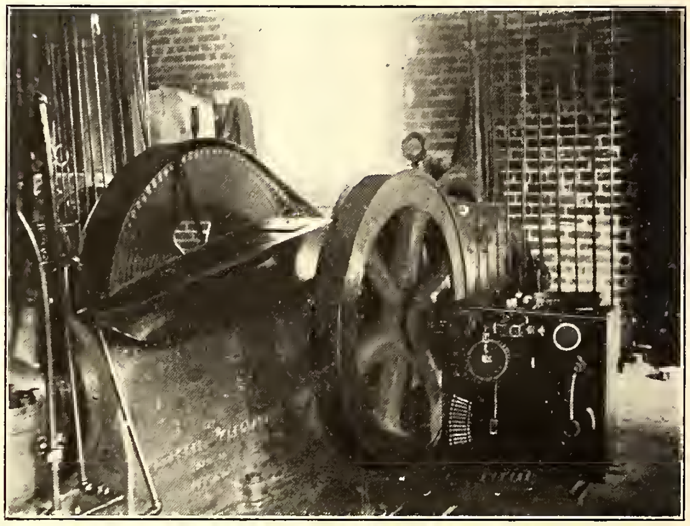
The standard car of the company is shown in the opposite engraving. As mentioned before, 450 of these cars were ordered of the St. Louis Car Company in order to put the system in good shape to handle World's Fair traffic. They are unusually wide as city cars average, and have wide aisles, even though equipped with cross seats. The front platform is intended only for the motorman. The rear platform is of the well-known Dupont type in its extreme form, being so long that two railings have been placed across it for the support of standing passengers. The car is semi-convertible, intended both for winter and summer use. The window sashes drop into side pockets and they are of a special design, which makes it possible to remove a sash instantly without taking out screws or bolts. The motors with which these cars are equipped are oil-bearing Westinghouse No. 95, arranged to be handled and inspected from above entirely. The car has a seating capacity of fifty.



EXTERIOR OF COMPRESSING STATION—ST. LOUIS TRANSIT COMPANY



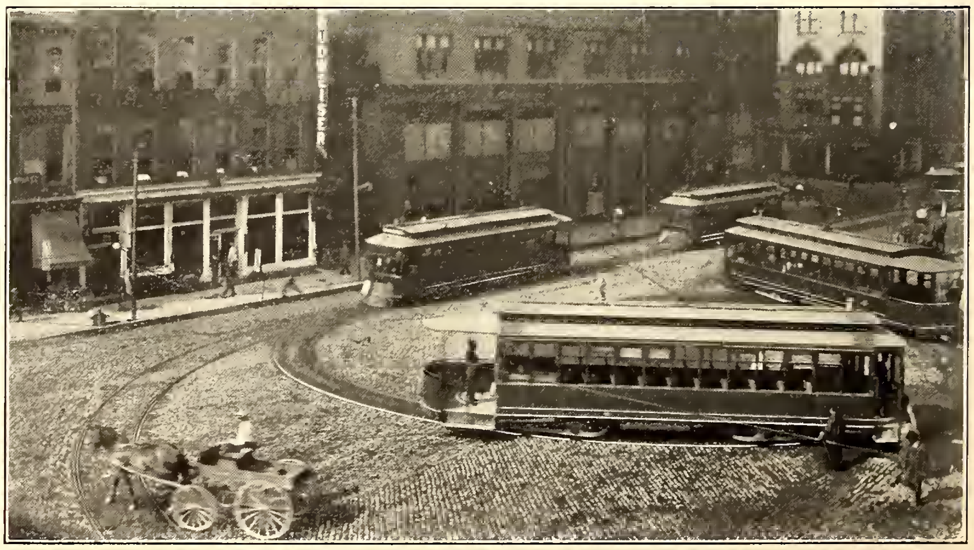
PORTABLE COMPRESSING STATION—ST. LOUIS TRANSIT COMPANY



COMPRESSING UNIT—ST. LOUIS TRANSIT COMPANY

The Westinghouse storage air-brake system used on the St. Louis Transit Company's cars is also a matter of present interest to street railway men, as this was the first large street railway company to decide to adopt the storage air-brake system for all its cars. The air is compressed to a pressure of 300 lbs. per square inch at compressing stations located at car houses or terminals of the line. Passing these points each round trip, the cars stop and connect the storage reservoirs on the car with the compressing station by means of hose connections located alongside the track. The storage reservoir on the car instantly rises to compressing station pressure. The large, high-pressure storage reservoirs on the car feed through a reducing valve into auxiliary reservoirs maintained at about 45 lbs. pressure per square inch, and these auxiliary reservoirs supply air through the motorman's valves to the brakes only. The storage air-brake system was adopted because it was believed to be simpler, more reliable and lower in cost of maintenance than independent motor-driven compressors on each car. The compressing stations at various points on the system are designed to operate automatically, and with only a small amount of attention each day, without requiring the continuous services of an attendant.

Besides the regular rolling stock, the company has two types of car for special uses which are of interest and are illustrated here. One of these is called the "moonlight car," and is used summer evenings for resort traffic. They are without a roof, and have simply a canvas canopy which can be stretched overhead. They are exceedingly popular warm summer evenings in St. Louis. The seating capacity is large, being ninety-six. The other special car referred to is a large car used in hauling cinders. These cars are arranged with side dump and are used to deliver cinders from the power stations to the various customers.



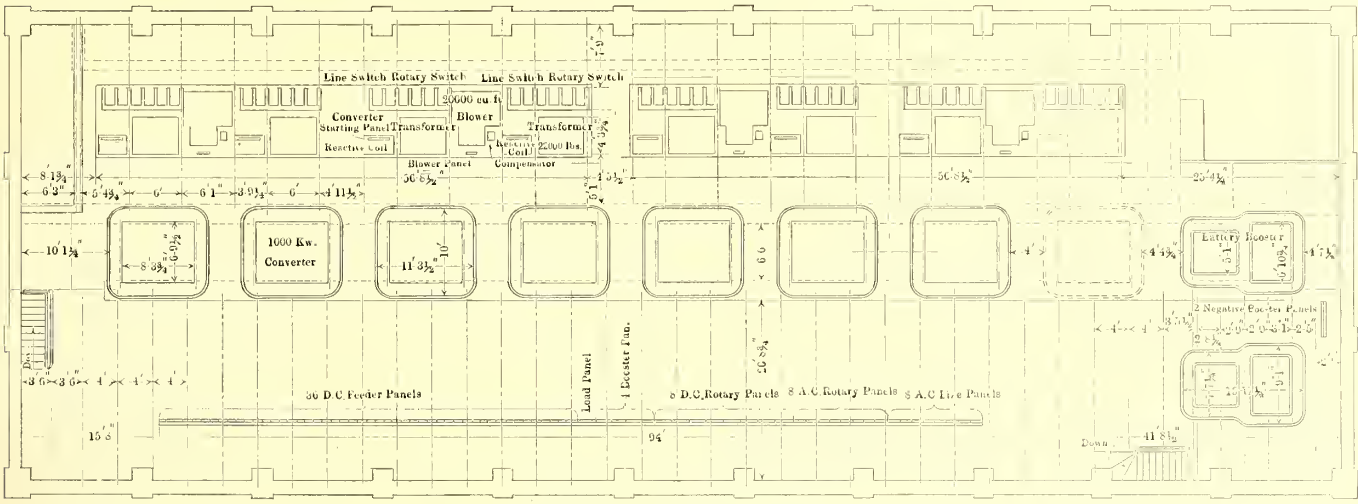
WASHINGTON AVENUE LOOP IN ST. LOUIS

THE NEW CENTRAL SUB-STATION OF THE ST. LOUIS TRANSIT COMPANY

BY CHARLES A. HOBEIN
Electrical Department St. Louis Transit Company

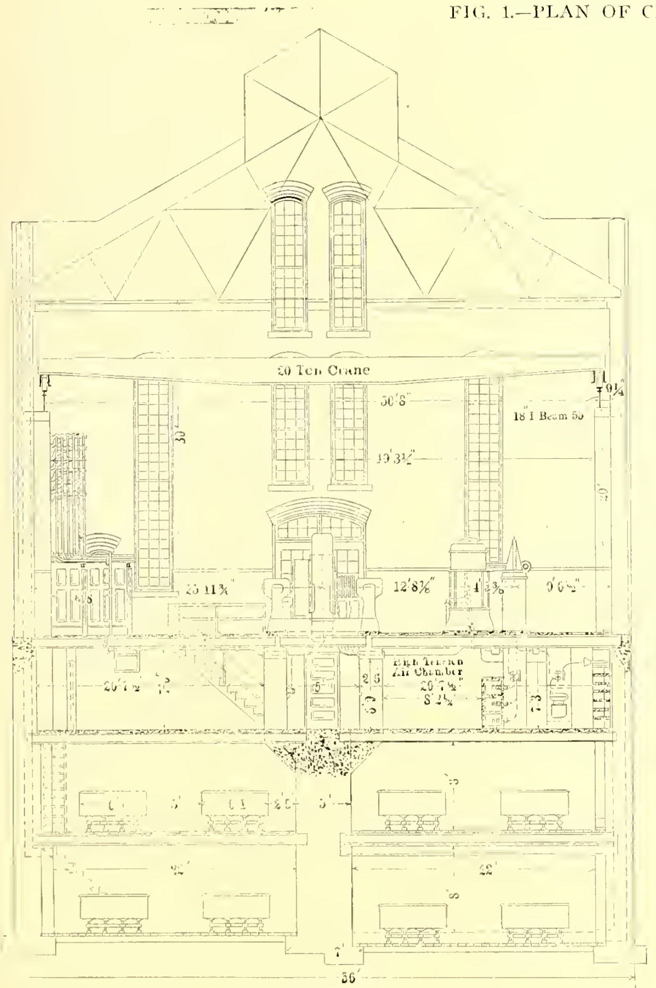
The power for the St. Louis street railways in 1899 was derived from eleven power houses. In this year the companies were consolidated, forming the St. Louis Transit Company. Four cable lines were changed to electric, and in the next few years the power houses were gradually shut down. One was greatly enlarged and a new power house built, so that at the beginning of the year 1903 the company was operating but four generating stations and one sub-station. These were: (1) the Central Station, which was the remodeled station; (2) the Northern Station, which was the new power house; (3) the old Union Depot Railway power house, and (4) the old Cass Avenue Railway power house. The two latter were only operated during the morning and evening rush hours. The addition of rolling stock to handle the World's Fair traffic required added power, and a contract was entered into with the Union Electric Light & Power Company to furnish alternating current at 6600 volts, 25 cycles, from its new power station which was but recently completed. This power was to be delivered to three sub-stations of the Transit Company, one of which, Delmar sub-station, was already in operation. The plans contemplated installing two 1000-kw rotaries in the Cass Avenue power house, thus shutting down the steam plant at that place; also the building and installing at a point as near the center of load of the system of a central sub-station containing seven 1000-kw rotaries and a 5000-amp.-hour 600-volt storage battery.

It is the purpose of this paper to deal with the latter problem.



PLAN VIEW OF CONVERTER FLOOR
SHOWING LOCATION OF APPARATUS

FIG. 1.—PLAN OF CENTRAL SUB-STATION



CROSS SECTION
SHOWING LOCATION OF APPARATUS

FIG. 2.—CROSS SECTION OF SUB-STATION

FIG. 3.—EXTERIOR OF SUB-STATION

An extensive investigation located the center of load at Fourteenth and Olive Streets. The station was built three blocks west and one block north of this point. Central station (a direct-current plant), which was then pulling the entire downtown section of the system, was 4 miles southwest of this center. Northern station, an alternating and direct-current plant, was 3 miles directly north, and Delmar sub-station 7½ miles southwest of Northern. Preliminary figures revealed the very remarkable fact that if this sub-station were built, enough feeder copper could be taken down, and sold as scrap, to go a great ways toward paying for the sub-station and equipment, exclusive of the battery. In the design of this station, the time-honored custom of erecting a fine and elaborate building has not been followed, but instead a neat and substantial building, arranged to accommodate the necessary apparatus, has been erected. Its plan is shown in Fig. 1, a cross section in Fig. 2, and an exterior view in Fig. 3. Below the street level are two floors to accommodate the battery. These rooms are each 56 ft. wide and 155 ft. long. Each contains 294 cells.

Foundations of the building are entirely of concrete and rest upon bed rock. The battery rooms are divided in the middle by a 5-ft. concrete wall, which extends from the lower floor to the floor line of the air chamber, where it widens at a suitable angle to a width of 10 ft., and supports the two 30-in. brick walls, 6 ft. 6 ins. apart, which extend to the rotary-converter floor to form the machine foundations. Suitable openings left in the concrete and brick walls permit of passage and air circulation. The battery floors have a slope of 1 ft. from front to rear of building to facilitate drainage. In the rear of the lower room is a sump to receive the drainage. The water is raised from this point to the sewer by means of a centrifugal pump direct connected to a 1-hp motor, located on the air-chamber floor. The battery floors are covered with a layer of brick laid flat and grouted and covered with pitch. Rooms are lighted by incandescent lamps, the sockets being tightly corked with wax to prevent the acid from entering and short-circuiting them. All I-beams are entirely surrounded with concrete to protect them from acid action.

The air-chamber floor is on a level with the street. It has the two 30-in. brick machine foundation walls dividing it into three parts; two rooms, each 24 ft. x 155 ft., and a 6-ft. 6-in. passage under the machines. The east room is air-tight and forms the air chamber proper. The blowers discharge into this chamber, and the transformers and reactive coils located directly above receive their cooling air. Flues left in the foundation walls convey air to the floors of the battery rooms, and it is discharged through flues in the opposite side wall to the outside. The supply is regulated by means of dampers in the supply flues. The air chamber contains the incoming line cables, high-tension bus-bar compartments, current-transformers, potential transformers, barriers, etc., which may be seen in an accompanying photograph. The other room is used for storage, and also contains the battery room drainage discharge pump, water-tilling apparatus and field rheostats. The main

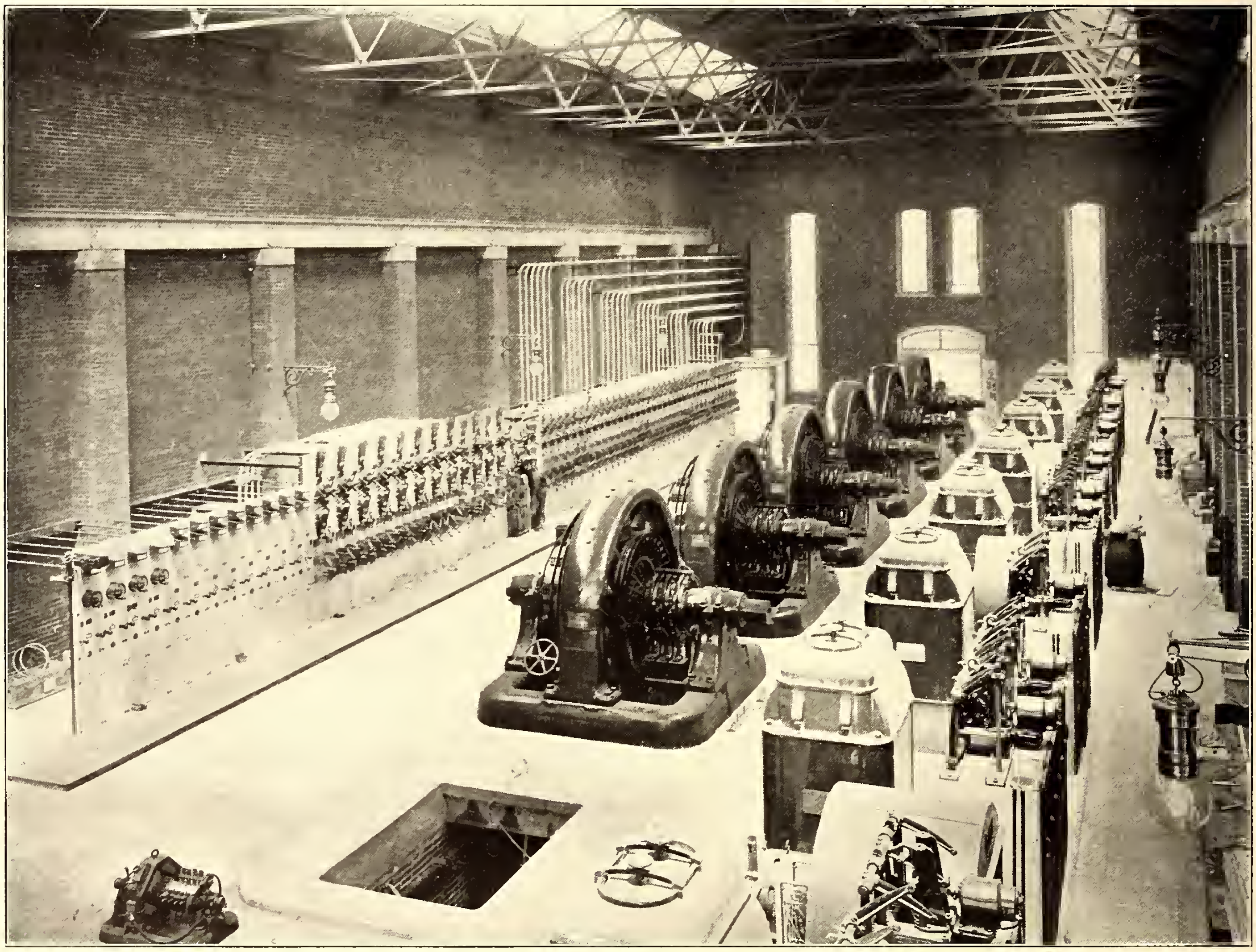


FIG. 4.—GENERAL VIEW OF MACHINERY FLOOR—ST. LOUIS SUB-STATION

floor is 8 ft. above the street level, and contains the rotary converters, switchboard, transformers, reactive coils, oil switches, blowers and two motor-driven boosters for controlling the battery.

The plan as carried out was to bring alternating current in on one side of the station through transformers and converters to the switchboard, and conduct out direct current on the opposite side of the station, as shown in the general view, Fig. 4.

The converters, as will be seen, were arranged in a row in the center of the building, the alternating-current apparatus being placed on one side of the center and the switchboard on the other. The battery boosters can be seen in the front of the building, Fig. 5. A 20-ton crane serves the converter floor, and articles can be picked from a wagon driven in on the air-chamber floor. An 18-ft. square opening in one corner of the converter floor gives access to the wagon. Smaller openings through the battery floors allow of the crane lowering or raising articles from these floors.

The batteries, Fig. 6, consist of a total of 588 cells, 294 in series forming one battery. Their combined capacity is 5000-kw-hours. The cells are the Electric Storage Battery Company's type G-79, and each is 6 ft. long, 22 ins. wide, and as deep, containing seventy-seven plates, 15½ ins. square and ⅜ in. thick. The boosters are of 252-kw capacity, driven by 360-hp direct-connected motors. The battery is intended to be floated on the station bus. Boosters are compound-wound and have the same effect as differential boosters. This was to have been arranged as follows: Fig. 7 shows a common arrangement of a compound-wound booster, connected to act with a differential effect. "B" represents the booster, and "R" a generator or rotary converter, while "L" "L" represent the motors on load on the system. The shunt field of the booster opposes the series field. It is easily seen that this arrangement could not be used in this case, as it is impossible to build a series field on a booster of large enough capacity to carry the entire station load which it would have to do. Therefore, the arrangement shown in Fig. 8 was advised by the battery company. "R" is a rotary, "B" the booster, and "L" the load. The booster shunt field rheostat is arranged so that it is possible to reverse the current in the field winding. It is seen that there is a storage cell and some resistance in series with the equalizer "E." This battery is so connected that when current is flowing in the equalizer, as indicated by the arrow, the equalizer battery is charging. This equalizer battery is the weak point of this arrangement. It is impossible to maintain it in its most efficient state, it being either overcharged or undercharged and quickly wears out.

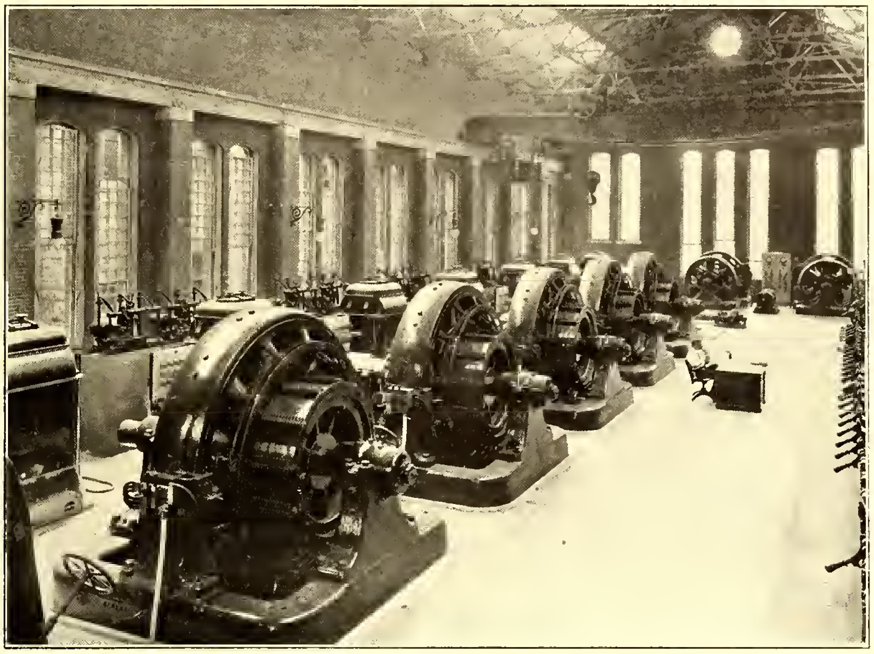


FIG. 5.—ROTARY CONVERTERS AND BATTERY BOOSTERS—CENTRAL SUB-STATION

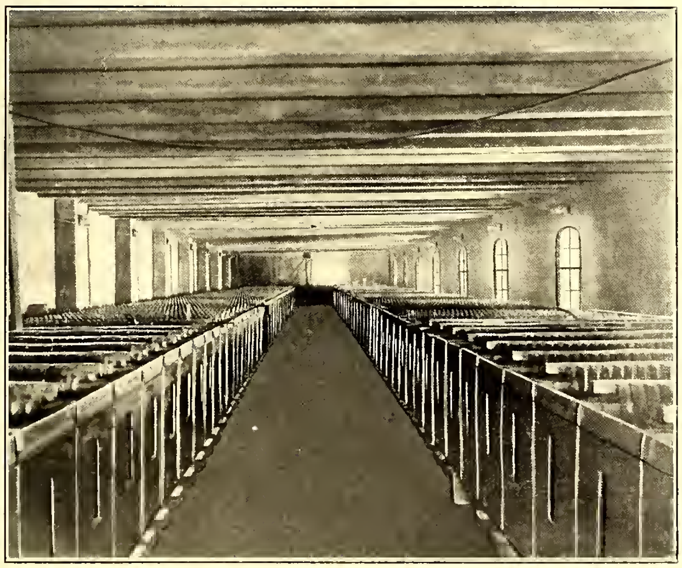


FIG. 6.—BATTERY ROOM

A happy solution has been found for this problem, and it is possible to entirely dispense with the booster series winding by the use of the new carbon regulator recently gotten out by the Electric Storage Battery Company. Its operation is as follows: Around the station bus (Fig. 9) which carries the rotary output is placed a "U"-shaped piece of iron "M." This the bus magnetizes and causes to move the lever "H," which is pivoted at "O." "S" is a restoring spring. The moving of the lever causes one or other of the two carbon pack resistances to be compressed, lowering the resistance of the circuit and causing current to flow through the field at the exciter "E." The wire at "X" is connected at the center point of the main battery, and is positive to one battery terminal and negative to the other. It will be seen, therefore, that when the lever "H" moves and compresses the other carbon pack, current flows in the opposite direction through the exciter field, and it follows that the booster field is likewise reversed, the booster having an opposite effect on the battery to what it had in the first case.

Distilled water must be supplied the battery. This installation requires about 1800 gallons per week. The cost of gas and water to produce distilled water forms quite an item in the operating expense account.

Power is delivered to the station over four three-conductor lead-covered cables. Each conductor is 0000 B. & S. stranded cable. These cables enter below the level of the street and are brought up into the air chamber, and run on concrete barrier shelves, Fig. 10, until they are opposite their respective oil switches, located upon the floor above. They then are belled out and the individual conductors pass into the switches. The necessary current transformers, potential transformers, disconnecting switches and static discharges are located in this air chamber. Each phase is entirely separated from the others

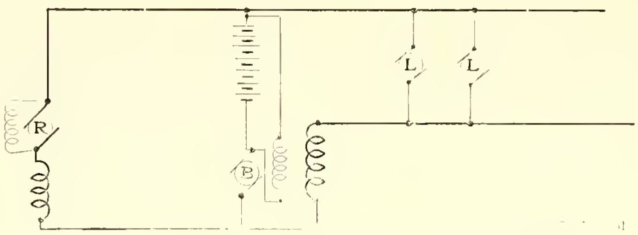


FIG. 7.—COMMON ARRANGEMENT OF BOOSTER

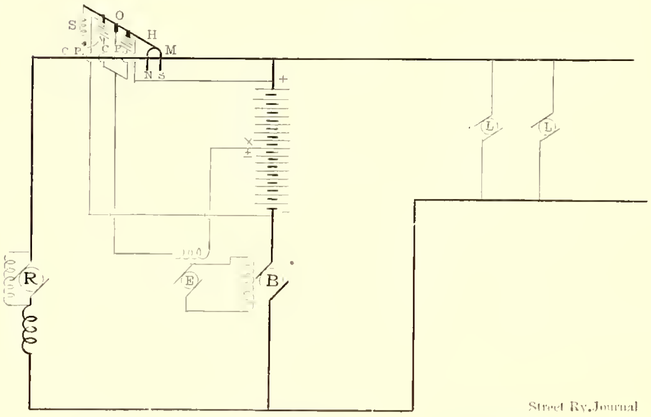


FIG. 9.—NEW ARRANGEMENT OF CONNECTIONS

by concrete barriers. From the line switch the wires drop to the high-tension bus-bars. These are located in a concrete compartment in the air chamber, which runs through its entire length. A good idea of the barriers, high-tension bus compartment and wiring may be obtained from the Fig. 10. High-tension bus consists of 1¼-in. x 2-in. copper. Studs through the back support the bus and form connecting terminals. The large openings in the face of the compartment give access to bus sectionalizing switches. The smaller square ones mark the location of bus supports. From the bus, leads rise to the machine oil switches and the current is lead from these to 1100-kw three to six-phase static transformers. The reactive coils are located at one side of the transformers, and on top of each is mounted a starting panel equipped with two three-pole double-throw switches.

The machines are started from the alternating-current side, and thus the bother of synchronizing is dispensed with. One-third, two-third and full-voltage taps are taken from the secondary side of the transformer to the starting panel. Field break-up switches are located on the machine frames. They consist of four-pole double-throw switches and break the field up into series of threes. To start, the field is left open and one-third-voltage current is supplied to the machine. When it reaches full speed it is given a field, and, if the machine has built up in the right direction, the two-third and full-voltage currents are supplied in succession. Should the machine build up wrong the field switch is put down. This connects the field directly across the station bus without the field rheostat in series with it and reverses the field. When this is accomplished the switch is thrown up. The equalizer and negative busses are located in the passage directly beneath the machines. There are no negative wires on the main switchboard except the instrument potential wires and those necessary for board lights.

The boosters are switched in with the battery on the negative side. The necessary switches are located on two isolated

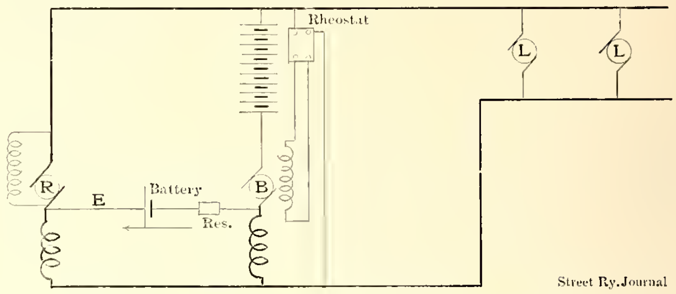


FIG. 8.—ARRANGEMENT FIRST PROPOSED

panels and are so arranged that either booster may be operated with either battery.

The four blowers are driven by induction motors, each blower furnishing 20,000 cu. ft. of air per minute.

The oil switches are motor-operated and double-break. The oil chambers are enclosed in concrete compartments, each phase being separate. The operating motor is located on top of the compartment. All oil-switch control leads, current and potential-transformer secondaries are delivered to the switchboard through conduit laid in floor.

The switchboard is of blue Vermont marble. It consists of four alternating-current line panels, eight alternating-current rotary panels, eight direct-current rotary panels, two booster-

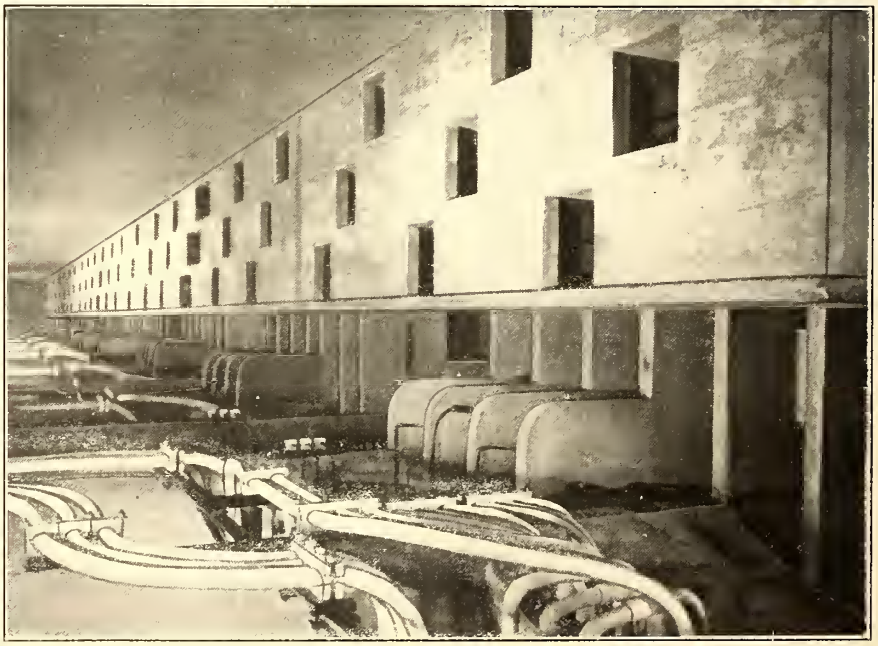


FIG. 10.—CONCRETE BARRIERS

motor panels, two battery panels, two load panels, and thirty-six direct-current feeder panels. The line panels are each equipped with an ammeter, a three-phase balanced-induction wattmeter, oil-switch control switch, overload relays, signal lamps and voltmeter plug receptacle. The alternating-current converter panels each have an ammeter, power-factor indicator, oil-switch control switch, relays and signal lamps. Each direct-current rotary panel's equipment is as follows: Circuit breaker, ammeter, rheostat operating mechanism, two double-throw quick-break main switches, auxiliary switch and a two-point plug receptacle. Booster-motor panels contain circuit breaker, ammeter, starting switch, one single-pole double-throw main switch and auxiliary switch. The battery panel is equipped with circuit breaker, ammeter, ten-point potential receptacle, two double-throw switches and auxiliary switch. The load panels hold two astatic ammeters, two differential voltmeters, one 20,000-amp. wattmeter and one 10,000-amp. wattmeter. Feeder-panel equipment consists of circuit breaker, ammeter and one single-pole double-throw quick-break main switch. The direct-current feeders leaving these panels are of round copper rods, 1 in. diameter, carried along the wall on special brackets to a terminal pole outside the building. The rod construction may be clearly seen in the photographs.

The switchboard supports two positive busses of 1/4-in. x 10-in. copper. The upper bus is of 10,000-amp. capacity, and the lower bus of 20,000-amp. capacity, at the points of maximum cross section. If it is desired to put the battery on certain feeder sections or one machine alone on certain sections, it can be done by simply using this upper bus. The oil switches, board signal lamps and relays are operated from 125-volt mains supplied by a 55-cell 17-amp.-hour auxiliary battery.

The station was erected and designed by the engineering departments of the St. Louis Transit Company according to the plans of A. B. duPont, general manager of the company at that time. L. P. Crecelius, the company's electrical engineer, superintended the designing and construction of the station.

The original plan of installing seven 1000-kw rotaries in the Central sub-station has been changed. Six 1000-kw units are now operating at that place, and the seventh was installed in Delmar sub-station. Work is now progressing on the installation of two 1000-kw and one 300-kw rotary in the Cass Avenue station, and three 1000-kw rotaries in a sub-station at 4000 South Broadway.

REPRESENTATIVE VIEW OF ST. LOUIS—OLIVE STREET LINE HANDLING WORLD'S FAIR TRAFFIC ON JULY 4, 1904

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JOHN GRANT

JAMES F. SHAW

W. C. ELY

J. C. HUTCHINS

G. T. ROGERS

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H. H. ADAMS

THE HISTORY OF THE AMERICAN STREET RAILWAY ASSOCIATION

THE FOUNDING OF THE STREET RAILWAY ASSOCIATION

BY HARDIN H. LITTELL

LOOKING back over twenty-two years one sees great changes in the street railway world. Many persons have grown almost to manhood who would not know what horse cars meant nowadays unless they visited New York City.

In the early days of my street railways experience it was my custom to spend my vacations visiting the larger cities and calling upon railway men who were entitled to the honor of having a good street railway system. The more I saw of the various systems and separate interests, the more I felt the need for a mutual acquaintance and common bond of fraternity based on social intercourse and friendly interchange of information and ideas. In the year 1881, on one of my trips, I paid a visit to Col. H. M. Watson, president of the Buffalo Street Railroad Company, and S. S. Spaulding, president of the Buffalo East Side Railway Company.

During our conversation the subject of forming a society or association of street railway men was discussed. In both of these gentlemen I found strong advocates of such a measure. On the same trip, at Providence, R. I., it was my pleasure to meet D. F. Longstreet, secretary and treasurer of the Union Railroad Company of that city. Mr. Longstreet entered earnestly into the plan of forming an association. He took it upon himself to work up an interest in the movement among his many friends in the railway business in the East. Julius S. Rugg, of the Highland Street Railway Company, of Boston, took a deep interest in the matter and rendered valuable assistance. Walter A. Jones, of the New Williamsburg & Flatbush Railroad Company, of Brooklyn, also became much interested. I also took up the subject either in person or by letter with Julius S. Walsh, president of the Citizens Street Railway Company, of St. Louis; George B. Kerper, president of the Walnut Hills & Eden Park Railway Company, of Cincinnati; Col. Thomas Lowry, president of both the St. Paul and Minneapolis Streets Railway Companies; Charles B. Clegg, president of the Oakwood & Dayton Railway Company, of Dayton, Ohio, and many others actively engaged in the management of railway properties. I first asked about ten prominent street railway men to join me in a call for the first meeting.

Some of them assented, others were of the opinion that if the call went out signed by a number of persons, some who had not been requested to unite in the call might feel slighted and an element of jealousy would be the result. A good attendance at the first meeting was much desired. So, after deeply considering the matter, I issued the call, dated Louisville, Ky., Nov. 8, 1882, for the first meeting to be held in far-away Boston on Dec. 12, 1882. It required considerable nerve to ask people in the South and West to go to Boston at that wintry season of the year. But I sent out the call and waited, I confess, with some anxiety for the extent of the response.

Replies began to arrive within a day or two, and in a short time the success of the meeting, numerically at least, was assured.

We gathered at Young's Hotel, in Boston, on Dec. 12, 1882, and to us from the South it was like journeying to the North Pole. I had not expected to have to call the meeting to order, but the duty devolved upon me, and at 2:15 o'clock in the afternoon we met. I stated the object of the meeting to those present: "Nearly all branches of industry and trade have their organizations, and it has long been to me a matter of surprise that the many street railway companies have not organized an association for the mutual benefit of all parties interested in this mode of traffic."

We all were gratified to observe fifty-six of the leading street railway men of the country in attendance, while twenty-two more sent letters or telegrams indicating their hearty sympathy and support.

I recall that one of the very first speakers made reference to the proud fact that at that time, in this country and Canada, there were 415 street railways, owning and operating over 3000 miles of track, employing 35,000 men, running 18,000 cars, using 100,000 horses, which annually devoured 150,000 tons of hay and 11,000,000 bushels of grain. Compare these glorious figures with the totals of to-day to gain an idea of the growth and transformation of the street railway business. It has declined in only one respect—horses.

But the horse was King in the old days. I recall the suggestion, at our first session, that there should be kept at the central or head office of the new association "correct information concerning the state of the horse, hay and grain markets in the different sections of the country, so that reliable information concerning all these vital interests can be obtained at all times." Over twenty years have passed since then, and so swiftly has the street railway business progressed that the question of the horse, hay and grain is now purely a metropolitan problem, restricted to New York City.

The opening session at Boston was devoted to perfecting the roll of the fifty-six street railway men present, to appointing a committee on constitution and by-laws and to general discussion of practical questions of interest to street railway men, such questions as track construction and roadbed. In fact, the meetings in the early history of the American Street Railway Association were more distinguished than some of their successors for earnest discussions of a great many very important matters. All the business was not rushed through in a session or two. Matters were not abruptly expedited in a few hours to clear the way for a grand hurrah. There was plenty of time for business, and also there was plenty of time for other pleasures. Great good came of these old-time discussions, and we learned a lot from one another in those early years when we took up and talked over problem after problem in street railway work.

The committee on constitution and by-laws was composed of Charles Cleminshaw, of Troy; Col. Thomas Lowry, of Minneapolis; Walter A. Jones, of Brooklyn; the Hon. Moody Merrill, of Boston; D. F. Longstreet, of Providence, and the writer. We reported the constitution and by-laws at the second session on Wednesday, Dec. 13, 1882. The discussion over its adoption was full of interest. Men spoke as they thought, and there was a free exchange of excellent ideas. D. F. Longstreet was the author of the constitution and by-laws. He had previously prepared them, and they were adopted with very little alteration. Then came the election of officers, as follows: President, Hardin H. Littell, of Louisville, Ky.; first vice-president, William H. Hazzard, of Brooklyn, N. Y.; second vice-president, Calvin A. Richards, of Boston, Mass.; third vice-president, George B. Kerper, of Cincinnati, Ohio; secretary and treasurer, Wm. J. Richardson, of Brooklyn, N. Y.; members of the executive committee, Julius S. Walsh, of St. Louis, Mo.; Charles Cleminshaw, of Troy, N. Y.; Col. Thomas Lowry, of Minneapolis, Minn.; James K. Lake, of Chicago, Ill.; D. F. Longstreet, of Providence, R. I.

The first member of the association was the Naumkeag Street Railway Company, of Salem, Mass., whose president, Abner C. Goodell, Jr., was number one in stepping up to the treasurer and paying the $40 admission fee and annual assessment.

Following the adjournment of the association was a banquet at Young's Hotel. It was held at 4 o'clock in the afternoon, and was tendered by the presidents of the street railway companies of Boston. We enjoyed it mightily. Col. Thomas Lowry was christened "Colonel" on that occasion, and the title has stuck to him valiantly ever since. We adjourned to meet again at Chicago, Ill., on October 9, 1883. As president, under directions from the association, I appointed committtees on track construction, propelling power, buildings, labor and wages, collection of fares, removing snow and ice, horseshoeing, heating and lighting. Papers were prepared on these subjects and were read and discussed at the October meeting, the second annual meeting of the American Street Railway Association.

It was long ago—almost quarter of a century. As I look over the list of those present at that first meeting I find many, many have passed away. It was an earnest little gathering, full of enthusiasm and the spirit that makes for progress and development. It did its work conscientiously. If Time were to arrange its reincarnation for a brief adjourned session, I feel sure this first meeting of the American Street Railway Association would adopt a resolution "pointing to itself with pride."

THE EARLY MEETINGS OF THE AMERICAN STREET RAILWAY ASSOCIATION

BY THOMAS LOWRY

I HAVE your request that I write a short article regarding the early meetings of the American Street Railway Association. I could write or say almost anything and would find none to contradict, as of the original organizers of the association, and its members assembled at annual meetings many years later, I do not find any familiar names.

I am still "in the business" and do not see any prospect, nor have I any inclination, toward getting out of it. As Fred Douglas said: "I was wid 'em in de beginnin'; I'se wid 'em now, and I stays wid 'em to de end." I remember well the discussions engaged in at the early meetings by Littell, of Louisville; Hazzard, of Brooklyn; Calvin A. Richards, of Boston; Kerper, of Cincinnati; Walsh, of St. Louis; Longstreet, of Providence; Lake, of Chicago; Cleminshaw, Holmes, Rugg, Samuel Little, of Boston; Watson, of Buffalo, and a host of others whose names I cannot now recall. They discussed propelling power, track construction, buildings, horseshoeing, repairs of track, "Is salt necessary, and is it injurious to horses and detrimental to public health," stables and care of horses, cable system, conductors and drivers, heating and lighting, taxes and many other problems then deemed difficult of solution, and all with reference to the operation of street railways by horses.

At the meeting of 1883, in Chicago, the chairman of the commitee on "track construction," Charles Hathaway, of Cleveland (one of the first and best contractors for building street railways), suggested that "when the traffic is very heavy we should recommend heavy tram rails from 40 to 45 lbs. to the yard, and well spiked to stringers, with good cast or wrought-iron joint plates at the end of the rails." Further in the report, he says: "We would not recommend T-rail except where it can be used on the sides of a street where there is comparatively little travel," etc. Later the "groove rail" was introduced, and is now used in many of our principal cities. It is now conceded by those best informed that a T-rail properly laid is better for the city and the company than any other rail in use. In the best constructed roads the T-rail, 80 lbs. to the yard,, 60 ft. long, with welded joints, laid on concrete, without ties, is used, and is conceded the best form of construction now in use.

I think it was at the convention held at Minneapolis in 1889 that electricity was first discussed seriously as a motive power. The next year at Buffalo the first paper for discussion was "A Perfect Street Railway Horse," and I then stated, in a few remarks before the convention, that "it would be the last convention to seriously consider horses for the operation of street railways." The small cars, 10 ft. and 12 ft. long, with a single truck and 6½-ft. wheel base, then considered a luxury in Boston, New York, Chicago and other large cities, have been replaced in many cities (New York and Chicago being the principal exceptions) by large passenger cars, in some cases equal, if not superior, to the best passenger coaches on well-equipped steam roads. Power plants for street railways are now being built with capacity to operate hundreds of miles of road from one station. I cannot predict for the future, but am ready to believe anything in the line of street railway development and advancement. I am in full accord with the sentiment some one wrote:

"What on earth we're coming to
Does anybody know?
For everything has changed so much,
Since twenty years ago.'

SKETCH OF THE WORK OF THE AMERICAN STREET RAILWAY ASSOCIATION

BY T. C. PENINGTON

THE real value of the work of an organization can be judged better after the lapse of some years than at the time its history is being made. The American Street Railway Association now has enough years behind it so that some intelligent opinion can be formed of what this body has done for the local transportation industry. A glance through the reports of the twenty-two annual meetings of the association, beginning with its first meeting in Boston, in 1882, impresses one strongly with the almost complete change in men and methods that has taken place since that time. It is notable, however, that in spite of these changes, the general character of the association has remained the same.

The first convention was held at Young's Hotel, Boston, Dec. 12 and 13, 1882. The owners and managers of street railways convened at that time in response to a circular letter sent out by H. H. Littell, of Louisville, who addressed the letter to all the street railway companies of the United States and Canada, at the request of a number of other street railway men also interested in the movement. The first meeting of the association being entirely for the purpose of organization, no papers were read and there were no discussions save regarding matters of organization.

At the second convention, which was held in Chicago, in October, 1883, the list of papers discussed gives the reader of the present day the first insight into the subjects which most interested the street railway men of twenty-one years ago. Some of the subjects are of as much interest to-day as then; others have not been heard of for many years in convention because of the disappearance of horse traction. Among the former class of subjects which are still of interest, we see "Track Construction," "Street Railway Buildings" and "Collection of Fares." "Removing Snow and Ice" is a subject which is still of interest, but is not by any means such a problem as it was in horse car days. For a number of years it has not been considered worthy of discussion at an annual convention because the majority of companies now have settled down to fairly satisfactory systematic means of battling with snow and ice. "Labor and Wages" is another subject still discussed, though somewhat in the abstract; while "Horseshoeing" and the "Heating and Lighting of Cars" belong strictly to past ages as subjects for convention discussions.

The early papers on track construction look strange to modern eyes. For example, the T-rail was objected to in the paper on "Track Construction" at this convention, and not on the grounds of paving difficulties either. The girder rail was brought up in discussion as a new thing at this convention, although, of course, such a rail had been in use on cable roads for some time previous. In all discussions on track work it was quite evident that the old types of flat rails laid on stringers were the usual construction. At that time San Francisco cable roads had been in operation ten years and the State Street cable in Chicago had just been started for traffic. There were naturally many references to possible changes of motive power from horses to something better in the future. Some expressed the belief that the cable road was to be the road of the future. This was but natural, as at that time the cable was the only thoroughly successful mechanical motive power for street railways. Some expressed great faith in the future of steam motors, and electricity was referred to as a rather uncertain possibility, although, naturally, with not any great enthusiasm over the results of the crude experiments which were then being tried.

H. H. LITTELL,
President,1882-1883

WILLIAM H. HAZZARD,
President,1883-1884

CALVIN A. RICHARDS,
President,1884-1885

JULIUS S. WALSH,
President,1885-1886

At the third annual meeting, held in New York City, October, 1884, we find a great deal of attention given to the question of track cleaning in winter and the use of salt. A strong sentiment against the use of salt had sprung up in many cities. The whole subject was gone over very thoroughly, and many reports on the results of scientific investigations were brought in as evidence, all of which seemed to show that there was no cruelty to horses or detriment to the public health in the use of salt on the tracks in winter. The information supplied by the association on this subject was, no doubt, of much value to the members who had to combat a certain amount of public prejudice on this question. Naturally, the motive power received much attention, just as it does in these days, and the report of the committee on stables and the care of horses drew out a lengthy discussion, which compares favorably as to the technical and practical knowledge shown, with discussions in recent conventions on the motive power of the present. The discussion on track was confined mainly to the stringer construction before spoken of, with brief references to the girder rail necessary for cable traffic. One of the features of this meeting was a report of a committee on "Electricity as a Motive Power," this being the first meeting at which this subject was discussed seriously and at any length. Naturally, the information given to the convention on this subject was very vague. At this meeting Calvin A. Richards, of Boston, made some glowing, but prophetic, utterances about the future of electricity as a motive power for street railways. Not only on this occasion, but at several succeeding conventions, Mr. Richards expressed eloquently his faith in the new motive power. To all objections he had the one answer, "Wait." One cannot but admire the enthusiastic faith of Mr. Richards in electricity as a motive power, especially since he was not a technical man, and formed his conviction not through any scientific knowledge, but drew his general conclusions from the conquests that electricity had already made in other fields. The first formal report of the cable system as a motive power was given to this convention. A matter of considerable historical interest to our friends, the Accountants, is the fact that a report was made by a committee on a "Uniform System of Accounts," giving a classification which had in view the same object as the modern classification of the Street Railway Accountants' Association of America.

At St. Louis, in 1885, "Diseases Common to Car Horses" still occupied the first and most prominent place on the programme. If the electric railway engineer of to-day thinks he has a monopoly on all the technical problems and perplexities ever connected with street railroading, let him read the proceedings of this and other conventions regarding the care and treatment of horses. He will realize that after all the technical problems involved are different in kind rather than magnitude. The "Progress of Electricity as a Motive Power" was reported upon, but the report was mainly historical, and brought out very little of practical interest with reference to more recent experiments on a commercial scale. In the discussion of this report a letter was read from a street railway company in Baltimore which had been operating two cars on the Daft system since Sept. 1, 1885. This letter answered a number of questions regarding the practical working of the system, and seemed to indicate that electric traction was at last approaching commercial success. The progress of the cable system was also reported on, and a paper and discussion on track work. The committee on rules regarding conductors and drivers made a report at this meeting, which was discussed at length. Here again we see the beginning of a movement which resulted at the last convention in the recommendation of a set of standard rules.

At Cincinnati, in 1886, the convention, for the first time, discussed a paper on "The Care, Prevention and Settlement of Accidents." A short and rather informal discussion on the "Care and Cleaning of Cars" at the previous convention brought out an extended report at this convention on the "Sanitary Condition of Street Cars," and also another on "The Ventilation, Lighting and Care of Cars." Considerable discussion took place as to the advisability of heating cars, but at this stage of street railway history most of the large companies in the North had adopted the practice of heating because of the additional traffic that they derived by having cars warm. The committee reporting on "The Progress of Cable Motive Power" was able to get together a much more useful compilation of definite engineering information about cable roads than had been before possible, because, by this time, cable roads had been installed in San Francisco, Chicago, Cincinnati, St. Louis, Kansas City and Los Angeles. The committee on "The Progress of Electric Motive Power" was also able to give much more complete and definite information about experimental electric railways than had been given at any previous convention. Much was said about the Baltimore & Hampden line of the Baltimore Union Passenger Railway Company, mentioned at the previous convention. This company seemed to have made a more favorable impression upon members of the convention than any of the other roads which were being operated experimentally in different parts of the United States at that time.

In 1887 the association met at Philadelphia, and by this time electric motive power was assuming such an important place on the street railway horizon that at least one-third of the proceedings of the convention were given over to this subject. Discussion of electricity as a motive power was for the first time taken up in an engineering way. Previous reports on this subject at earlier conventions had mainly taken the form of an outline of what had been already done, without going into the engineering problems involved in the construction of an electric railway. Besides the thorough committee report on this subject, a long discussion took place. In those days it was a question as to whether the storage battery, overhead trolley or underground conduit electric railway system would eventually win out. Some of the best engineers expressed the opinion that each of the three systems would eventually have its place in street railway work. William Wharton, who was on the committee making the report on electricity as a motive power, this year, invited the members of the convention to see the operation of a storage-battery car exploited by a company in which he was interested in Philadelphia. F. J. Sprague was also present at this convention and was invited to participate in the discussion. He did not commit himself to any one of the three systems mentioned, but was firmly convinced that the electric motor had come to stay. Charles J. Vandepole was also invited to take part in the discussion, which he did, giving some ten cities in which electric roads had been, or were being constructed by his company. This convention was not without divers other representatives of electric railway systems which were in the experimental state. There were short papers and discussions on "Roadway Construction" and "Legal Decisions," but for the main part the convention of 1887 was given over to motive power subjects.

THOMAS W. ACKLEY,
President,1886-1887

CHARLES B. HOLMES,
President,1887-1888

GEORGE B. KERPER,
President,1888-1889

THOMAS LOWRY,
President,1889-1890

At Washington, in 1888, there was somewhat of a reaction from the great amount of attention given to the discussion of electricity as a motive power at the previous convention. As one of the members remarked, "I am a practical fellow and I run a railroad with horses." While the discussion of cable and electricity was interesting to many companies about to make a change, there were still many members whose chief interest still lay with the horse car system, and who were evidently dissatisfied with having mechanical traction occupy the whole time of the convention. Accordingly, this convention was somewhat more evenly balanced as regards the variety of subjects discussed than its predecessor. The report of a committee on "The Conditions Necessary to the Financial Success of Cable Power" analyzed this subject in a much more scientific manner than had been done before in the discussion of cable power. This report took up the conditions necessary to the financial success of cable power and the volume of business, engineering and mechanical construction, engines and winding machinery. In fact, the report was a complete, though brief, review of cable practice at that time. On account of the number of cable roads then in operation in the United States, there were many intelligent cable road engineers at this convention, who took part in the discussion. The proceedings of this year, therefore, form one of the most valuable contributions to cable road literature to be found. Had it not been for the advent of electricity the proceedings would have been referred to, to a very much greater extent, in after years than they have. The committee on "Location and Construction of Car Houses and Stables" presented a long report that was of much interest to the horse car contingent, but the rumblings of the new motive power, electricity, which were becoming so distinctly audible at this convention, created a thirst for information about it that made it difficult to keep the convention away from that subject. The committee on "Street Railway Taxation" reported for the first time at this convention, and the subject is one which we have still with us. Street railway mutual fire insurance had been talked of at nearly every convention since the beginning, but for various reasons the movement never amounted to anything. Although there was no set paper nor report on this subject at the Washington convention, electricity as a motive power did not fail to receive considerable discussion. Many representatives of various systems were present, and enough of these gentlemen were allowed the floor so that the non-technical street railway man of those days must have been left in a wonderful state of bewilderment after the discussion was over. F. J. Sprague again addressed the convention this year, telling of the progress he and his company had made during the year. From this discussion it appeared that an immense amount of progress in electric traction had been made during the year and street railways were going into the business on every hand.

In 1889 Minneapolis was the place of meeting. A subject of permanent interest, namely, a "Street Railway Employees' Mutual Benefit Society," was reported upon and discussed. It is unnecessary to say that a number of street railway companies have since adopted the plan of organizing or allowing their employees to organize mutual benefit and relief associations, and are financially giving considerable assistance to such associations. By this time the success of electricity as a street railway motive power was sufficiently assured and established so that the discussions were on an entirely different basis from those preceding. For the two years previous, the clamor of the advocates of various tried and untried electric railway systems had been annoying to some of the horse car men, who came to the convention primarily to learn useful points as to the practical every-day operation of their roads. Electric traction having been by 1889 installed by a number of companies, it was possible to compare it with cable traction, and in a report on the "Conditions Necessary to the Financial Success of Electricity as a Motive Power," the comparative cost of cable and electric construction were analyzed and a number of figures were given as to the cost of electric operation. While most of these figures would hardly bear scrutiny in the light of to-day, after fifteen years of experience, they were undoubtedly of considerable help to the companies considering a change of motive power at the time they were given. The report concluded with the statement "that electricity as a motive power is as far ahead of the cable as the cable was an advance over horses." Many of the members were inclined to question this statement for a number of years after it was made, but it has since been demonstrated to be true. As the first Sprague road at Richmond, which was started in operation the early part of 1888, had been a subject of so much interest, and had received so much attention from street railway men, the association can perhaps be pardoned for giving the floor to a representative of the Sprague Company, who explained at length why local conditions and mismanagement at Richmond were responsible for a rather dilapidated state of the electric railway there. However, electric traction needed no apology by that time. H. A. Everett, of Cleveland, told of operating thirty motor cars to his full satisfaction on the East Cleveland road. Mr. Monks, of Boston, told of the successful beginnings of electric traction on the West End road, and some one from every part of the country reported successful operation by electricity. The use of "Motors Other Than Animals, Cable and Electric" was discussed and reported upon, but with no more evidence that a successful motor could be found than in the report of the year previous. The horses were not all dead yet, however, and came in for a small amount of attention in the report of a committee on "Food and Care of Horses."

In 1890, at Buffalo, the convention opened with the report of a committee on "Perfect Street Railway Horses," but the discussion was rather limited, and the association proceeded to the consideration of mechanical motive power. In the report of the committee on "Electric Motive Power Technically Considered," we find much more inclination to go into the details of electrical operation and maintenance than at any previous meeting. The cost of maintenance of electric motors, which was naturally a question of much interest and speculation, was taken up in this report and definite figures were given as to the cost and life of various parts of electrical equipment. An electric line which had been in operation for over a year in Buffalo, offered an opportunity for inspection, and some exhibits of electric cars and appliances were made at the Cold Spring car house. There was some discussion on a report concerning the "Relative Cost of Motive Power for Street Railways," and this question was more extensively discussed at later conventions. "Plans for Development of Traffic" and the subject of "Public and State Treatment of Corporations" took up the remainder of the time at this convention.

HENRY M. WATSON, President, 1890-1891

JOHN G. HOLMES, President, 1891-1892

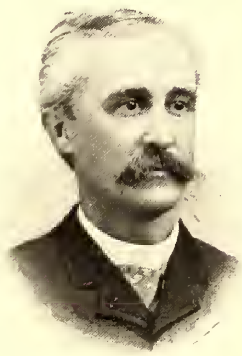
In 1891 Pittsburg was the place of meeting. By this time electric traction had gained such an established foothold that three of the five papers were given to subjects pertaining to electric traction. Of the two papers, one was on "A Year's Progress of Cable Motive Power," and the other a continuation of previous report on "Public and State Treatment of Corporations." There was still much discussion as to whether the overhead trolley, underground conduit or storage-battery system would be the coming system, but in the meantime the overhead trolley was going up everywhere, with the exception of a few experimental roads. At this convention the relative costs and advantages of cable, electric and horse motive power were analyzed more thoroughly than ever before, and while each system had its advocates, the conclusion seemed to be reached that for very heavy traffic the cable afforded the most economical motive power; for moderate traffic electricity was considered the most desirable, and for very light traffic horse traction would be the only motive power justified. As this was the first convention at which horse traffic received no attention, other than to compare it with other methods, the year 1891, as far as the work of the American Street Railway Association was concerned, marked the end of the era of horses as street car motive power, except that at later conventions the cost of horse traction as compared with cable and electric was considered.

The Cleveland convention in 1892 was decidedly an electrical affair. It is notable that this was the first convention at which the return circuit received formal attention. "Street Railway Roadbed and Underground Wiring" brought up the question of rail bonds, supplementary return wires and other means of improving the conductivity of the rail return, and a discussion of these subjects has been live matter ever since. At this convention a very interesting historical review of the events leading up to the formation of the American Street Railway Association was given by D. F. Longstreet, of Denver. Mr. Longstreet's account of the cold reception with which his idea of forming an American Street Railway Association had met among some of the Eastern street railway companies is amusing and surprising in these days when the advantages of organization and the exchange of ideas are better appreciated than in the early days. There were indeed many local jealousies which tended to prevent such an organization being formed. The report on roadbed, before mentioned, brought out the fact that street railway companies, with the advent of electric traction, were being obliged to entirely discard old ideas in track work and adopt the most substantial girder rail construction. It was about this time that companies were beginning to find out what terribly weak spots the joints in ordinary track were under electric traction. At this meeting the advantages of the T-rail began to be generally recognized, and the inability to adopt it in many cities regretted by the companies which could not use it. It was also at this convention that the possibility of using continuous track with joints welded or riveted which would not provide in any way for contraction or expansion, first became apparent from the reported results of experiments on continuous track. One of the most valuable features of this convention was the comparative data of the operating expenses of a number of cable and electric roads. In this report the conclusion was reached by the committee that the cable road had reached a stage where but little room was left for improvement, but that electric systems would continue to increase in efficiency until all rivals were outdistanced; a conclusion which we now see to be entirely sound. "Standards for Electric Street Railways" was a subject reported upon, and, among other things, a standard method of accounting was recommended, so we see again the beginning of the Street Railway Accountants' Association of America. The committee naturally found it very difficult to recommend any dimensions of parts as standard, and the impossibility of standardizing at that time can be easily seen by glancing over the suggested dimensions for various parts, nearly all of which have been increased in practice of later years. The report even went into the question of rating of motors at length, but this branch of the subject has never been followed up further by the American Street Railway Association, but has been left to the American Institute of Electrical Engineers.

In 1893, the year of the World's Columbian Exposition at Chicago, Milwaukee was chosen as a place near enough to the Exposition for convenience, and yet far enough away to keep the convention free from its distractions. An extended report and considerable discussion was had on "Power House Engines." A committee on "The Best Method of Heating and Lighting Cars" discussed mainly the heating question. At that stage of street railway development, it was mainly a question between stoves and electric heaters. "The Use of the T-Rail on Paved Streets" received attention again, and was discussed at length. "The Use of Storage Batteries as Auxiliaries to Power Stations" was for the first time brought up in a street railway convention this year. Before this time storage batteries had been mainly considered as the possible sources of motive power carried on the car. Direct-connected engine and generator units were just coming into use for railway power stations in 1893, and a report made on this subject was therefore very timely. The report illustrated some of the few large direct-connected railway generators in operation at that time. This year practicaly marked the end of the belt-driven period on electric railway generators.

D. F. LONGSTREET,
President,1892-1893

HENRY C. PAYNE,
President,1893-1894



JOEL HURT,
President,1894-1895

H. M. LITTELL,
President, 1895-1896

In 1894 the association went South to Atlanta. The year previous there had been a notable increase in the length of papers and reports, and at the Atlanta convention the programme was even more crowded. "The Use of the T-Rail on Paved Streets" was again taken up, and a report giving the cities in which the T-rail is used in paved streets has proven of much value to street railway companies in securing municipal permission to lay the T-rail. The report included data from twenty-six cities using the T-rail. Many cities were not included and others have since adopted it. Perhaps the gradual evolution of the street railway business was better shown in no other way than by the reading at this convention of a report on "Mail, Express and Freight Service on Street Railway Cars." A number of papers on special mechanical and electrical subjects, by manufacturers and others, were accepted at this convention for insertion in the minutes. Both air and electric brakes began to be pushed prominently to the front. Perhaps after all, one of the most important reports was that by H. I. Bettis on "A Uniform System of Street Railway Accounts." While reports of a similar nature had been previously presented, this brought matters to a head, so that probably the direct result of this report was the organization of the accountants, which took place a little over two years later.

The Atlanta convention brings us down to the past decade, and it is probably unnecessary to outline as fully the work of the association within that time, because this work is better known, and also because it is not as easy to judge of its permanent value. Accordingly, in the review of the past ten years, mention will be made principally of such features of the work as lasted through several conventions.

At the convention of 1895, which was held in Montreal, the question of transfers received more attention than at previous

general it was, of course, a much simpler piece of engineering than the one of 1903.

At the convention at Niagara Falls in 1897, reports on the use of multiphase current transmission and the application of storage batteries to electric traction, showed what progress electric railway engineering was making, but, after all, perhaps the report of most lasting value presented was that on municipal ownership of street railways, in which European conditions were analyzed very thoroughly and the drawbacks of municipal ownership in the present state of American municipal politics pointed out.

In 1898 the convention again went to Boston, the city of its birth. One of the principal subjects for discussion at this convention was a comparison of single and double-truck cars. This question, which was practicaly brought up the first time at Boston, has always provoked considerable discussion whenever touched upon since in convention. A change in the general sentiment regarding double-truck cars has been noticeable, both in the proceedings of the convention and on the streets of American cities, for, as we all know, there has been a great increase in the number of double-truck cars. Maintenance and inspection of equipments was also given considerable attention.

ROBERT McCULLOCH,
President,1896-1897

ALBION E. LANG,
President,1897-1898

CHARLES S. SERGEANT
President,1898-1899

JOHN M. ROACH,
President,1899-1900

conventions, and it may be said in general that this question of transfers and how best to prevent their abuse and misuse has received much more attention during the past ten years than formerly, because of the great increase in size of the street railway systems operated under one management, due to consolidations and the suburban extensions resulting from the adoption of electric traction. Conditions of the past ten years have necessitated transfer systems which were unthought of in days when there were many different companies operated in a city and transfers were not expected. Transfer problems are therefore of comparatively recent origin, and the transfer has been heard from several times in conventions since the rather complete discussion given to it at Montreal.

The convention returned to St. Louis again in 1896. Among the more prominent subjects at this convention was that of track and track joints. Cast welding was at this time just entering the field. A report on the design of power stations to produce the most economical results summarized briefly the best practice at that time, and it is of interest to compare this with a report on the same subject by the same author before the Saratoga convention in 1903, when the plans for a mammoth alternating-current generating station, 5000-kw steam turbines, was presented as representing the most advanced modern practice. The report of 1895 outlined a power station in which the maximum size of the units was 1500 kw, and in

At this convention a report was discussed on "To What Extent Should Street Railway Companies Engage in the Amusement Business?" Beginning with 1893, there had been a great deal of activity among street railway companies providing pleasure resorts for inducing traffic. It was not until 1898, however, that this branch of the business was sufficiently recognized to be given a place on the convention programme.

The convention met again in Chicago in 1899. Maintenance of equipment, track construction and train service were the principal operating subjects discussed, and a paper on "Investments in Street Railways, How They Can Be Made Secure and Remunerative," received considerable attention.

At Kansas City, in 1900, "double-truck cars" again came up for extended discussion. The work in this convention was also notable because of the amount of information regarding painting and maintenance of car bodies which it drew out.

The convention at New York in 1901 was notable, not only for the size of the attendance, but for the size of the published proceedings. The increasing importance of interurban roads was manifested at this convention by the attention given to a paper on "The Relation of Interurban Roads to City Roads," which was a review and discussion of traffic agreements between city and interurban lines. Another paper indicating the importance of the interurban road was one on block signals.

Ever since the association has started there has been some attempt to get nearer to standards in street railway equipment. Committees have reported from time to time on standard nomenclature and standard dimensions for various parts of the equipment. The convention at New York goes down into history as notable for having had presented to it the first report recommending standard forms and dimensions for many things in connection with electric railway equipment. Other reports of a similar nature were presented in succeeding years, and at the last convention the matter was practically turned over to the new American Railway Mechanical and Electrical Association, but the report at New York forms an important mile post in the history of the attempt to adopt electric railway standards. That more progress has not been made in this direction is due to the inherent difficulty of introducing standards among electric railway companies at the present time.

At Detroit, in 1902, the convention met amid distinctly interurban surroundings, at the center of one of the most important interurban systems in the country. Although subjects pertaining purely to the operation of interurban roads had not previously occupied as large a portion of convention programmes as might be expected, considering the very rapid growth of interurban roads recently, the general trend of all discussions at Detroit showed plainly what an important part the operation of interurban systems is taking in the electric railway interests. Freight and express business as carried on by interurban roads formed the basis of an extended report presented to the Detroit convention. The adjustment of damage claims has received more attention the last few years than formerly, and was one of the prominent topics at Detroit. That this question is receiving an increasing amount of attention at conventions is probably due to the tendency of the times toward an increasing number of unjust damage claims and the allowance of exorbitant damages by juries for personal injuries not due to the fault of the company.

When the convention met at Saratoga in 1903, there had sprung up during the year a new organization which is manifestly destined to make considerable change in the character of convention programmes in the future. The American Railway Mechanical and Electrical Association will doubtless have given to it by common consent the discussion of the mechanical subjects connected with street railway operation. Although the Saratoga convention is not old enough in history so that a fair judgment can be formed as to things it did, which will be of lasting benefit, one matter was brought to a head which has been running through convention proceedings ever since the organization of the association, namely, that of standard rules. As the proper conclusion of several years' work of a committee on standard rules, the Saratoga convention adopted a standard set of street and interurban rules for the government of conductors and motormen, and recommended that these rules be adopted by all companies in the business, at the same time recognizing that improvements will probably be made from time to time in the rules as adopted.

In a brief sketch of this kind it is manifestly impossible to mention in detail many excellent reports and papers on various subjects which have been presented from time to time, and which form a mine of valuable information. It has been possible only to simply call attention to papers and discussions which represented general tendencies in various directions of activity, noting the beginnings of certain movements and following them through the history of the association.

In conclusion, it may be said that a general review of the work of the American Street Railway Association for the past twenty-two years shows that the progress of the art has been so rapid that the conventions are merely mile posts on the road of progress. As is fitting in a conservative body like the American Street Railway Association, many of the new things have not been brought up in convention until they have been tried on a large scale in actual street railway practice. It would not be profitable for the association to take valuable time in conventions for the discussion of suggested improvements which have not demonstrated their worth; the proceedings of the association are therefore necessarily a little behind the real progress of the street railway art. In the discussion of new inventions, beginning with the introduction of mechanical traction as a substitute for horses, and ending with the steam turbine as a substitute for reciprocating engines, there has always been one element in the association eager to discuss the new

WALTON H. HOLMES,
President, 1900-1901

H. H. VREELAND,
President, 1901-1902

and untried, and another protesting against such a policy and desiring to confine the convention proceedings to questions of operation and existing appliances. These two elements have so balanced each other that the association has never, in the long run, given any undue amount of time to the discussion of the very new things, and at the same time has not been behind in the march of progress.

The preceding remarks are all historical. I would in a few words criticise a weak point in our conventions. While we all like a "good time" and enjoy very much the hospitality of our friends who invite us to their respective cities, don't you think, Reader, we should give a little more time to business? or in other words, "business first, pleasure afterwards." Let us be prompt to attend the business sessions and stay until adjournment, help the business along by giving our mite to the discussions. We owe to the company which sends us as delegates attendance at all sessions, and also to the gentlemen who spend days and weeks getting up papers for our enlightenment, and hereafter let us work first and play afterward. The writer enjoys a "good time" as well as any one, and perhaps is entitled to as much of this criticism as any one, but let us all try and attend to business first in the future and then visit with our friends, very many of whom we only see once a year.

THE EVOLUTION OF THE INDUSTRY

IN HORSE CAR DAYS

BY C. DENSMORE WYMAN

ONE may plead guilty to having witnessed and actively participated to a greater or less extent in the discussions, plans and actual work incident to the evolution of the modern electric railway without such a plea being accepted as a confession of great age, or without characterizing its maker as a person properly to be styled after the fashion of newspaper reference as the "Oldest Inhabitant." As a single life time spanned the gap between the Declaration of Independence and the laying of the first rail of the Baltimore & Ohio Railway, the dean of the steam railroad fraternity, so the period of experiment and endeavor covering the development of the modern street and interurban car has been a marvelously brief one, when we consider the importance of such a step in the economic history and development of urban and suburban communities.

It seems but yesterday that the ponderous and aldermanic omnibus, as if weighted with the memories of its distingushed ancestry, lumbered over the streets of New York and refused for a time to yield its place to, what it apparently considered, the impertinent and "smartish" street car that, with business directness, hastened along an iron way to its destination, instead of winding over the cobbles and through the dust of the ordinary city highway. But the horse car, with its modern conveniences and more rapid pace, soon found such favor with the public as to become a necessity for general city transportation service, and the 'bus was relegated to the limbo of the outgrown and the superseded. And later, in answer to the demand for a more rapid means of transit than could be afforded by animal power, came the cable and the electric trolley car to work in like manner the downfall of its horse-propelled predecessor.

These changes, to be sure, have taken place with various overlappings, as though the representatives of each were loath to part company, and in New York the tinkle of the street car bell yet mingles with the brazen clamor of the trolley car gong, while over the water the tram is yet regarded as savoring less of gentle ancestry and position than the old-fashioned 'bus, and is thus securing a tardy recognition.

The step from the omnibus as a means of regular city transit to the horse car was more deliberately taken than that from the latter to the electric trolley, but this was largely due to the fact that when that form of traction asked admission to the field hitherto occupied by the omnibus lines, questions of franchise, involved in the granting of rights to lay permanent tracks in city streets, excited widest discussion and not a little opposition. Even in our land and age of accelerated motion and restless genius, there was great disposition to hesitate before granting such privileges; for, although omnibus companies had been given charters for regular routes in some of the larger municipalities, such charters did not involve the placing of a permanent style of construction in the cities' highways, and, hence, did not invite special criticism, either for legal, business or æsthetic reasons. The change proposed was a radical one, and such changes always excite apprehension as to final results. When Rowland Hill's penny-post scheme had gained such support as to be very seriously considered in Parliament, Sir Robert Peel, the greatest financial minister of his day, was its strongest opponent and prophesied nothing but loss and failure as a result. In the light of the present status of street railway franchise questions and the benefits which have accrued to the cities of the country in which liberal charters for urban transportation privileges have been granted, it is amusing to read the prophesies of danger and hazard to the public, presented in the newspapers, legislative and municipal halls at the time the street railroad companies were seeking street rights, as sure to come if cities should be gridironed by street railway tracks.

The steam railroads, aided financially and in other ways by the States and towns which they proposed to traverse, secured legislative permission to condemn property and acquire rights of way before the street railroads entered the field. But when the latter sought to operate within cities upon streets dedicated to public purposes and hitherto used in common by vehicle owners and 'bus proprietors, they encountered vigorous opposition, and were obliged to meet and overcome legal and social arguments, the echoes of which have not entirely died away.

Those of us, therefore, who were actively engaged in the horse car business may claim that the years covering the introduction and development of that species of urban traction were the arena in which was fought out many of the broad questions incident to the general city transportation question, and that no given period has been more prolific in the discussion and settlement of problems, the wise solutions of which have made for the growth and enlargement of the great urban communities of the country.

When the writer first became connected with one of the horse railways in the city of New York there was no Railroad Commission in the State. No general railway enactments by which a street railroad might incorporate and acquire rights to do business had been passed, and companies were obliged to operate very largely under special acts which from time to time had been passed by the Legislature covering their privileges and limitations. Accident law, too, as applied to happenings of that sort in connection with street railway transportation, was meager and confusing, and the great dictum of "Stop, look and listen" had not been enunciated.

The decade from 1874 to 1884 may be fairly considered the period of greatest development in horse car history, for during that time the street railroads of the progressive cities of the country, responding to the demands for improved cars and more frequent service, introduced and adopted many conveniences in the form and style of vehicles and in their practical operation, and thus secured favorable recognition and a liberal patronage.

In New York City at the close of the period named, there was hardly an avenue traversing Manhattan Island from north to south, below Fifty-Ninth Street, which did not have upon it and give its name to a horse railway line, and many of the crosstown lines in the metropolis had already been projected or built. Some twelve or fifteen separate and independent companies were serving an insistent and critical public, and, with one or two exceptions, all were prosperous and progressive.

The securities of these companies had not the honor of a place on the active list of Stock Exchange offerings, and while for this reason they lost the advantage of being easily bought and sold, they avoided the hazard of manipulation for stock jobbing purposes and did not figure in the daily record of the ups and downs of bull and bear movements; but their dividends were as even tenored as the jingle of the nickel in the fare box, and they were held strong and fast by cautious investors and financial institutions.

During this period, improvements in constructions of cars, such as the monitor roof, the present style of coupling, the cash register, the open-sided, cross-seated summer car and many other innovations, which in form enlarged and strengthened are used to-day in our electric cars, were introduced and adopted.

The principles of general organization were studied and applied, and out of the desire of street railroad managers to discover what was best in that direction, and to secure such exchange of opinion and judgment as would make for the discovery of the best practice, was born the American Street Railroad Association, that organization which has borne such magnificent fruit since its first meeting in 1882. Nor can we fail to mention that street railroad literature came into being during horse car days, and we who have been so long the beneficiaries of the journals devoted to the interests of our kind of transportation business cannot acknowledge in too strong terms the debt we are under to these publications.

We cannot forget that in horse car days very many of the questions affecting labor and the problems of the relations of employer to employed were as calmly, patiently and studiously considered as they have ever been at any time by the managers and directors of corporations, and the general lines of conclusion in regard to the rights of labor and the rights of the employer reached, after much study and some conflicts, during horse car days, remain unimpeached for the present time. It is perhaps notable that in the city of New York, since the time of the last general clash between the horse car employees and the companies, no strike or serious railroad conflict has occurred.

One is tempted while writing of the horse car days to name the men whose far-sightedness, business intelligence, public spirit, and whose financial faith solved in such an excellent manner for their day the question of urban transportation. It was their work which gave such an impetus to the territorial expansion of the cities of our country, and which added so greatly to the wealth and comfort of their inhabitants, but the limits of this brief reminiscence will not permit the inclusion of so splendid a roster.

One characteristic of the horse railroad director and manager of the period covered by memory of the writer must not be left unmentioned, and that is the lively expectation that his open and willing mind, universally evidenced by his constant search for some better motive power for cars than that afforded by horses. He was above everything else progressive, and was ready to adventure time and money to discover a more rapid and a better source of power than he had at hand, and the records of the annual meetings of the association bear witness to the many discussions had by the representatives of the horse car companies as to the feasibility of employing as a motor, steam, electric, cable or compressed air. In the investigation of each of these motive powers the early railway companies spared neither time nor money, and it is to the credit of the penetration and zeal of the horse car manager that when once a demonstration had been made, even in the crudest way, that cable or electric power could be utilized practically for the propelling of cars, he exhibited comparatively no hesitation in making the change.

"From the days of the first grandfather everybody has remembered a golden age behind him," but we sometimes are tempted to despise the old and simple as cheap and unimportant.

The days covering the organization of the horse car companies, and the development of their business, and ending with the change of their motive power to cable and electric traction, were days potential in all that has gone to produce the present improved status of the art or science of street railroading. If we wish to characterize them broadly, we might say they were days covering the discovery of the broad, general principles of street railroad organization and methods, while the present régime is more concerned with questions of technique, of scientific engineering and of comparative statistics.

Viewed in perspective and without any disposition to magnify the excellencies or to forget the deficiencies of the horse car era, we can but acknowledge, as we look back over its work, that it presents a most interesting chapter of a fruitful period in the history of street car transit for cities and towns, and that to the skillful, energetic and public-spirited men engaged in the business at that time, not only are we who remain in the line of work which they projected and instituted, but all citizens in town and country, indebted for the enlarged and multiplied utilities brought within their reach during the last few years in the line of better urban and interurban transportation.

> "Still o'er the earth hastes Opportunity,
> Seeking the hardy soul that seeks for her."

EARLY ELECTRIC RAILROADING IN NEW ENGLAND

BY E. C. FOSTER

SIXTEEN years ago, at the beginning of the electric railroad development in New England, I was connected with the Lynn & Boston Railroad Company, in the capacity of superintendent. Amos F. Breed, of Lynn, was president of the company, and E. Francis Oliver, of Boston, was the treasurer. Our corporation, like most other street railway companies of that time, was controlled by the president, treasurer and their friends, the balance of the securities being distributed among local people.

I, personally, am not familiar with the first negotiations which took place relative to the equipment of our system with electricity, because they were taken up by our president and treasurer and discussed at considerable length with Gen. Eugene Griffin, who then represented the Thomson-Houston Electric Company, and is now vice-president of the General Electric Company. The subject was first seriously considered in the year 1887, when it was proposed to build and equip electrically 1 mile of track located on Ocean Avenue, in the town of Revere, where now are the famous Revere Beach and the world renowned State bath house of the State of Massachusetts.

At that period Revere Beach was used as a recreation resort by the people of Boston and vicinity in only a limited way, and for a long time the Revere Street line was the only one running to the beach. This road had formerly been operated by a steam dummy. Subsequently a second connection to the beach from the main line, which extended between Lynn and Boston, was constructed by the way of Beach Street, Revere, from Broadway, and when in 1887 electricity was proposed, the plan was to build an electric line on Ocean Avenue, connecting these two lines—namely, Revere Street and Beach Street, and extending even further than Beach Street, in the direction of Boston, making the distance to be equipped about 1 mile.

Many conferences were held between Gen. Griffin and other representatives of the General Electric Company, and Messrs. Breed and Oliver. Mr. Breed was very conservative and Mr. Oliver an ultra-conservative, and, as they had nursed the property from a non-dividend paying one, with the stock selling at 75 cents per share to a par value of $100, they were naturally inclined to be cautious and conservative.

One of the most serious objections that they had to the equipment of the line electrically was the height of the car floor above the rail, made necessary by the use of two motors of the F-30 type. This elevation created a possible danger, in their minds, to the passengers, especially to ladies and children, when entering and alighting from the car, and many earnest and sincere conferences were held on this particular subject after all other points had been decided upon. I remember very well that our treasurer was very much concerned about this one particular feature. But after due consideration, it was decided to build this experimental line and equip it electrically. The equipment consisted of but one car, and that an open cross-seat car, as the line was to be operated during a short period in the summer season.

After all details had been arranged and everything was satisfactorily adjusted, the construction of the track was commenced and prosecuted vigorously until the road was completed. The equipment of the car was also undertaken by the Thomson-Houston Company, and Mr. Ballard, then one of the trusted employees of the Thomson-Houston Company, and now one of the chief operating superintendents of the mechanical department of the Boston Elevated Railway Company, was put in charge of this work. There were many obstacles to be overcome, but they were successfully surmounted by Mr. Ballard and his associates, so that on July 4, 1888, the line was put in operation. The power for propelling the car was purchased from the North Shore Electric Company, which was controlled and operated by the Thomson-Houston Company.

At that time there were no such conveniences for car repairs as are in existence to-day. For instance, we had no pit, and any work required on the motors had to be done by the mechanic laying upon his back in the dust underneath the car and working in that position.

The equipment, as I recall it, cost $3,200 for one pair of motors of 15-hp capacity each. They were very heavy and cumbersome, yet they furnished the motive power for the moving of the car with as many people as could be packed upon it, and as the road was something of a novelty, it being one of the first roads equipped in the State of Massachusetts by electricity, the patronage at times was very great.

The cost of duplicate parts for repairs was something enormous, but we were inexperienced, and not knowing the actual cost, believed that they were all right. I recall very well that we paid $7 for a trolley wheel such as we are purchasing to-day for from 52 cents to 58 cents each, and all other duplicate parts were charged for in the same ratio. This condition prevailed for a time, as every one connected with street railways was a horse railway man, and not having had any experience electrically, depended entirely upon technical men and believed that any price that was charged for repair parts was all right.

Subsequently, a second line was equipped by the Lynn & Boston Railroad Company, that operating over Union, Rockway, Hollinsworth, High Rock Avenue, Essex and Market, Oxford Street and Central Avenue. This road formed a belt line about 2 miles in length, and ascended a grade of about 9 per cent and descended one of 12⅞ per cent. When this line was equipped and put in operation it seemed to the ordinary person that the power contained within the motor was almost beyond comprehension. It did not seem credible that a car without any visible power could glide along as it did, ascending and descending grades with absolute safety. This line was often referred to at that time by the experts of the Thomson-Houston Company as an example of what electricity could accomplish as a motive power, and was visited by many railway managers from different parts of this country and abroad.

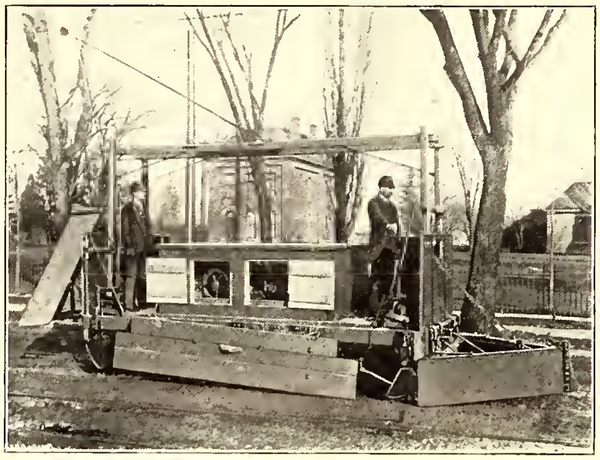
THE FIRST ELECTRIC CAR ON THE LYNN & BOSTON RAILWAY

Subsequently, a third line, that from Central Square to Nahant Beach, was equipped and operated. This line was constructed under the supervision of an engineer named Jones, who since that time has represented the General Electric Company in South Africa.

After operating the line on Revere Beach during the summer season and commencing to operate the line over the "Highland Circuit," as it was commonly called in Lynn, during the winter season, many obstacles were encountered in the way of snow and ice, and the question arose whether a snow plow could be operated by electricity or not.

An experiment was tried in our shops in Chelsea, under the supervision and management of H. E. Farrington, then master mechanic, who conceived the idea of building a snow plow somewhat upon the lines of the old-time horse plow. The plow was operated by two F-30 motors, connected with the axle by sprocket chains, thereby reducing the efficiency very materially. This type of plow has continued to be operated up to the present time, with many modifications. Although the plow of to-day, as operated by motors attached directly to the car axles, is much greater in capacity and contains many modern improvements, the first idea, as in many other machines of great importance in the commercial world to-day, has simply been improved, but not materially changed in design.

The third problem was that of crossing a steam railroad track. At that time all the gates protecting the general public at such crossings were of the single rigid arm type, and it was impossible to lower and elevate them without striking the wires, and as the steam railroads had the authority to maintain the gates as they did, the electric cars had to coast across the steam tracks. A young man living in Lynn conceived the idea of overcoming this difficulty by the erection of four posts—two on each side of the steam railroad track, those two on each side being connected by a double steel truss, with space between the two trusses to admit of the lowering and elevation of the gates. The posts were 14 ins. square, and the truss was about 4 ft. in height, and of sufficient strength to support its own weight, so that it made a very formidable looking structure in the street. The young man who conceived this idea believed that he had a



AN ELECTRIC SNOW-PLOW OF 1889

fortune in sight, but, like many other unfortunate inventors, he was doomed to disappointment, and subsequently took down the structure at his own expense, as he had erected it. Some other active-minded person had conceived the idea of putting a hinged extension on two of the arms of the gate, so that in reality the arm of the gate was reduced in length by about 15 ft., and would pass by the trolley wire when being lowered or elevated. This was such a simple device that every one wondered why somebody else had not thought of it long before. As an evidence of the importance of this subject it might be said that the problem had previously been submitted to the engineers of the Thomson-Houston Company, and they had given it up, not knowing how to solve it.

Many other difficulties which presented themselves to the operating man were gradually overcome, and to-day have become nothing but commonplace events. The method of connecting the rails at that time was crude, but the problem was not a difficult one to solve. There were many other questions in connection with the operation of the electric railroad at the early date which none but those who had to do with the operation can realize. The Crescent Beach Division of the Lynn & Boston Railroad Company, mentioned above, was the first electric railway built by the Thomson-Houston Company, and the first instance of carrying passengers for hire in street cars by electric power in Massachusetts, as well as one of the first to be operated in the United States.

"The crude experiments already made with electricity as a motive power in propelling cars clearly foreshadows the inevitable application of the new motor to our immediate interests,"—*From Chicago Meeting, 1883.*

THE EARLY WORK OF THE DAFT COMPANY

BY LEO DAFT

AFTER a number of experiments in the line of electric traction during 1881-2, the Daft Electric Company, of which the writer was the founder, deeming it advisable to meet the often expressed disbelief in the possibility of running several trains in parallel by a practical demonstration, hastily built two more small locomotives in addition to the two which had been running on the short narrow gage track in the yard of the Greenville factory for several months, and in December, 1882, made almost daily public tests with the four motors running parallel. Curiously enough, that which seemed to occasion most comment among the street railroad men was running the machines in opposite directions on four sections of the same track.

While of small dimensions, these motors could hardly be called toys, since one of them was frequently made to tow a flat car loaded with 3 or 4 tons of iron, and as they were single-reduction sprocket geared, the armatures were not infrequently suspected of smoking and other bad habits.

The control was by commuted fields and carbon-rod rheostats, and the brakes were electric of the bipolar moving-core variety. The track was 16-lb. rail of 22-in. gage, and spiked on ties projecting well above the ballast, without any attempt at other insulation.

Seeking opportunities for more practical work, early in 1883 the writer designed the electric locomotive "Ampere" for

FIG. 1.—DAFT MOTOR "AMPERE"—1883

trial on the Mount McGregor steam railroad at Saratoga, and during the summer of that year equipped about $1\frac{1}{4}$ miles of that road with a 35-lb. third rail, mounted on resinized wood blocks in the center of the track, with soft rubber insulation under the foot of the rail and bolt heads. The pressure was 130 volts, and except in drenching rains the leakage was insignificant. The best work of this motor consisted in towing an ordinary day coach containing sixty-eight passengers, making a load altogether of some 17 tons over a curve of about 100 ft. radius on a gradient of 93 ft. per mile. An accident due to the breaking of a temporary coupling occurred on the first day of public running, but after repairs were made the "Ampere" continued running intermittently for two or three weeks.

This motor was double-belt reduction, with both drivers engaged from a countershaft under the body, and was controlled by grouping the commuted field windings in various ways by means of the controller shown on the switchboard in Fig. 1. The other switches were for brake and main cut-off, or "canopy" switch. The electric pendulum brakes are clearly shown in the cut, which is from a photograph taken in the factory yard.

Following this experiment, two or three small show roads were equipped by the Daft Company in 1884, and were operated by the motors "Paccinnotti" and "Volta" at the Iron Pier, Coney Island, and the Mechanics' Fair, Boston. In these cases the drivers were insulated from the shaft on one side and the current obtained from the outer rails. Some 35,000 passengers were carried in each case during the season.

Among the visitors to the Coney Island exhibit was one of the most progressive street railroad men in America, the late T. C. Robbins, then general manager of the Baltimore Union Passenger Railroad, who lost no time in communicating with the Daft Company, and early in 1885 invited the writer to visit Baltimore with a view to equipping the Baltimore & Hampden branch of the road with electric tractors. In a subsequent letter to the Daft Company, Mr. Robbins described this branch in the following terms: "There are not 2 miles of street railroad in the country more difficult to operate, owing to the unprecedented grades and curves," and again: "There are not 300 ft. of level track at any one point on the road. The grades vary from nothing to 350 ft. to the mile, with curves from 40 ft. to 70 ft. radius on heavy grades." The curve difficulty was further increased by the broad gage of 5 ft. 4½ ins., then common in Baltimore. Altogether, the prospect for an initial contract was so far from alluring the writer had no difficulty in disguising his enthusiasm. But like the old woodchuck story, the road "had to be there," so he returned to New York with the first really business railroad proposition yet received, in the shape of a proposal for the Daft Company to equip with two independent motors and the necessary track equipment and wait for payment until the road should have been in satisfactory operation for one year! If the more or less gentle reader can imagine the true nature of this proposition in those days he must be another Kipling. But in spite of the friendly efforts of Mr. Robbins the powers were obdurate, and the writer had to return again to New York, after a stormy conference, with a contract embodying some modifications of the original terms, and his heart "in his shoes."

But the worst was to come. When the designs for the motors and other apparatus were well under way, a hasty summons from Mr. Robbins called the writer to Baltimore, only to learn that an eminent scientist had been consulted by one of the more timid directors, and after carefully examining the road had declared that "the man who undertakes to operate this section by electricity in the present state of the art is either a knave or a fool" (!), and such was the power of this really eminent man's name that the directors were a unit in firmly declining to allow their "business reputation to be trifled with" by engaging in what appeared in the light of this opinion as a "wildcat contract." Vainly the writer argued that the weight of failure would rest almost entirely on the construction company; the directors were deaf alike to argument or entreaty,

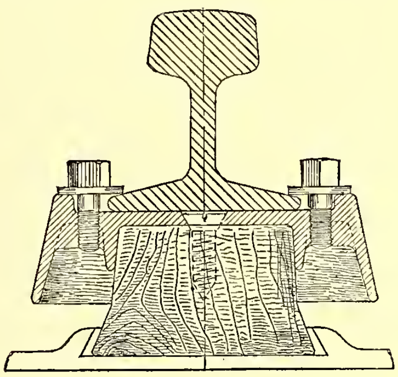


FIG. 2.—INSULATOR USED AT BALTIMORE, 1885

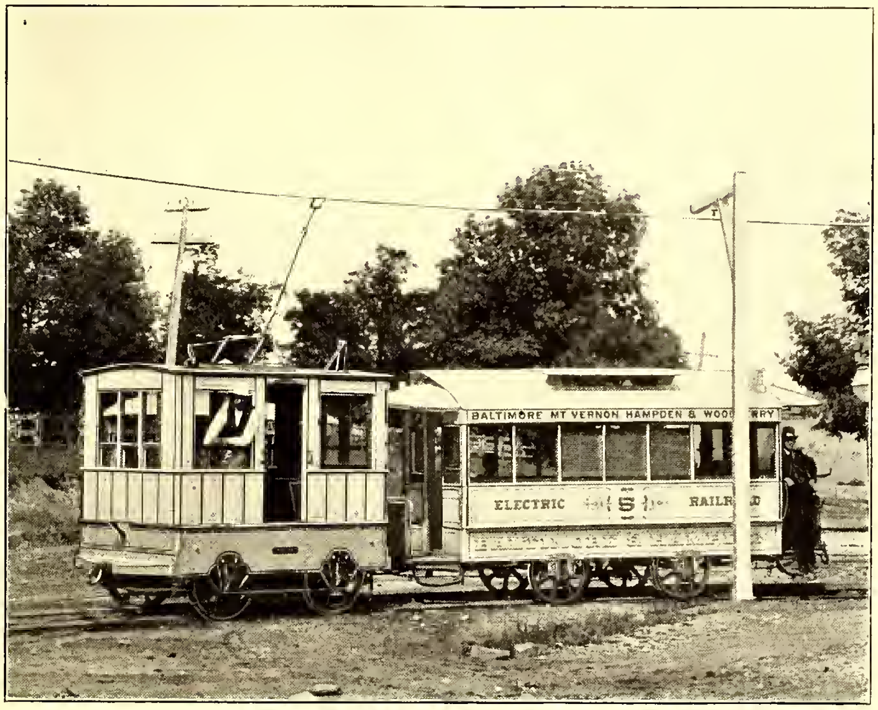


FIG. 3.—DAFT UNDER-TRAILING CONTACT USED IN BALTIMORE IN 1886

and the day was practically lost when that sturdy old nobleman, T. C. Robbins (for in the Emersonian sense I know no other word that fitly describes him), stood in the breach and gave the directors the alternative of carrying out the agreement or losing their general manager. They did not lose their manager; and but a few months afterward the eminent scientist rode over the entire line during a heavy thunderstorm in half the time previously taken by the horse cars, and the writer regrets to add that an irreverent conductor actually collected his fare! At the end of the first year of operation the equipment was formally accepted, the remainder of the purchase price paid, and an order was given by the company for additional motors and other material.

The "Morse" and "Faraday" were first delivered, and were simply dummy cabs equipped with series motors, having commuted fields for grouping, as previously described. They were single reduction, with cut-steel pinions and cut cast-iron gears, weighed about 2½ tons each, and collected current from the third rail by means of phosphor-bronze double flanged wheels, resiliently mounted, and with ample provision for lateral motion. The cars were of the then standard 16-ft. type, weighing some 5500 lbs., and occasionally carried seventy-five passengers. For various reasons it was necessary to place the power house at the Baltimore end of the track, where two Daft dynamos were belted up to a jackshaft which was run by an Atlas 16-in. x 24-in. medium-speed engine, and it should be noted that an automatic cut-out formed part of the equipment. With the dynamos always connected in series the normal voltage was 260. The 35-lb. third rail was supported on the now familiar umbrella insulator with wooden block standards baked and saturated with resin, Fig. 2; the leakage was small except during the violent rain storms, peculiar to that region, when the foot of the third rail was occasionally submerged for 200 ft. or 300 ft., but without interfering with the traffic. The rails were bonded with tinned copper wire, riveted to the web with tinned copper rivets.

FIG. 4.—THE "BENJAMIN FRANKLIN" NO. 1, USED ON NEW YORK ELEVATED RAILWAY

Much of the work of installing both power house and track was confided to the now well-known engineer, Horatio A. Foster. His host of friends well know with what characteristic thoroughness and ability his share of the work was performed.

After the first year the equipment was increased by two more, and somewhat stronger motors, and in the holiday rush hours a two-car train was occasionally used. The normal mileage of each motor was 75 per day. The first under contact trailing-arm device, designed and patented by the writer, is shown in operation in Fig. 3, and was used at long crossings early in 1886.

On Aug. 15, 1885, the road first began regular operation, though the motor "Morse" had made many experimental trips, and on the morning of that day the motor "Faraday," piloted by Guy M. Gest, the "father of the motormen," who had been indefatigable for some time in training men for all kinds of work and being generally a host in himself, pulled out of the yard with a 16-ft. car in tow, containing some forty passengers; and the first commercial electric railroad in America had hung up its shingle! Among the passengers was John K. Cowen, then chief counsel to the Baltimore & Ohio Railroad, who suggested that the first nickel taken by the conductor should be given to the writer, and accordingly this was done at the end of the return trip, together with a letter written by Mr. Cowen and signed by the conductor, J. T. Parrish, which is now in the writer's possession.

The road continued in successful operation for four years, or until the fall of 1889.

While the work of equipping the Baltimore road was progressing the writer had been making experiments with a view to the use of electric traction on the elevated railways in New York, and to that end had designed a locomotive more ambitious than anything yet attempted, which was finished at the Greenville factory early in May, 1885. This was the "Benjamin Franklin" No. 1, consisting of a heavy boiler-plate frame containing the motor, pivoted at one end and adjustable by means of a pivoted vertical screw at the other for convenience of raising the cut-steel pinion out of mesh with the cast-steel gears on the driving axle.

The gearing was single reduction, the two steel-tired drivers were 48 ins. diameter, the trail wheels were 33 ins. diameter, and the frame was surmounted by a dummy cab, shown in Fig. 4, made from photograph taken on the Ninth Avenue track at Fourteenth Street. The control was by means of commuted fields, similar to that of the "Morse," and partly by external resistance; the pressure was at first about 300 volts, but this was later increased by the addition of another dynamo to the two already installed, and the three in series increased the pressure to about 450 volts, which necessitated the use of further external resistance in starting. The power house was an abandoned sugar refinery on Fifteenth Street, and was equipped by the Daft Company with a Wright-Corliss engine, supplied with steam from boilers formerly used by the refining company. Permission having been obtained several months before to use the track of the Ninth Avenue Elevated from Fourteenth to Fiftieth Streets, a distance of about 2 miles, including several gradients, the work of placing a 60-lb. third rail supported on umbrella insulators, was completed in June, 1885, and during the following month the "Ben Franklin" began running experimentally at night, the road at that time being clear of traffic between 10 p. m. and 4 a. m., towing two, three and occasionally four-car trains. The third rail being rough and rusty, caused the phosphor-bronze collecting wheels to make so fine a pyrotechnic display that on more than one occasion the policemen threatened to arrest the entire crew for an incendiary attempt, but after clambering up the lattice pillars, the crew in charge of the entire section naturally declining to open the station gates, they were deterred by the suave address of our good friend, G. W.

Mansfield, who courteously intimated that the penalty of stepping on the track was instant electrocution. The experimental running was continued at frequent intervals until December, 1885, and again during a part of the summer of 1886. The best work done by this motor was towing a four-car train from Fourteenth to Fiftieth Streets, including the long gradient of 1.86 per cent from Forty-second to Fiftieth Streets, in nine minutes, as shown by the records. The motor was of about 75 hp, weighed 8½ tons, and much too light for any regular four-car traffic, besides being obviously defective in other particulars.

During the summer of 1888 the "Ben Franklin" was partially reconstructed at the Greenville works, two extra drivers being added and the four coupled by connecting rods, rendering the whole wheel base available for traction, and a much larger motor substituted for the one of 1885, besides other changes, including the use of intermediate external resistance in control, and the former third rail having been disposed of, a copper rod ⅝ in. diameter was placed on improved umbrella insulators for the entire distance, and at the side instead of the center of the track.

A fourth dynamo was installed at the power house, and in October, 1888, the experiments were resumed with higher pressure and much better results generally. Previous to placing the motor in the dummy, Prony brake tests were made in the power house, resulting in a development of 128 hp. For some two or three weeks of probation the new "Ben Franklin" was required to run only at night, during stop hours as before, since the admirably cautious Col. Hain, then general manager of the road, to whose uniform courtesy and kindliness the writer wishes to bear tribute, was naturally averse from risking interruption of traffic until he had "seen how the thing worked," was at last prevailed upon to allow the running to continue during the day upon two imperative conditions: First, that the train should only be operated by the writer himself or his chief assistant, F. H. Reed, and secondly, that in the event of the least interruption to the regular traffic the motor and equipment should be immediately removed and all privileges considered at an end. The records of the Ninth Avenue Elevated Railway for that period show that though the running with a four-car train was continued between the regular steam trains and during rush hours for several weeks in October and November of 1888, with the writer acting as motorman, no such interruption occurred, though those who took part in the work will remember moments of dramatic intensity which they would not again willingly encounter.

FIG. 6.—MOTOR CAR IN ORANGE, N. J., WITH MOTORS UNDER CAR

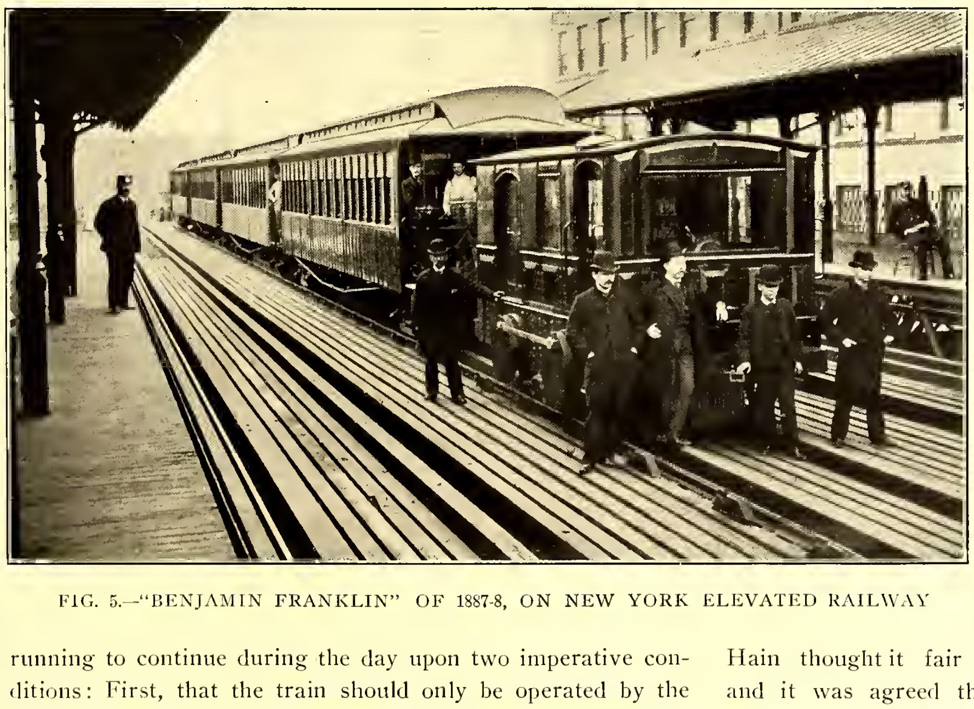


FIG. 5.—"BENJAMIN FRANKLIN" OF 1887-8, ON NEW YORK ELEVATED RAILWAY

The mention of Mr. Reed's name in connection with the elevated railroad work affords the writer an opportunity to pay a tribute to his sterling worth. For nearly five years, during the most strenuous of the pioneer days, much of the time as chief assistant, he showed an ability, ingenuity and devotion to duty under the most trying circumstances, which the writer can only recall with warm admiration, and which qualities, added to his unflinching loyalty, have properly resulted in a success at which his host of friends rejoice.

When the day running had been continued for a week or two the writer was summoned to the general manager's office and thus accosted by its genial occupant: "We see you can yank an empty train out of the switch at Fourteenth Street and jump it up to Fiftieth Street in time to get out of the way of the others, but how about a train with people hanging on to the straps?" In reply the writer stated his willingness to submit to any tests Col. Hain thought it fair to impose under the circumstances, and it was agreed that a flat-car train, loaded with railroad iron to the weight of an ordinary loaded four-car train, should be placed at the disposal of the Daft Company for daylight running to demonstrate the ability of the motor in commercial work. This being done, during one endless day it was towed up and down the entire section, between the steam trains, while the writer stood at the controller with his hair growing grayer at the end of every trip. Those who know the difference between a "live" train filled with alert swaying

FIG. 7.—TRAINS PASSING ON BALTIMORE ROAD

bodies, and on easy springs, and a "dead" one made up of almost springless flat cars loaded with immovable material, will understand the predicament. That the colonel was having his little joke was attested by the two steam locomotives held in the switches at each end, ready to pull the electric train out of the way at short notice in case it broke down; but their services were not needed, and, much to the colonel's surprise, the train pulled into the switch at Fourteenth Street after the day's run "with all colors flying." The daylight running with the ordinary four-car train was continued for some weeks longer, and then as a further trial night work was resumed, with the object of testing the ultimate capacity of the motor on the gradient between Forty-second and Fiftieth Streets by adding cars to the limit.

This was done until a train of eight cars was successfully hauled over the section at a mean speed of 10 miles per hour, and up the gradient of 1.86 per cent at 7 miles per hour.

Returning to earlier street car work, in 1886 a car was equipped for the first section of the Orange Cross Town line, which ran on that section for a short time, was equipped with the motor underneath the car and with double-reduction cut-steel pinions and cut cast-iron gears, and was not only electrically lighted, but provided with electrical push buttons and bell for the convenience of passengers. Fig. 6 is from an old engraving of this car, which is chiefly referred to as evidence that the Daft Company never then or at any other time equipped cars "with motors on the platform," as has been stated several times, but always, with one single exception, where it has been the rule to place them ever since. The exception was one open car for the Los Angeles road, in which case the motor was placed in the center in a compartment which required the sacrifice of two seats for that purpose. Two cars for Ithaca, five for Mansfield, Ohio, and twenty for Asbury Park were practically of the same design—that is, motors underneath the cars, cut-steel pinions and cut cast-iron gears.

The Asbury Park road was opened in September, 1887, and the equipment of twenty cars was required to meet the heavy fluctuations of traffic incident to a crowded summer resort. The track was a belt line of 4 miles in length. In March, 1889, after the road had been running some eighteen months, a fifty-five-hour test for general performance, with fourteen cars running, was made by the well-known expert mechanical engineer, F. E. Idell. From this report, published in the "Stevens Indicator" for April, 1889, the following is extracted:

FIG. 8.—MOTOR CAR ON ASBURY PARK ROAD—1887—F. H. REED AS MOTORMAN

"With a power plant capable of driving twenty cars, and running but fourteen, the cost of motive power per car, in use, was about $3.13 per day of seventeen to eighteen hours. This includes interest and depreciation on the cost of the power plant, motors under the cars and overhead system, wages of two engineers and two firemen, coal, oil, waste and water.

"If twenty cars were run, the cost of motive power would be $2.68 per day. If horses were used, 140 to 200 would be necessary for the same service, and the cost of keeping these would be at least 50 cents per day per horse, or $5 per car per day. Consequently at Asbury

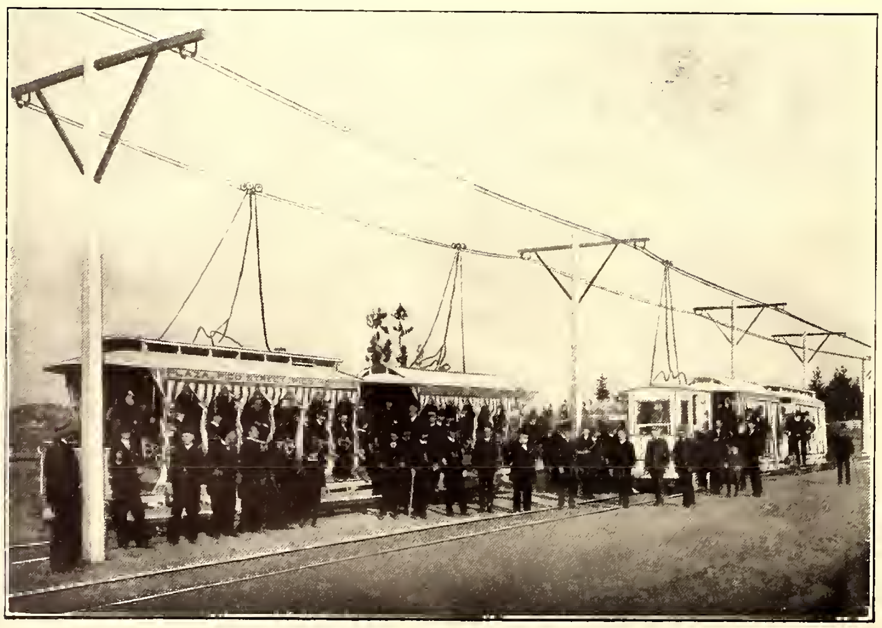


FIG. 9.—DAFT MOTOR CARS IN TRAIN—LOS ANGELES—1887

Park the electric road is being run at one-half the cost that a horse road would be in the same locality." Fig. 8 is from a photograph showing a car on this road.

Early in 1886 an application was received from the promoters of the Pittsburgh, Knoxville & St. Clair Railway to consider its equipment by electricity, and the writer, looking over the proposed route, found, among other appalling features, a gradient of over 15 per cent and ten curves of short radius on considerable gradients, together with a conduit of some 800 ft. long at the lower terminus. The total ascent in the 1½ miles of track was 500 ft., and the curve difficulty was further aggravated by the gage of 5 ft. 2½ ins., then standard in that region. No mechanical tractor for street railways had anywhere

FIG. 11.—MOTOR TRAIN CHANGING FROM TROLLEY TO CONDUIT—PITTSBURG, 1887-8

FIG. 10.—MOTOR TRAIN ON 15 PER CENT GRADIENT—PITTSBURG, 1887-8

been built capable of such work, and the proposal ought to have been promptly rejected as prohibitive; indeed, the writer strongly objected to the undertaking as too much in the nature of "tempting Providence," but rash promises had been made and an offer of several thousand dollars advance payment sufficing to turn the scale, a contract was signed which for sheer hardihood, to call it by no harsher name, is probably unequaled in the annals of street railway practice.

In a winter climate such as that of Pittsburg, gradients of 12 and 15 per cent cannot be safely negotiated with a motor and trailer aggregating 11 or 12 tons without special devices, and a rack rail was accordingly provided on the heaviest gradients, with which an adjustable cast-steel sprocket wheel was made to engage, when occasion required, by means of an attachment under the motorman's control.

The five motors required for the proposed schedule were provided with four 33-in. drivers, connected with quartered-connecting rods and toggle-geared brakes, double-reduction cut-steel gearing, and weighed about 5 tons. After the usual delays incident to early work, two of the motors were delivered in August, 1887, but owing to troubles in road construction it was not until the following March that the road began carrying passengers, and the few succeeding months were full of the tribulations which might have been anticipated from such an attempt. At length it was brought into fairly regular operation, largely owing to the indomitable courage, skill and unwearying perseverance of Robert McA. Lloyd, who was placed in charge by the writer, and of whom it is his pleasure and privilege to say that during Mr. Lloyd's connection of some four years with the Daft Company, he invariably displayed that high-minded thoroughness in his work and indifference to personal considerations which marks the man of worthy achievement the world over, and has since made him a leader in his calling.

Illustrating some of the events of that strenuous time, the following extracts from the engineer's reports may be of interest: "Finding a core contact in No. 3 armature while she was down the road with a car, we took out No. 5 motor and pulled back a carload of people with No. 3 in tow, the whole train of 17 tons ascended the 12 per cent gradient at the usual speed and neither the motor nor generators seemed to mind it. I'm not afraid to tackle any of the hills after that." On one occasion a motorman neglected to let down the sprocket while descending the 15 per cent grade, and the result is described by the engineer in his report dated Aug. 15, 1888, as follows: "The

FIG. 12.—DOUBLE TROLLEY CAR ON BLOOMFIELD ROAD—1887-8

motor and car, with all the wheels locked, slid to the bottom, over one-third of a mile, on a perfectly dry rail."

Figs. 10 and 11 give some idea of why this interesting performance was possible. It will doubtless be understood that the writer has omitted mention of the magnificent work of Sprague, Van Depoele, Short, Knight-Bentley and others, simply because he was requested to review some of his own work only, and has already exceeded his allotted space.

EARLY EXPERIMENTS IN BOSTON

BY CHARLES S. SERGEANT

IN 1886 Henry M. Whitney undertook the development of large tracts of land in Brookline by the construction of a wide boulevard to provide access to and through this land from the city of Boston, there being but little of the land conveniently adjacent to railroad stations, or provided with any other means of transit. This boulevard was laid out by Messrs. Olmstead, the noted landscape gardeners, as an extension of Beacon Street, Boston. It had an average width of 160 ft., and was divided into sidewalks, planting spaces for trees, two driveways—one of 30 ft. and one of 50 ft. in width—a bridleway of 20 ft., and a reservation for a street railway of 20 ft. To provide street railway service two companies were incorporated in 1887—the West End Street Railway Company and the Suburban Railway Company; these companies shortly became consolidated. The original intention was to have this street car line extend directly on Beacon Street, through the Back Bay section of Boston, and a proposition was made that on reaching the Common at Charles Street the tracks should be placed in the Common in a sunken way, in a manner not to deface that beautiful park, but this portion of the plan was not realized. Beacon Street in the Back Bay was not considered to be a suitable route for a street railway, and the plan was therefore changed and the location diverted via West Chester Park (now Massachusetts Avenue) and Boylston Street to Park Square, near the Public Garden.

While these plans were maturing, Mr. Whitney and his associates acquired a controlling interest in the capital stock of seven of the eight horse railroads then serving Boston and its immediate suburbs. The line omitted was the Lynn & Boston, which entered Boston through Chelsea, thence passing over the tracks of the Boston companies. These eight street railways were then consolidated with the newly-formed West End Street Railway Company. On Nov. 12 and 19, 1887, the consolidation was completed and the operation of the properties taken over by Mr. Whitney and his associates, Mr. Whitney being the president of the West End Street Railway Company. The returns of these several companies to the Board of Railroad Commissioners, for the year ending Sept. 30, 1886, showed that in all they ran by horse-power 15,105,000 car-miles, and carried 86,250,000 revenue passengers. The business of the Boston Elevated Railway Company (now operating these properties), for the year 1903, shows a car-mileage of 47,688,000, and revenue passengers carried 233,500,000.

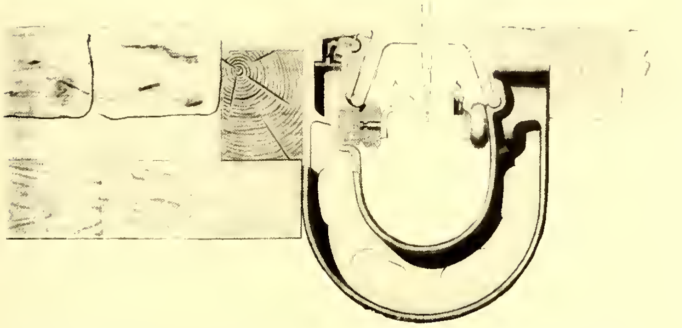
As soon as the railroads were consolidated in 1887, the question of a change in the method of propulsion of cars was taken up. Certain experiments were being conducted at that time with storage-battery cars, but they had been so unsuccessful as to point to the use of a different power, and the best available seemed to be the cable system. It was practically decided, therefore, to introduce a cable system in Boston. Engineers were secured, the preparation of plans was commenced, land was acquired for the power houses, and it would have soon resulted in the provision of a cable system for Boston if at this time Mr. Whitney's attention had not been directed to the overhead trolley system, particularly the road which had just been put in successful operation in Richmond, Va. In 1888, therefore, Mr. Whitney and his associates visited Richmond and saw what had been done there. They also investigated the so-called "Bentley-Knight underground conduit system," and returning to Boston abandoned the idea of introducing cable roads. They planned as the first electric line the equipment of the tracks of the West End Street Railway with the Sprague overhead trolley system, from Brighton, Allston and Reservoir to the beginning of the Back Bay at the Charlesgate, and from that point to Park Square they proposed to introduce, and did introduce, the Bentley-Knight conduit system. A sketch showing a cross section of this system is appended. The length of this underground conduit system was about 8200 ft.; that of the line from the Charlesgate to the Reservoir was 16,333 ft., and from Charlesgate to Oak Square, Brighton, was 24,330 ft. These

EARLY SPRAGUE CAR IN BOSTON

lines were opened and operation commenced in January, 1889, the plows for the conduit system being attached to the incoming car and the trolley removed from the overhead wire at the Charlesgate. The early operation of this road was attended with many exasperating failures, as well as amusing incidents. Engineers surveying in the street not infrequently burnt up their metal tapes by allowing them to drop into the slot of the conduit; tampering with the conductors therein by the small boy with a wire was frequent, and as no drainage system was provided, many failures occurred from that cause. The difficulties with the conduit system continued to such an extent that it was finally abandoned, the conduit was removed and the overhead trolley was substituted.

In February, 1889, the West End Street Railway Company contracted with the Thomson-Houston Electric Company to electrically equip a line from Harvard Square, Cambridge, to Bowdoin Square, Boston, to be operated on the single-trolley system. Twenty cars for this line were supplied by the Thomson-Houston Company. There was very serious opposition to the introduction of overhead wires in the city of Boston, and it was only by the operation of these short sections and the demonstration made by them of the safety and comparatively unobjectionable features of the system that public opinion finally sanctioned, piece by piece, the complete introduction of the overhead trolley system. Volumes might be written, setting forth the many phases in which this opposition took form, and perhaps the old officials and employees of the horse railways were the most skeptical of any as to the electric system becoming a success. The earlier operations were all attended with heavy net losses, but, as the electric companies met and overcame one failure after another, it became apparent to the public that electric motive power was to revolutionize street transit, and the early opposition ceased, except as to certain localities.

It is interesting to note that for the fiscal year 1888-89, of a total car-mileage of 16,500,000, 525,000 miles were operated by electric motive power, two-fifths of this being mileage of trailer cars; and it was not until the year 1892 that the electric-mileage constituted one-half of the total car-miles. The last mileage of horse cars in Boston was operated as late as the year 1901, although for some years prior to that but one unimportant



SECTION OF BENTLEY-KNIGHT CONDUIT AS LAID IN BOSTON

line was equipped with horse power. This line was that through Marlborough Street, Boston, in the residential Back Bay district, and so persistent was the opposition to the introduction in that street of electric power that the line was finally abandoned and the tracks removed.

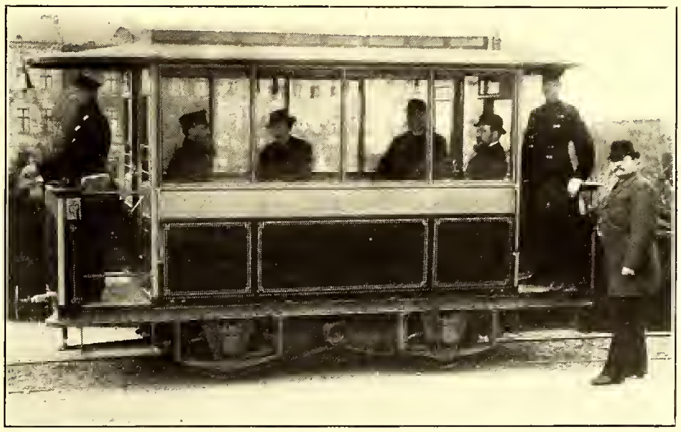
From the commencement of operation with electric power very careful accounts were kept of the many failures and of the costs of maintenance, and for the first few years the most sanguine of men could not have demonstrated from the results obtained any possible economic future for the trolley system. The enlightened and energetic manner in which the various difficulties occurring were overcome by the engineers of the electric companies constitutes one of the marvels of nineteenth century progress, probably without a counterpart in any other industry. It was also extremely difficult to determine the probable earning capacity of electric lines. When they became fairly reliable in operation they were so much preferred by the public, as one line after another was equipped, that they showed a phenomenal rate of earnings per car-mile; but, as more and more of the system became equipped, the competition of the different lines restored them to a more nearly common level, and the earlier estimates of the marvelous earning power of electric cars met a sad collapse. The gradual method of introducing electric power made it a comparatively easy matter for the company to care financially for the shrinkage in value of the horse equipment, which at the beginning of the period under discussion consisted on the West End system of about 9000 horses.

Among the earlier amusing incidents may be mentioned that of a wise and dignified city official, who, having seen for the first time an overhead trolley car in operation, expressed great surprise that the company did not provide stronger and more sturdy trolley poles, for he believed that those employed to push the cars were altogether too light. Others were certain that disaster would result because no provision was made in the overhead trolley wires for expansion and contraction, and those who were certain that they felt shocks and electric thrills whenever they boarded an electric car are too numerous to mention. Fortunately, the most conservative were at last convinced of the utility and necessity of the overhead system, but there are probably few to-day who reflect upon the remarkable revolution it has made in the development of the territory served.

THE EARLY ELECTRIC RAILWAY WORK OF WERNER VON SIEMENS

So much has been said of the early electric railway experiments of Werner von Siemens in Germany that some particulars of the first electric road in Germany may be of interest. This road was placed in service May 31, 1879, on a specially constructed belt line, 300 m (about 983 ft.) long, at the Berlin Trades Exposition.

The engraving on the next page shows the first electric train on this line. It was made up of an electric locomotive and three small cars. The capacity of the locomotive at 150 volts was about 3 hp, and its speed was 7 km (4.2 miles) an hour. Power was taken from a third rail, consisting of a flat iron bar placed between the running rails. The latter were bonded and served for the return circuit. On the iron frame of the locomotive was mounted longitudinally a bipolar, drum armature, direct-current motor connected to gearing giving a speed reduction of 1:2.45. The motor was controlled by operating a



CAR USED IN 1881 ON THE GROSS-LICHTERFELDE LINE, TAKING CURRENT FROM ONE RAIL AND USING THE OTHER FOR THE RETURN CIRCUIT

lever which cut resistances in or out of circuit. As the motor was not reversible, changes in the direction of the locomotive were obtained by employing two conical gears mounted on a common axis and arranged to engage with a third conical gear. The running direction depended upon what pair of gears were permitted to mesh with each other. The wooden covering of the otherwise open motor served as a seat for the motorman.

Despite the fact that this experimental railway proved very successful, 86,398 passengers being carried safely between May 31 and Sept. 30, 1879, the public showed little confidence in electric traction. Werner von Siemens, however, was fully alive to the possibilities of the new traction method, and finally, after repeated rebuffs, the firm of Siemens & Halske obtained permission to build a line in Gross Lichterfelde, near Berlin. This line was completed for public use on May 16, 1881. The motors were operated at 180 volts. One of the running rails was used for the power circuit and the other for the return. The rails possessed no insulation other than that furnished by the wooden ties upon which they were laid. To prevent short-circuiting through the axles, every wheel tire was insulated from the hub by a wooden band. The current passing through the tire was transmitted to a metal bushing through metal springs or brushes, whence it was taken to the motor. The latter was connected to the axle through spiral wire ropes running over rope sheaves. The direction of running was changed by reversing the polarity of the motor. This equipment was capable of 40 km (24 miles) an hour. The car, which is shown on the previous page, could carry twenty-six passengers.

In the same year, 1881, von Siemens exhibited at the Paris Exposition an electric railway employing an overhead current collecting scheme which embraced the use of a split tube carrying current and a contact pencil which slid along the aperture in the tube. The following year, von Siemens built an overhead line in Charlottenburg, using rolling contact. The sliding trolley bow, now so commonly used on the Continent, was first employed on the Gross-Lichterfelde road in 1887.

While the overhead system electric railways made rapid progress in the United States, very strong opposition was manifested toward them in Europe, and resulted in the installation of quite a number of lines operated by accumulator batteries. Recognizing that neither this method nor a surface contact system were commercially practicable, Siemens & Halske evolved a side conduit system, which was first installed at Budapest in 1889, and employed a complete metallic circuit with V-shaped angle-iron bars for the conductors.

ELECTRIC LOCOMOTIVE AND THREE CARS FIRST OPERATED ON MAY 31, 1879, AT THE BERLIN TRADES EXPOSITION

"To move a large numbers of cars, as, for instance, upon the Third Avenue or Broadway lines in New York City, the electrical conductor must be of great size, if the current is of low tension; while, on the other hand, if a small or moderate sized conductor be used, the current must then be of dangerously high tension. * * * No electric car, or any self-propelled vehicle, will climb grades of more than 6 per cent in slippery weather, with absolute certainty. If we go beyond 6 per cent we must have some artificial adhesion; we must introduce some rack on the road, or cables, which have a positive motion. Anyone who attempts to guarantee a self-propelled vehicle on grades of more than 7 per cent will most certainly lose his reputation."—*From Philadelphia Meeting, 1887.*

THE DIFFICULTIES WHICH CONFRONTED THE EARLY ENGINEERS

BY W. E. BAKER

YOU have very kindly asked me to write a few lines in regard to some of the troubles under which the engineers labored during the early electric railroad work in Boston. It is not always pleasant to recall the troubles of the past unless, as in this case, they have been happily overcome. Many of the experiences and troubles with the early equipments are now either forgotten or only remembered in times of leisure. For the most part it keeps us all busy to keep up with the progress in electric traction. Electric railroading has made rapid history in the last fifteen years. Time slips along so fast as measured by the development of electric traction, in its many and varied directions, that what happened only a few years ago, measured by the time interval, seems almost a cycle since when timed by the progress made in the electric traction field.

The questions which were troublesome in the days of 1889, when permission to use the overhead wire in Boston was first granted, interest us no more. We no longer ask, Will this be a method of city transportation that will displace the horse car and the cable? Can it be operated at a reasonable expense? Is it safe? Will it be attractive to the public? These were then the questions of deep interest.

One of the principal troubles in those days was adverse opinion, both lay and technical. Such is commonly, or it might be said always, the case with attempts to introduce radical changes, particularly in transportation methods or in improved machinery. The advent of electricity for traction purposes had many and determined opponents. The "deadly trolley" was a by-word. It was a menace to life and limb. The escaping current would pursue people to their destruction while they followed the peaceful tenor of their way.

The story that one man had captured some of it in his cellar and was operating some mechanical contrivance was largely advertised and exaggerated.

Every credit should be given to the men with courage and public spirit who faced the objections and the failures of the early and costly experiments with storage batteries and underground conduits, until the positive advantages had become evident, hostility had ceased, and the "trolley" had become a recognized factor in the progress of the nineteenth century. It is still doubtful whether the full force of the social changes which this progress is sure to bring about is yet fully realized.

Macaulay, in describing the social condition in England in 1685, states that the chief cause which made the fusion of the different elements of society so imperfect was the extreme difficulty which our ancestors found in passing from place to place, and that of all inventions (the alphabet and the printing press alone excepted) those which have abridged distance have done most for the civilization of our species.

In the list of civilizing inventions the trolley must occupy one of the foremost places. In the early days of America, the Indian trail through the primeval forest was the forerunner of the highway; after this came the path blazed by the pioneer, scarcely more distinct or passable than the Indian's trail; finally, rude highways were constructed for the use of carts, and barely 100 years ago had they become sufficiently improved for the use of carriages and stages. We may safely venture the statement that at the close of the last century all other methods of public travel did not promote the original purpose of highways as much as did the use to which the street railway car subjects them. There is no known method of conveyance by which such large numbers of passengers can be transported through the streets or highways with so much convenience, expedition and safety to themselves and to their fellow travelers, and with so little noise, confusion and dirt as by the electric railway.

To America is due the credit of invention both of the horse railway and of its successor, the electric railway; and to America belongs the fullest development of intramural transportation; and to no locality in America should more credit be given, or have greater changes been wrought by the carrying out successfully of the latest ideas and achievements in this direction than to the city of Boston and its suburbs, where the first great development took place.

Of course, there were many difficulties of detail to contend with in the early days, but they were all troubles that merely required a short experience for the most part for correction. However imperfect were the early motors and their accompanying appliances, such as overhead wire, trolleys, controlling devices, etc., they contained the essential germ of the principles that had only to be developed in detail to reach the present satisfactory performance.

Time is too short to dwell upon the difficulties which then seemed large, but which now look small. The only use that should be made of them to-day is that they should encourage us to look forward within the next decade or so to further great improvement in intramural transportation. That this will come about, those who have been acquainted with its development have had for many years no doubt. In fact, the handwriting is plain upon the wall. Electricity has displaced the horse; it has already started in its career to displace the steam locomotive.

THE INCEPTION OF THE CONDUIT SYSTEM IN NEW YORK CITY

BY M. G. STARRETT

On Aug. 1, 1904, the New York City Railway Company had 725 horse cars and 117 miles of horse car track still in operation. This extended use of animal power for street railway service often creates some surprise on the part of the visitor to New York, exceeding, as the figures do, both in number of cars and mileage all the rest of the country. Properly to understand the reasons for the use of the conduit system on the main longitudinal lines and principal cross-town lines on Manhattan Island and animal power on practically all of the other divisions, it is necessary to rehearse briefly the history of passenger transportation in New York during the later eighties and early nineties.

About this time the syndicate which subsequently organized the Metropolitan Street Railway Company commenced the purchases and consolidations which later brought under one head all of the surface transportation systems in New York City and which are now operated by the New York City Railway Company. At that time the overhead trolley was extensively used in all the larger cities both in the East and in the West, and was recognized everywhere as the then most approved form of surface traction. Unfortunately, however, for the future of this form of electric power on Manhattan Island, there existed in New York in 1890, as at present, a widespread popular prejudice against overhead wires of all kinds, nor was this entirely unreasonable. The commercial interests of the city had necessarily required a myriad of electrical circuits exceeding that in other cities; and the telegraph, telephone, electric light, stock exchange and other wires which had been installed during the growth of the city were carried almost entirely overhead. The Edison Illuminating Company, it is true, had established an underground feeder system, but all of the other wires were suspended from rude poles or immense wooden structures erected on the tops of buildings, so that Broadway and some of the other main avenues of the city, with their single, double or triple lines of gigantic poles and numberless cross-arms, presented an appearance not unlike that of a treeless forest.

One of the first acts of Mayor Grant, who was inaugurated in 1889, was to commence a crusade against these aerial wires. The companies were ordered to put their wires underground or abandon their circuits entirely, and under the direction of the Mayor the offending poles were chopped down with an energy befitting the most enthusiastic middle-age iconoclasts. The means adopted were severe and arbitrary, but were at least effective, and as the city administration had the support of the public at large, who objected to overhead wires from both æsthetic and practical reasons, the result was extremely efficacious. This crusade effectually estopped any trolley construction south of the Harlem River, with the exception of a short line belonging to the Union Railway Company. This line, about half a mile in length, was built on 138th Street in September, 1892, and was the first electric railway in the city of New York.

In Chicago, San Francisco and other cities throughout the country, cable traction was at that time extensively used, and for the Broadway line, which had what was then considered an enormous traffic over a comparatively short line, this seemed the best power then available and was adopted. The Broadway cable line was opened from the Battery to Central Park in July, 1893, and was so successful that plans were immediately made for extensions through Columbus and Lexington Avenues to Harlem. The cost of both construction and operation of the cable system, however, was so great that it was recognized that its application must be confined to lines of the first importance, and that a more flexible and economical system must be found for the remaining lines of the system.

In the effort to find a motive power which would be satisfactory for some of the streets where cable could not be used, Mr. Crimmins, then president of the Metropolitan Traction Company, proposed to install overhead wires on the Sixth Avenue surface line, which runs beneath the elevated structure throughout its whole length. It was argued with reason that there could be no logical objection to overhead trolley wires in such a location, but so great opposition developed that the project was abandoned, and with it all hopes of the further use of the overhead trolley system on the island of Manhattan.

The situation then facing the officers of the Metropolitan Traction Company was a serious one, as the leases and purchases of a large number of lines had been made with the expectation of introducing some improved form of motive power. Finally, in November, 1893, the company submitted the following letter to the Board of Railroad Commissioners, offering a prize of $50,000 for a system of street railway propulsion superior to the cable and the trolley:

On streets where the lines are straight and the business is heavy the cable system is the most economical yet invented. For general use in a city, winding about through the streets following the routes of travel which the public wish to pursue, it is impracticable. You require straight routes for cable roads. We have, in addition to the lines upon which the cable will be laid, over 80 miles of street railroads now operated with horses all below the Central Park. It is to these lines in particular that we now desire to direct your attention.

Up to the present time the only system whose practicability has been demonstrated is the overhead trolley. We are well aware, however, that its application in the streets of New York would not meet with the approval of the community. What we most desire now is to hasten the development and perfection of a better system. We therefore submit the following proposition:

First. We will set aside the sum of $50,000 to be awarded as a prize to any person who shall, before March 1, 1904, submit to your honorable board an actual working system of motive power for street railway cars demonstrated to be superior or equal to the overhead trolley.

Second. The qualities necessary to meet this requirement shall be left to your decision; but with the present state of the art, a system to win the award must necessarily approximate the trolley as a standard of economy in operation, but should be without the features objectionable to the public that are in it.

Third. We shall exact no rights in the invention in return for the $50,000, and shall have nothing whatever to do with the making of the award further than to pay any expenses which your honorable board may deem it necessary or wise to incur, either in the employment of experts, the giving of hearings, or the conduct of experiments—this in order that no effort may be spared to achieve the desired result.

Hundreds of schemes were submitted to the officers of the company, but nothing practical resulted from this offer.

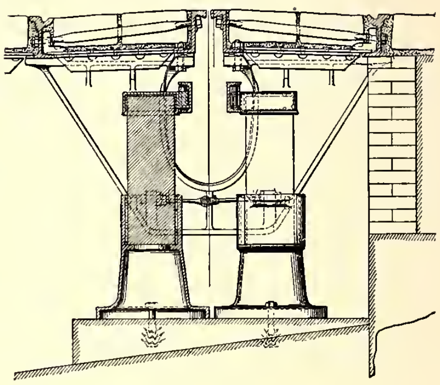
Foreseeing that any efforts of this kind, depending upon outside inventive talent, would be futile, and induced by the fact that a short underground conduit line was in successful operation in Budapest, though under radically different conditions than existed in New York, the company decided to experiment with this system. As the Railroad Commissioners had stated that they were unable to act as judges of the prize competition without legislative action, the Metropolitan Company, early in 1894, withdrew its offer of a prize, and working in conjunction with the General Electric Company, proceeded to develop its conduit plans.

The Lenox Avenue line in Harlem was the scene of the trial. The conduit on this line was built for the cable system, but was easily adapted for the purpose of the experiment which was most thoroughly conducted. The line was equipped with twelve cars and operation was begun in 1895.

The electrical construction first used on this line differed materially in its details from the type in use to-day. Heavy channel sections were used as electrical conductors and were supported by insulators carried on pillars built up from the bottom of the manholes. The insulators were of a distinctly inferior type, and the line was operated with only 300 volts difference of potential between the conductors.

Troubles—due to the low voltage employed, to the failures of insulators and especially to the defective form of plows or current-collectors—were numerous and can only be appreciated by those directly engaged in the work. Gradually, however, the causes of the troubles were located, proper remedies applied, and the line was gotten into operative shape after the type of the insulators had been changed, the generators and motors had been rewound for the standard voltage and the current-collectors or plows redesigned.

Shortly previous to, or concurrent with, the Lenox Avenue experiment several trials had been made with storage-battery cars, a surface-contact system and with compressed-air motors. The storage-battery cars were tried on the Second Avenue and Madison Avenue lines, but with indifferent success. Nothing came from the trial of the surface-contact system, and the experiments with compressed-air motors did not promise enough at that time to insure their serious consideration by the officials of the company.



FIRST FORM OF CONDUIT ON LENOX AVENUE

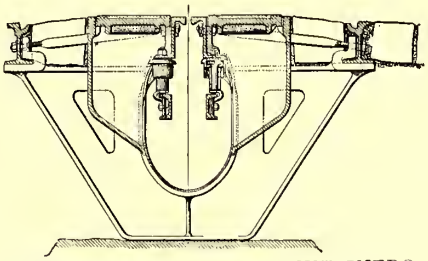
About this time F. S. Pearson, the chief engineer of the Metropolitan Street Railway Company, went to Budapest and made a thorough inspection and examination of the conduit system as installed and operated in that city. His report, together with the results of the operation of the Lenox Avenue conduit line, resulted in the decision to extend the conduit system to the principal lines of the company, and early in the summer of 1897 construction work was begun on the Madison Avenue, Second Avenue, Amsterdam Avenue, Eighth Avenue and Twenty-Third Street lines.

The form of construction employed was a modification of that used for the cable system, being shallower and somewhat lighter. All details of the original Lenox Avenue line were redesigned and adapted to the conditions found to exist in New York City. The insulators were suspended from the slot rail, the conductor bar section was changed and considerably reduced in weight, while new rail sections were also designed for both slot rails and tram rails. Another important improvement consisted in the method of building the conduit. In cable construction and in the first underground electrical work the conduit was built from the bottom up; that is, the foundations for the yokes, which were of brick, were first installed, after which the yokes were placed upon them and lined up. The track rails and slot rails were then laid on the yokes and aligned, after which the concrete was packed around formers which were carried from yoke to yoke. The method adopted in 1897 and since used is most easily defined as being from the top down; that is, the rails are supported in position by timbers over the trench, the yokes are put in place and attached to the rails, and the cement is then packed around formers, as before.

The conduit system is installed to-day practically in the same form as in 1897, but few changes—and those minor ones—having been made. The spacing of the cleaning manholes is shorter now, and some few slight changes have been made in the concrete sections and forms to facilitate and cheapen the construction, but, in all essentials, the system is the same to-day as in 1897.

Particulars of the cost of this work have been published heretofore and do not call for repetition here, but, in a general way, it can be stated that this form of construction costs from $90,000 to $125,000 per mile of single track, varying with the amount of special work included and also with the street conditions.

It is very evident that only lines with heavy traffic would be justified in adopting this system, and there are many of the crosstown lines to which, on account of the excessive first cost,



MODIFIED FORM OF CONDUIT INTRODUCED IN 1895

it is not adapted. For this reason extensive experiments have been made during the past five years with two forms of motive power, compressed air and storage batteries, for the purpose of developing a system of propulsion which should be suited to the demands of the crosstown lines and which still would not be prohibitive in its first cost.

The storage-battery system of traction was given a thorough trial on the Thirty-Fourth Street Crosstown line, while the compressed-air motors were given an equally exhaustive test on the Twenty-Eighth and Twenty-Ninth Streets line. The results were unsatisfactory in both cases, and the operation of cars by these methods was discontinued; and to-day the underground conduit, as developed through the Lenox Avenue line experiments, and perfected and installed on over 200 miles of track, remains the only system of improved motive power in use by the surface cars on the island of Manhattan.

Various modifications of the New York system have been made in London, Paris, Berlin and other Continental cities. These modifications have been mainly in the structure of the yokes and other parts of the system required to conform to local conditions, while the main features of the system as developed here have been adopted in every instance.

The conduit system has both advantages and disadvantages, as compared with the overhead trolley system. All the electric part of the construction is underground, therefore the feed wires and electric conductors are protected from damage by wind and weather, and the cost of maintenance of the electric conductors is somewhat reduced as compared with the overhead trolley system. On the other hand, the cleaning of dirt from the conduit and manholes is an added expense, and the presence of the center slot complicates the construction of special track work and, of course, the expense of its installation and maintenance. The absence of all construction above the surface of the street is, of course, advantageous from an æsthetic point of view, while all possible danger to the public from accidental contact with the electric conductors is avoided.

Occasionally during severe winter weather some trouble is experienced from the accumulation of ice and snow in the conduit and in the handholes around the insulators, but serious trouble has never occurred during the seven years that the system has been in operation.

THE DEVELOPMENT OF ELECTRIC TRACTION ON THE PACIFIC COAST

BY GEORGE B. WILCUTT

THE development of the electric system of street railways on the Pacific Coast has differed somewhat from that in many other sections of the country in that it has replaced the cable system to a considerable extent. The earliest transportation facilities, as elsewhere, were furnished by 'buses, which in due time were replaced by the steam dummy and horse car, which San Francisco, as the metropolis of the coast, was the first city to introduce. The first steam dummy line in that city was opened in July, 1860, and it was followed in 1862 and later years by various horse lines, by which the steam dummies were eventually replaced.

This was the character of transportation facilities on the coast until September, 1873, when, through the inventive genius of A. S. Hallidie, the cable system of street railways was perfected and rendered a complete success, enabling the many heavy grades prevailing in San Francisco to be readily surmounted. Railroad companies and capitalists were not slow to avail themselves of its advantages, and from that date until 1892 a number of cable roads were constructed—converting, in many instances, hitherto inaccessible districts into the most beautiful and valuable residence sections. Horse lines were replaced by the cable system as far as practicable, as it was found that the operating expense per car-mile was somewhat reduced, while the carrying capacity of the car was increased more than two-fold, thus meeting satisfactorily the city's increasing requirements.

While this condition prevailed in San Francisco, other coast cities were not idle. Cable road construction predominated between the years 1885 and 1889, on account of heavy street grades or imperfections of the electric system, the earliest cable line outside of San Francisco being opened in Los Angeles in October, 1885. This was followed by others in Oakland, Seattle, Tacoma, Portland, San Diego and Spokane, which were completed between the years 1886 and 1889. In most of these cases the roads were mediums for placing real estate upon the market, and as the expense of standard construction was prohibitive, special methods were introduced to lessen the cost—proving unsatisfactory in the majority of cases.

The earliest recorded electric line on the coast was that at Los Angeles—built on the Daft system—opened for traffic about January, 1887. It was some 3 miles in length, of both single and double-track construction, and equipped with separate motor and trail cars. The trolley was of the "traveler" (four-wheel carriage) type, and by means of a double trolley wire provided both for the feeder and return current. Side-pole construction at curves in place of the bracket construction was apparently also a matter of interest in those days. In the railway journals of that time the speed of the cars is given at 12 miles per hour, and as a further matter of interest we find it stated that as many as 500 passengers were carried per day. The road is also referred to, apparently as an exceptional case, as carrying 1500 persons upon three cars in an afternoon. Like other electric lines of that period, it was found to be unreliable, resulting in suspensions of traffic of uncertain durations, and after an existence of a few months it was disposed of to other railroad interests and eventually reconstructed.

Other coast cities were not far behind Los Angeles in early experiments with electric traction, for during the year 1888 lines were opened in San Jose, Sacramento and San Diego. These were followed a year later by others in Seattle, Tacoma, Portland and Spokane.

The line in San Jose was the first on the Pacific Coast of the underground conduit type (Fisher system), and was some 8 miles in extent. The conduit carried both feeder and return conductors, the track rails not being utilized for the latter purpose. In a short time various difficulties were experienced, resulting in defective insulation, with consequent loss of power, and about one year later the system was abandoned and the road reconstructed to the overhead system.

The electric road in Sacramento was also of interest, for it was the first trial on the coast of the storage battery for street car propulsion. The equipment consisted of a single car, furnished, as it was reported, by a Philadelphia company for experimental purposes, but the system proved no more satisfactory for the purpose there than elsewhere. It is of further interest to note that at a later date the lines in Sacramento were the first on the coast to be operated by current, generated by water-power and transmitted from a distance.

The line in San Diego was of interest as being one of the first to be constructed by John C. Henry, that pioneer engineer, who, with others, labored and aided greatly in developing electric traction.

The San Francisco & San Mateo Railway was the pioneer electric line of San Francisco, its construction being commenced in 1891, and the road opened for traffic in April, 1892. One feature of this line was heavy grades, it having one of about 10 per cent, regularly operated in both directions, and a second one of about 15 per cent, used by descending cars only. In the latter case, special devices, such as a drag and also a counterweight system, were adopted, but proved unsatisfactory and were early abandoned, since which time the car brakes alone have been relied upon. This line, which was some 21 miles in extent, of both single and double-track construction, was laid out through a sparsely settled portion of the city and its suburbs, and as its track and equipment was not of the best, and its route paralleled other railroads in great part, its business did not prove satisfactory, resulting in the road coming into the hands of a receiver after being in operation some two years. It was later purchased by the bondholders, rebuilt and equipped with modern rolling stock.

The completion of the first electric line in San Francisco was followed a few months later (in October, 1892) by that of the Metropolitan Railway, some 11 miles in extent. Heavier grades prevailed on this road than on the San Mateo line, it having a number running from 10 per cent to 13.8 per cent, over which the cars were regularly operated. The cars of this line were originally equipped with the Robinson radial truck, but as they were unable to fill the requirements of operation over the many curves and heavy grades which existed they were soon discarded. As the latter road was built through a more populous route than its predecessor, its business was fairly satisfactory, and some two years later it was acquired by a larger company, whose lines it paralleled.

Up to this time the older railway companies of San Francisco had been investigating the electric system, but realizing that it was largely in an experimental state, they preferred to delay the reconstruction of horse lines and retain the cable system, whose advantages had been demonstrated, until the success of the electric system was more fully assured.

In 1892 plans were inaugurated and adopted by several of the older lines to replace both horse and cable with electric power, and also to construct new lines under that system. In 1893 the consolidation of many of these companies hastened these plans, and from that date to 1896 the construction of electric lines was pushed—over 80 miles of single track having been constructed during those years. This construction has been continued until at present 186.88 miles of single-track electric lines are under operation in San Francisco, and about 2000 miles upon the Pacific Slope.

The character of early track work on the coast, as elsewhere, was very light, so that it had to be replaced in a comparatively short time, but recent construction, in the majority of cases, has been substantial.

Single-truck cars were originally in favor, but the many advantages of the double truck has resulted in that pattern coming into general use. The cars are, in great part, of the combination open and closed type, which has been found particularly adapted to the requirements of this coast, and which avoids the necessity of a double equipment, so often required in other localities. Many of the cars are equipped with air brakes, especially those running upon the higher speed suburban lines. Others have both wheel and track brakes, the latter proving a very useful accessory. The brake feature is an important one in the operation of electric cars upon the Pacific Coast, for with the comparative absence of snow and ice, heavy grades may be readily surmounted or descended—a condition which would be impossible in Eastern cities. Grades of 5 per cent are of frequent occurrence, while many steeper grades, ranging as high as 14½ per cent, are regularly operated over by means of the car motors only. In certain instances, however, it has been found necessary to employ special devices to operate cars over heavy grades, and in San Francisco a grade of about 25 per cent and a little over 600 ft. in length is overcome by such means.

Despite the general absence of snow and ice, "greasy" tracks are occasionally experienced, necessitating the general use of sand boxes, with which most cars are abundantly equipped.

In the earlier days of electric railways the current was generated by use of stationary steam engines, but the utilization of the water-power supplies of the coast received early attention. One of the first roads to be operated by such means was the East Side Railway Company, some 14 miles in length, extending from Portland, Ore., to Oregon City. The portion adjacent to the latter terminal (some 7 miles in length) was put in operation in May, 1893, by current generated by direct-current generators at railway voltage.

The economy of water-power having been fully demonstrated, the transmission of current from more remote sources of supply naturally followed, and in July, 1895, the electric road in Sacramento was operated by such method. The power was transmitted from Folsom, some 24 miles distant, where the current was generated at 800 volts, and raised by step-up transformers to 11,500 volts for transmission to Sacramento. In the latter city it was reduced and converted to railway voltage. At about the same date the railway lines in Portland, Ore., were operated from Oregon City, about 13 miles distant, by a current generated and transmitted at 6000 volts, and converted for use by rotary converters.

The subject of long-distance transmission of power has since that date received considerable attention by electrical engineers, and the distances of such steadily increased, until at the present time the street railway lines of Oakland, Cal., one of the largest systems on the coast, are being operated by current transmitted at 50,000 volts for a distance varying from 150 to 200 miles.

The scope of the electric traction service has been greatly increased, for, while at first the business was generally restricted to passenger traffic only and over limited territory, at the present time many interurban lines are in full operation, paralleling steam lines in many cases, and in others acting as useful feeders for same, their business involving both passenger and freight traffic.

A number of additional interurban lines are in course of construction, with others in contemplation, and there is every indication that before many years the Pacific Coast will be well supplied with such and that they will prove an important factor in the development of its resources.

THE COLUMBIAN INTRAMURAL RAILWAY

BY BION J. ARNOLD

THE Columbian Intramural Railway was brought into existence by a party of men who believed that a railway of some character upon the grounds of the World's Columbian Exposition, held at Chicago in 1893 to commemorate the four hundredth anniversary of the discovery of America, would be a paying investment. Various plans were proposed, but the concession from the Exposition to construct the road was finally given to a corporation known as the Western Dummy Railroad Company. It was understood that electricity was to be employed as the motive power, and that this road would be an experiment on a large scale, tending to prove or disprove the claims of electricians regarding the merits of electricity for the propulsion of heavy trains. After the formalities incident to such an important concession had been completed, steps were taken for the construction of the road.

It was at first proposed that the capital should come mainly from residents in Chicago, but the requisite funds were finally furnished principally by Boston and New York capitalists, who were willing to take great risks to ascertain the truth regarding the electrical propulsion of trains. The road was built by the Western Dummy Company, as a construction company, and after the road was completed it was turned over to the Columbian Intramural Railway Company as the operating company.

The problem which confronted the engineers intrusted with the construction of this road was somewhat unique, inasmuch as it involved the construction of an elevated railway which, if financially successful, must earn sufficient money to pay for itself during but six months of operation. It was, therefore, necessary to construct as economically as possible and to secure as much of the machinery as practicable upon a rental or loan basis.

In order to construct a safe but inexpensive elevated structure, and one which could be easily dismantled, wood was used almost entirely, and steel was employed only for girders and the rails. The structure was built of 12-in. x 12-in. pine timbers, provided with timber footings at their bases, and extending upward a distance of from 12 ft. to 15 ft., where they carried cross sills. Upon these cross sills were supported standard 15-in. I-beams. The object attained by using these I-beams was that of utilizing standard stock material that could be disposed of after the road was dismantled at as near the original cost as practicable.

In order to properly cover the grounds and pass between the various buildings, the road necessarily had many curves, and was provided with a loop at each end. The operation of the trains was thus continuous, which made the best possible arrangement for handling large numbers of people and for the operation of electrical trains, for at that time the motor-car system was used and the multiple-unit system had not come into existence.

The structure was equipped with the first example of third-rail construction in this country. The third rail was of the same section as that used for the track rails—that is, 60 lbs. per yard, was supported on creosoted wood blocks, and was carried on the inside of the tracks, 18 ins. from the inside track rail and 6 ins. above it. Parallel to this third rail was another rail, also insulated, which extended three-fifths of the distance from the power house to the further terminus, and which was used as a feeder. The two conductor rails were bonded together. The actual length of the line was 14,800 ft. of double track and 1900 ft. of single track. There were ten stations in all.

Each motor car was equipped with four GE 2000 motors, which were geared so as to work up to a maximum speed of 35 miles an hour. They were controlled by a series-parallel controller with three running points, viz., all motors in series; two parallel groups of two motors, and all four motors in parallel. The controller was operated by compressed air.

The power house consisted of as many kinds of machinery as there were manufacturers represented. It was, therefore, a somewhat difficult plant to construct, not only on account of the mechanical difficulties encountered, but from the fact that all of the machinery was loaned to the railway company, and therefore deliveries could not be hurried in the ordinary ways of handling such work.

While the power plant contained one-belted unit of about 1000 hp, the remainder of the generators were direct-connected units. This station was the first to employ heavy direct-connected units, the largest unit being of 1500-kw capacity, direct-connected to a cross-compound engine. Oil was used for fuel in the power house and proved very satisfactory, although somewhat more expensive than coal, which was prohibited by the requirements of the Exposition.

The effects of the operation of this road and its success in handling heavy trains were such that it attracted the attention of steam railroad owners and proved to be the forerunner of the typical elevated railway of to-day.

At that time both the South Side Elevated Railway and the Lake Street Elevated Railway, of Chicago, were being operated with steam locomotives, while the Metropolitan Railway, of the same city, was under construction and designed to be operated by steam. The first and most important effect of the Intramural results was made evident in an alteration of the plans of the Metropolitan system so that electricity was adopted and the contract for steam locomotives was canceled. The next result was the design and construction of the Northwestern Elevated Railway, of Chicago. This was the first elevated railway that was ever designed exclusively for electricity, except the Intramural road, although the first to adopt electricity after the Intramural road was the Liverpool Overhead road in England.

Soon after this the use of steam locomotives was abandoned on the South Side Elevated Railway, of Chicago, and electricity adopted. The Lake Street Elevated soon followed, and in the course of a few years the Manhattan Elevated, of New York, was equipped. To-day the entire elevated railway systems of this country and of Europe are equipped with electricity, and I believe it is fair to claim that the Intramural Railway, at Chicago, was the chief element which led to this result.

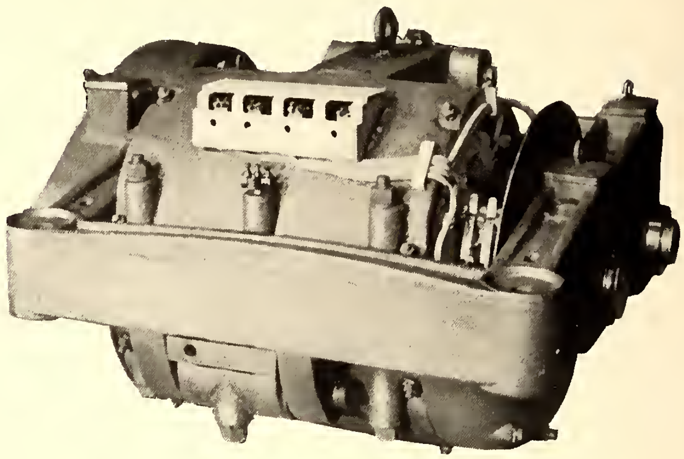
PIONEER ELECTRIC RAILWAY WORK OF THE WESTINGHOUSE COMPANY

BY B. G. LAMME

THE Westinghouse Company took up the development of railway apparatus as early as 1888, although it did not put apparatus on the market until the early part of 1890. The persons who were particularly interested in the development of this early work were George Westinghouse, Albert Schmid, Philip Lange, Oliver B. Shallenberger, H. P. Davis, N. W. Storer and the writer. Albert Schmid was superintendent of the Westinghouse Works, then at Garrison Alley, Pittsburg, and he was intimately in touch with the general designs of the apparatus, particularly the mechanical features. Philip Lange, during the early development, was superintendent of the detail department, and was directly interested in the controllers, switching appliances and other details. Mr. Shallengerber was the electrician of the company, and as such was more or less interested in the work, but Mr. Shallenberger's duties were primarily in the direction of alternating-current apparatus, and he did not have as direct contact with the development of the railway apparatus as other engineers. H. P. Davis became actively interested in this work in the early part of 1891, working in conjunction with Mr. Lange in the detail department. Mr. Storer did not become actively engaged in this work until about 1892 or 1893, although he was in close touch with it previous to this, in the testing room. The writer was actively engaged in the early development of the work from the start.

In the latter part of 1889, Albert Schmid informed me that the Westinghouse Company was planning to take up actively the manufacture of a direct-current railway system, and he instructed me to immediately begin the study of the various systems and apparatus already on the market, especially the railway motor itself. He told me that I should be prepared to furnish electrical data for a suitable railway motor as soon as any definite instructions were given out that a line of apparatus was to be built. These instructions were carried out, and as the entire line of work was new to the company, I necessarily came in touch with the detail work as well as with the motor itself. The electrical designs of the various early motors were prepared by me under Mr. Schmid's instruction, and, as indicated above, the characteristic mechanical features of the designs were furnished by Mr. Schmid. E. C. Means, at that time chief draughtsman of the company, also assisted Mr. Schmid in the general features of the design.

In the early part of 1890, W. L. R. Emmet, the well-known engineer, now prominently identified with the General Electric Company, was employed by the Westinghouse Company to take up actively the development work on the d. c. railway system which this company was then preparing for the market. Mr. Emmet had formerly been employed on similar work with the Sprague Company. After the first Westinghouse double-reduction system had been placed upon the market and was in

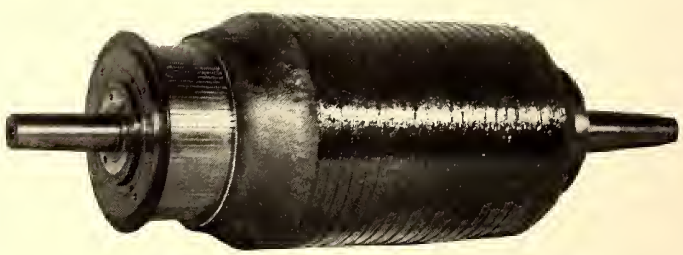


NO. 3 RAILWAY MOTOR

successful commercial operation, Mr. Emmet severed his connection with the Westinghouse Company.

A great number of other engineers have been more or less interested in the development of the Westinghouse railway system, particularly in later work. It may be of interest to note that most of the above-mentioned engineers are still in the employ of the Westinghouse interests and in close touch with modern developments in this line of work.

Taking up the development of the motor in the proper order, it should be noted that in 1888-9 the Westinghouse Company did some work on adaptation of the Tesla motor to street car work. This work was experimental and never reached the stage of true commercial test. The motors were the type of Tesla motors then being built, with polar primaries and dis-



NO. 3 MOTOR ARMATURE

tributed short-circuited secondaries. Such motors, of course, did not have suitable characteristics for traction service. This line of work was abandoned, and a short time afterward the development of the direct-current system was actively taken up.

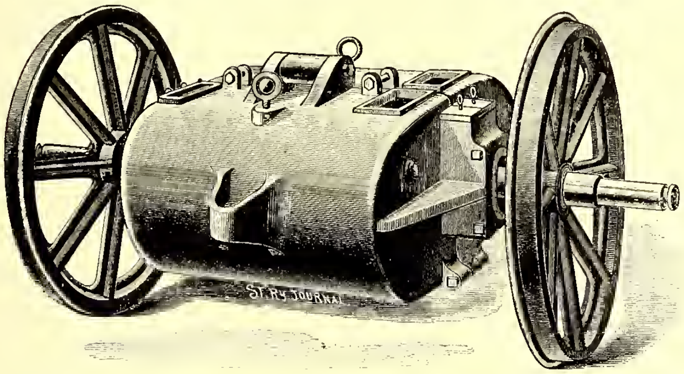
As stated before, in the latter part of 1889 the company planned to get out a direct-current system. This work was pushed through rapidly, and early in 1890 a direct-current railway system was completed for shop tests, and the first motors were put in service on July 3 of that year, on the Pleasant Valley line in Pittsburg. The motor was a two-pole machine, with cast-iron field and surface-wound armature, like all practical motors at that time. The field was wound with two sets of coils, and speed regulation was obtained by the sectional field method in which two coils were in series for lowest speed, and one coil was short-circuited for increased speed. About 300 of these motors were put on the market.

The control system used with these motors was straight rheostatic, except the short-circuiting of one field winding for higher speed. The armatures were connected permanently in parallel, and the field windings of the different motors on the car were in parallel. No attempt was made to equalize the armatures, as there was apparently but little unbalancing in these machines, probably due to the very large air gaps.

These early motors had the gears enclosed in cases. The motor was double reduction. The general type of this motor was very similar to that of the other systems in commercial operation at the same time.

The controller consisted of a wooden drum with metal strips on the outside. The general appearance was similar to the Sprague controller, but the steps were principally for rheostatic control instead of commutated fields.

The rheostats put out with these early motors are worthy of mention. These rheostats were peculiar in the fact that they were made of copper wire instead of high resistance material. Three coils were used. Each coil was made in the form of a thin cylinder. The three coils were of different sizes, so that they could be assembled in concentric form with air spaces between. The reason for adopting this design was that



NO. 4, OR GEARLESS MOTOR

a very simple construction was permitted, as the coils were wound of commercial cotton-covered wire on the simplest kind of former and were then taped. It was considered that while the resistance of copper was comparatively low, yet the heat conductivity of such wires was very great, and that a very considerable rheostatic capacity could be obtained without excessive weight. Such a rheostat was, of course, costly, principally on account of the material in it. This rheostat gave fairly satisfactory results and was practically as good a piece of apparatus as many other parts of the system. On account of the cost of the material in this coil, steps were soon taken to design a cheaper rheostat, and various forms were gotten out for test, some of which soon superseded the copper-coil rheostats.

Shortly after the No. 1 motor was gotten out, the No. 2 motor was also put on the market. This was very similar to the No. 1, except that it was for narrow gage.

In the summer of 1890, while the No. 1 and No. 2 motors were being put on the market and given tests for commercial service, the Westinghouse Company was engaged on the design of a single-reduction motor, as it was the impression of the company's engineers that if a suitable single-reduction motor could be obtained it would drive the double-reduction motors out of the market. Two of these single-reduction motors were brought through in the fall of 1890 and given long-continued shop tests, and were then, in January, 1891, put on a car on the Second Avenue line in Pittsburg for the test of commercial service. These first motors were, except in minor details, the same as the Westinghouse No. 3 motor, which was shortly afterward put on the market. This No. 3 Westinghouse single-reduction motor was a noteworthy one in many respects, in that it embodied many of the features which have since been adopted almost universally in street car construction. The following features were used in these early motors:

(1) The motor had four poles.

(2) The poles were radial.

(3) Poles were placed at an angle of 45 degs. from the horizontal or vertical.

(4) The poles were placed inside the yoke and were entirely surrounded by the yoke.

(5) The yoke also extended over the projecting end of the field coils, thus protecting them from injury.

(6) There was one field coil on each pole.

(7) The coils were wound without shells or bobbins and were insulated after being wound.

(8) The field frame served to enclose the motor. (The No. 3 motor was not entirely enclosed, but there were end covers on the lower half of the machine.)

(9) The poles were very highly saturated at the face, thus reducing the cross induction and preventing change in lead.

(10) The armature was slotted.

(11) The slots were open.

(12) The core was drum wound.

(13) The coils were machine wound.

(14) The present well-known two-circuit or series type of winding was used, allowing two brush arms on a four-pole machine without cross connections on the winding or commutator. The two brush arms were on the upper side of the commutator.

The following features have since been adopted in street railway motors:

(1) Entirely enclosed frame.

(2) Laminated poles.

(3) Bolted-in poles.

(4) Pole faces partly cut away to obtain saturation and to prevent cross induction.

(5) Bearings carried by the field frame instead of by a separate surrounding frame.

Also improvements in shape of armature coils, ventilation of armature core, etc.

It will thus be seen that the number of features embodied in the No. 3 motor, which has been adopted in modern practice, was very great compared with the number of features which has since been added in railway motors.

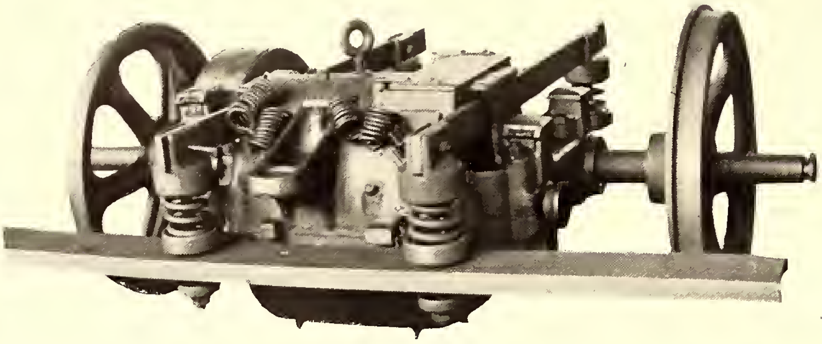
The control system on these early No. 3 motors was practically the same as used with the No. 1 and No. 2.

These No. 3 motors, like the No. 1 and No. 2, had cast-iron field frames and poles. The motors were rather heavy for their output, although the weight per horse-power was about the same as for the No. 1. The amount of material which was idle electrically or magnetically on the No. 3 motor was rather small compared with the amount of such material in the No. 1 and No. 2.

After the No. 3 motor had been developed sufficiently to show that it was a commercial machine, a design for a gearless motor was taken up. The first gearless motor put out was called the No. 4. It was also a cast-iron machine and was relatively very heavy. The speed of the 25-hp No. 4 motor was about 200 revolutions at normal load.

This No. 4 motor was an enclosed motor and had four poles, two salient and two consequent. The armature was directly on the car axle, and the field frame also had its bearings directly on the car axle.

A small number of these motors was built and given the test of commercial service. Some of them were operated for a year or so. The motors operated well enough, but were too heavy to be commercial. Track constructions in those days were very inferior to present practice, and the motors, in addition to being rigidly mounted on the axle, were very much heavier per horse-power than modern motors.



NO. 12-A MOTOR

On account of the great weight of the No. 4 gearless motor, a smaller and lighter six-pole motor was gotten out. This was called the No. 5. It was of about the same capacity as the No. 4, but was about two-thirds the weight. The frame was of cast iron, practically enclosing the machine. There were four salient poles and two consequent, the latter being at the top and bottom. A few of these motors were built and given the test of commercial service, but experience had shown that the gearless motor was not a suitable one for street railway service, due principally to mechanical considerations. Therefore no further attempts were made to develop the gearless motor for ordinary light traction service.

The No. 3 motor was made in three ratings, viz: 20 hp, 25 hp and 30 hp. The general construction of these three motors was the same, the difference being principally in the amount of copper in the armature and field windings. There was also a demand for a motor of somewhat greater capacity, and a 40-hp of similar design was gotten out. This was a rather special motor, and but few were sold.

After the No. 3 had been in the market for some time and had proven a great success, there was a demand for a motor of similar capacity and electrical features, but of considerably smaller dimensions. In 1893 a new motor was designed which contained many of the principal features of the No. 3 motor, but was of much less weight and somewhat different construction of frame. This was called the No. 12 motor. A later modification of this was called the 12-A. The No. 12 was a cast-iron machine, like the No. 3, but was without the surrounding frame, the bearings being carried by the field frame of the motor itself. The motor was practically enclosed, like modern motors. The armature contained about half as many slots as the No. 3 armature, and there were two coils side by side per slot. Otherwise the motor was very similar to the No. 3. This motor and its successor, the No. 12-A, were made in three ratings, viz: 25 hp, 30 hp, standard speed, and 30 hp, slow speed. The 12-A motor contained almost all the prominent features of the present types of railway motors, the principal difference being that it had cast-iron poles and yokes, while present designs of motors have cast-steel yokes with laminated poles.

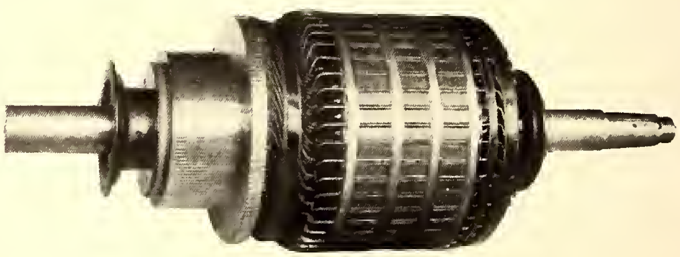
The next important motor gotten out by the Westinghouse Company for street railway service was called No. 38. This motor, with its modifications, the 38-A and 38-B, contained some departures from the 12-A in the use of cast-steel field with laminated poles cast in, and an armature winding with three coils per slot instead of two or one. This motor was designed in 1894. It can be considered the pioneer of the present cast-steel motors with laminated poles. It was put on the market in the spring of 1895.

A somewhat later motor, built on lines similar to the No. 38, was the No. 49, rated at 35 hp. This had cast-steel yoke with laminated poles cast in.

In later motors for street railway service gotten out by the Westinghouse Company, the bolted-in pole construction has been adopted instead of the cast-in poles, and many other features have been more fully developed.

The above gives a general description of the various types of motors gotten out up until about 1897, and covers only those which were given commercial tests. A number of experimental motors were built, especially about 1890-91, which were never put upon the market, and in some cases were simply built for obtaining certain data.

About the time that the No. 1 motor was gotten out, some tests were made on driving street cars by means of friction wheels. A motor was built and placed upon a truck in the shop, for making such tests. This motor was of the consequent-pole type, similar to the well-known Weston type of machine, with four field coils and two consequent poles. The armature was geared to a countershaft, and to the countershaft was attached two friction rollers or wheels, which bore down upon the car wheels, each roller lying between two car wheels. This construction was given certain shop tests, but was found to be rather inflexible and was very noisy. It was decided that it would not be a suitable article for commercial service, and was therefore not given the outside tests.



NO. 12-A ARMATURE

A series of tests was also made on the use of magnetic gearing. Grooved wheels were used, the grooves being in the shape of V's. By means of magnetizing coils on the axles or shafts a magnetic field was set up between these driving gears. Tests were made to determine the power that could be transmitted by this device, but it was found that it would be insufficient for the torque which would be necessary for street car service.

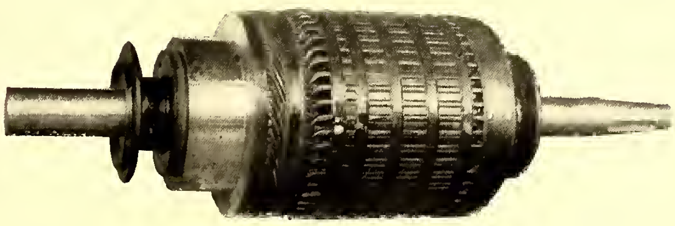
A considerable number of experiments were made with different methods of street car regulation, such as commutated fields, sectional field coils, etc. A series of tests was made with commutated fields, three field coils being used in somewhat the same manner as the Sprague system. This system of regulation was found to be unsuitable with the Westinghouse No. 1 and No. 2 motors, due principally to the fact that commutated field control is not satisfactory except where the field inductions can be worked over a relatively wide range. No. 1 and No. 2 motors being of cast iron, it was found that there was not any particular advantage in using the commutated field method of control. There was found to be a slight advantage in the use of the sectional field method with two field coils, one being large and the other comparatively small. These two coils were in series for starting and for lower speeds, but for higher speeds the smaller coil was short-circuited. Tests were also made with the sectional field method with several coils, all being in series at start and short-circuited successively for higher speeds.

With the No. 3 motor straight rheostatic control was used, previous to the introduction of series-parallel control, as it was considered that the sectional field method did not present sufficient advantage to compensate for the extra complication of eight field coils instead of four.

Some mention has already been made of the rheostats and controllers used with the early system. All the early commercial controllers were of the drum type and were placed on the car platform. As stated before, the first controller was straight rheostatic, with one notch for short-circuiting one field coil. Several variations in constructional features of this controller were gotten out and put on the market.

In 1891-2 considerable work was done in the direction of using series-parallel connection of the motors, for determining whether speed control in this manner was feasible. This work was carried out in connection with the No. 3 motors. In the early part of 1892 a series of tests was made, both in the shop and in service, with a pair of these controllers, and shortly afterward this method of control was put on the market by the Westinghouse Company. The series-parallel method of control soon became so thoroughly established that it was practically the only street car control manufactured by the company. There have been many modifications and improvements in the series-parallel controller since first brought out by the company, among them being the addition of the magnetic blow-out, but the drum construction placed on the platform has been retained, except for very large equipments.

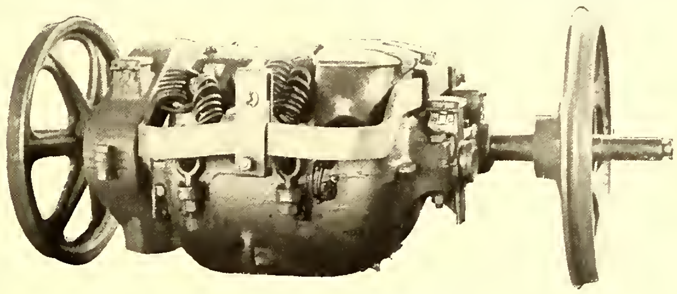
Mention has already been made of the first rheostat made



NO. 38 MOTOR ARMATURE

by the Westinghouse Company for street car work, this consisting of concentric copper coils. This was soon superseded by a rheostat made of iron wire spirals in a supporting frame and covered with a heavy wire netting with a rather large mesh. This rheostat, on account of its appearance, was named the "bird-cage" type. The use of this rheostat was continued for a considerable period, but was then superseded by a rheostat made of iron strap wound in spirals on supporting shells. A number of these spirals were assembled together in one frame. This was a more substantial rheostat than the "bird-cage" type, and was soon used almost exclusively. The adoption of the series-parallel control reduced the size of rheostat required, and thus to a certain extent simplified the problem of its construction.

One difficulty found with the early No. 3 motors was in unbalanced armature currents with two or more motors per car. The armatures of these motors were connected in parallel and the field coils were also paralleled, instead of each armature being connected in series with its own field. It was therefore found necessary to equalize the motors by adjusting the air gaps. This was done by putting sheet-steel strips between the two halves of the yoke. Two ammeters were connected in the



NO. 38 STEEL MOTOR

armature circuits, and the fields were adjusted until both ammeters averaged the same over the working range of the current. This arrangement was later abandoned in favor of the present connection, by which each armature is in series with its own field, thus automatically producing the required balancing action.

One of the most serious difficulties which developed in the early street railway service was in connection with the mica on the No. 3 motors. The first few motors had mica about 1-32 in. thick between bars. In those days the mica was not split and then built up, as in present practice, but was generally punched out of solid pieces and was extremely hard. This 1-32-in. mica appeared to work in a very satisfactory manner, but as it was thinner than the usual practice on the No. 1 and No. 2 motors, about 1-16-in. thickness was then adopted for the No. 3 motors. Practice soon showed that this mica would not wear satisfactorily and there was continued trouble due to it. It was soon determined that if the mica was cut down below the surface of the copper the motor would work satisfactorily until the copper wore down to the level of the mica. This showed conclusively that the trouble was with the mica. We then went back to the 1-32-in. mica, and had very little trouble, particularly as we had begun to build up the mica of thin sheets, somewhat like present practice. It is interesting to note this early experience in cutting the mica below the copper, in view of similar practice in some modern large motors. It has been announced as a great discovery that cutting the mica below the copper was a great improvement in large street car motors. In fact, it is an improvement if the mica in such motors is giving trouble due to lack of proper wearing qualities, but the purpose of cutting down the mica on these late motors is to accomplish the same results as in this early experience above cited.

In 1892 two single-phase motors of about 10 hp were built by the Westinghouse Company for determining the possibilities of using alternating current for traction work. These motors were designed for 2000 alternations per minute and about 200 volts. They were of the series type, with commutators, and had a relatively large number of poles. These were placed upon a car and tested on a short piece of track with some very short curves and rather steep grades. Tests showed that the motors were not powerful enough to operate the car on the curves and grades, also the track was very poorly built and not properly bonded, and the voltage drop in the rails was excessive. A very small generator was used for these tests, and its capacity was insufficient for the service. On the car a transformer served to transform from about 400 volts on the trolley to that required for the motors. There were several taps on this transformer, and by means of several single-pole switches the voltage could be varied to the motors.

There did not appear to be sufficient field for such a system and it was decided not to undertake any larger motors. It was considered at that time that such a system would be ideal for locomotive work, but as there were no such projects in view then, no work was done in building large motors of this type.

In the early part of 1895 the problem of the use of polyphase motors for traction service was taken up and a pair of such motors were built and tested at the East Pittsburg works. These motors were built for 25 cycles and of a nominal capacity of 75 hp each. The primaries and secondaries were wound for 500 volts, and the winding of the rotating part was connected to three collector rings. These motors were designed to be used with both rheostatic and with tandem-parallel control, and shop tests were made with both methods of speed control. With the tandem connection half speed was obtained by connecting the secondary of one motor to the primary of the other in the now well known manner. The results obtained with these motors on shop tests indicated that they could not compete with the standard direct-current systems as regards performance, etc., besides requiring the complication of two trolleys.

Two 100-hp polyphase motors were also designed in the latter part of 1895, and were built and given shop tests on a short track just outside the East Pittsburg shops. These motors were started and regulated by means of variation of the voltage supplied, such variation being obtained by means of a two-phase induction controller. It was also found that this system would not compare favorably in economy with the direct-current system, and after a series of tests it was abandoned. Among other experiments with these 100-hp motors, they were wound for two numbers of poles, so that they could be run efficiently either at full speed or at half speed. This was found to be more economical than the single-speed equipment, but yet did not compare favorably with the direct-current system. These polyphase motors also were tried with variable-speed gears of various kinds, but were not found satisfactory.

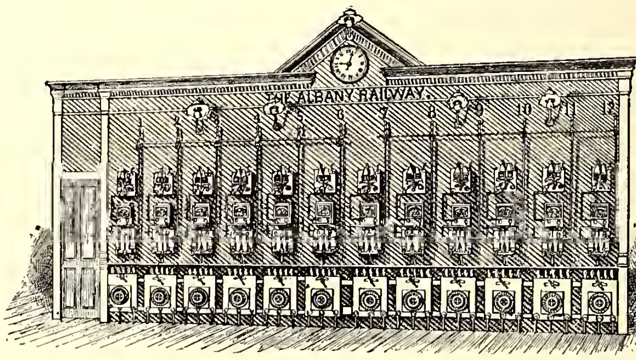
Since 1896 the development of the electric traction motors by the Westinghouse Company has been along fairly well established lines, except in the single-phase system, which the company has lately put upon the market. Some polyphase-motor equipments have been built and installed for haulage of canal boats on the Miami & Erie Canal. This has been about the only radical departure from standard direct-current systems which the company has had in commercial service for any long-continued period.

"We are impressed at once with the national importance of the street railway interests, and this feeling grows deeper and broader as we consider the financial relations of our calling with the millions involved; the varied, useful and indispensable relations it sustains to the well-being of every person in every city and every town of any importance in the whole land; the mighty factor it has become in making or unmaking values in properties of all kinds; and especially does this feeling become almost overwhelming when we consider to what grand proportions this industry has grown during a lifetime of the youngest of our members."—*From Washington Meeting, 1888.*

THE DEVELOPMENT OF THE RAILWAY SWITCHBOARD

BY W. E. HARRINGTON

THE development of the modern railway switchboard is an interesting illustration of the great advances made in electrical engineering. The switchboard used in the early days was crude and lacking in almost every respect the completeness of detail of that of to-day. Nevertheless, it is doubtful whether, if we omit the veneering of the modern board, a layman would be able to distinguish the improvements which have been embodied during the past fifteen years in the direct-current boards. The changes have been along lines dictated by experience; a little here, a little there. The introduction of alternating current for power transmission in large stations has brought about a class of switchboard that stands aloof from the average and most extensively extensively used types.



EARLY TYPE OF WOODEN SWITCHBOARD—ALBANY

The early switchboards were mounted on wooden frames, set close to the wall, and were equipped with round copper bus-bars, bird-cage rheostats with loose spiral wound iron or German silver resistance wires, fuse blocks, ammeters of questionable character, incandescent lamps for voltmeters, and plugs instead of switches.

The writer remembers distinctly the first installation made by the old Sprague Company at Atlantic City, N. J., in 1889; the generators were of 60-kw capacity and were shunt wound. Where it was deemed advisable to compound the generators, the method of connecting the equalizers was a serious problem, with only a brief reference in S. P. Thompson's book on "Dynamo Electric Machinery" as a guide. The practice in many quarters was to use three-pole switches for +, — and equalizers. The writer has seen in basements of some of the largest power stations that were erected ten years ago, thousands of feet of copper cable installed to provide an exact and equivalent length of equalizer between generators.

The modern switchboard is one that is built upon the following general lines:

Single pole switch, with equalizer and negative switch at generator.

Iron frame, slate or marble panels.

Flat bus-bars, high and low pressure.

Single pole, double throw switches.

Ammeters.

Automatic magnetic circuit-breakers.

Rheostats away from board.
Negative panel.
Wattmeters.
Main ammeter.
Voltmeter, one for bus-bar.
Voltmeter, one for generators.

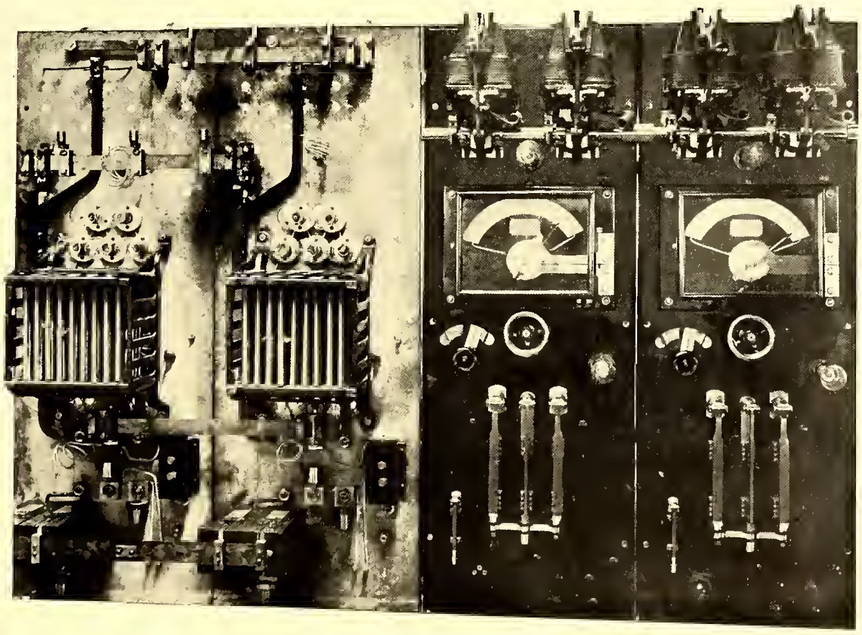
The double-deck switchboard, with the generator panels on the lower deck and feeders on the upper deck, permits of the easiest disposition of the wiring distributing.

The lower deck is usually from 6 ft. to 9 ft. from the wall of building, thus permitting the upper deck to be set back for a railed walkway in front, and sufficient room is left in the rear for the connections.

Angle-iron framing with smooth slate oil finish and the instruments mounted directly thereon, meets with the greatest favor. Great care should be exercised in the selection of the slate to see that it is free from metallic veins. Marble makes a handsome board, but exceedingly difficult to keep clean and free from oil stains. Flat bus-bars permit of ready extension by adding more bars, and by using single-bolted clamps excellent conductivity is obtained. Good mechanical workmanship, neatness and the orderly arrangement of leads can be secured by the construction described above, making the modern board absolutely fireproof and free from those electrical troubles so frequent in the earlier forms.

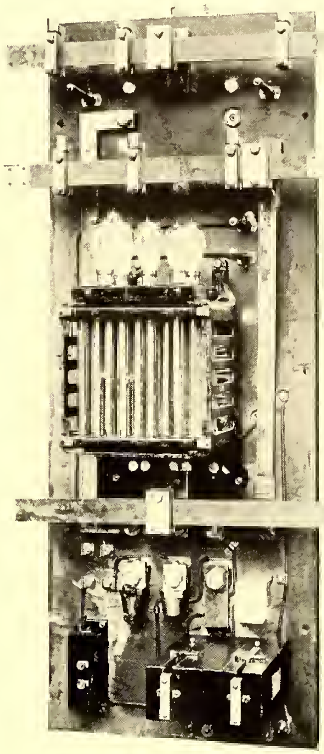
Two sets of bus-bars, one for the usual operating power station voltage, the other for a higher voltage, and obtained either by running certain generators at a higher voltage or by the use of boosters, secure a flexibility in the transmission of energy. This is extremely necessary in railway work, with its fluctuating loads which shift from one feeder to another from day to day; in fact, from hour to hour. The introduction of two bus-bars has given a much simpler and less expensive aspect to the old question of copper distribution with its large investment features.

The later designs of direct motor-driven boosters, self-contained and mounted upon a common base, have also introduced a feature in railway power transmission that cannot be ignored by a progressive manager. The use of single-pole, double-throw switches with the split pattern blade, spring connected, not only permits making better contacts and greater ease in manipulation, but also a quick snap "break."

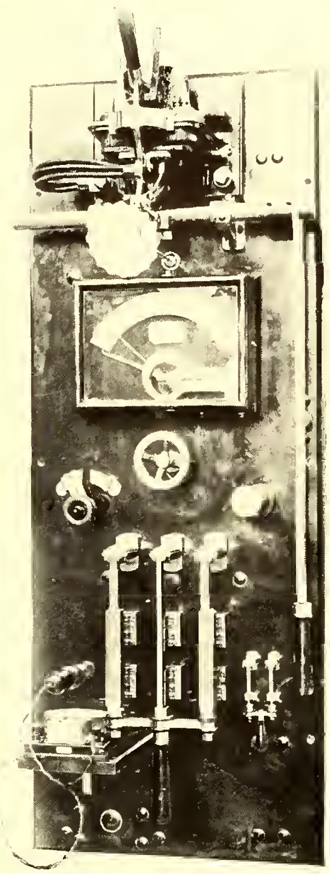


FRONT AND BACK VIEWS OF SWITCHBOARD MADE UP OF TWO GENERATOR PANELS—JUNE 18, 1892

Automatic magnetic circuit breakers have undergone a most interesting series of changes. If there is any one detail following fashion in electrical engineering practice, it is the use of automatic magnetic circuit breakers. The present style is to employ laminated contacts,



BACK VIEW OF SINGLE GENERATOR PANEL—OCT. 6, 1892



FRONT VIEW OF SINGLE GENERATOR PANEL—OCT. 6, 1892

although they are expensive, delicate in contact adjustment and liable to burn out. The knife-blade type of automatic magnetic circuit breakers with broad, ample final "break" on carbon, has proven its trustworthiness, low first cost and correspondingly lower maintenance and operating cost. The writer is familiar with one case alone where the difference in first cost of the circuit breaker was 60 per cent in the prices of the laminated and blade types.

Another interesting application of circuit breakers is the employment of two breakers connected in multiple instead of one, the two combined equal in capacity to the one that ordinarily would be installed. In all cases where this method of installation has been practiced excellent results have been obtained, and at a materially lower cost. The price of an automatic magnetic circuit breaker of large capacity is considerably more, proportionately, than that of two combined, each of one-half the capacity of the larger size.

Ammeters with shunts, illuminated dials, "dead beat," jeweled bearings, immune to the effects of stray lines of force, accurate and positive in reading, have become a feature of our modern switchboard, although they are not appreciated as one would expect of such an important and essential detail. Another feature is the use of rheostats with special resistance metals, disposed to provide for expansion and contraction, and with leads to the contacts and switch handle, which permit the housing and mounting of the rheostats at a point which is away from the immediate proximity of the switchboard.

The wattmeter has become such an important feature in a power station that it should be treated as a special feature. No switchboard should have less than two to permit of frequent adjustment and calibration, particularly if two bus-bars at different voltages are used. The use of two illuminated dial voltmeters has become standard, as it permits the ready and accurate balancing of generator voltages before "throwing into bus."

Large stations, such as have been erected in recent years in New York, have, of course, adopted the refinements of switchboard construction, such as the use of skeleton operating boards with the circuits shown in diagram, and the generators represented by the burning of incandescent lamps. The switches and breakers on these boards, breaking large currents in oil contained in brick compartments and operated electrically and away from the operator, are representative of the highest development in switchboard practice. Boards of this character have been so fully described in the columns of the JOURNAL that it is not necessary to go into further detail.

THE DEVELOPMENT OF THE INTERURBAN ELECTRIC RAILWAY

BY HENRY A. EVERETT

IN 1892 Will Christy, of Akron, suggested to me the construction of an interurban electric railway to operate between Cleveland and Berea, a distance of about 12 miles. This was the first long-distance electric line which was seriously considered by me, and I declined to take it up, because at that time it seemed an unusual venture to attempt the construction of an electric line through so sparsely settled a territory. Within the next six months, with his usual tenacity of purpose, Mr. Christy got me to embark in the undertaking to connect Cleveland and Akron electrically by building the Akron, Bedford & Cleveland Railway. The distance between the two cities is about 35 miles. The cost of construction was $22,000 per mile of track, including equipment, and in order to interest the investing public the property was bonded at less than one-half the cost, namely, $10,000 per track-mile. We endeavored to dispose of the first mortgage bonds on this line in all the money centers from Boston to Chicago, but were politely turned down, the undertaking being, to quote the language of a well-known New York firm, "a very ambitious project."

The Akron, Bedford & Cleveland Electric Railway was probably one of the first interurban electric roads constructed for high speed. It was laid with a 56-lb. rail, the then steam railroad standard, and was expected to operate at a speed of 20 miles an hour between cities. The through traffic on the line was large, and three-quarters of the revenue came from passengers going from one terminal to the other. The earnings started upon a basis of a little less than $3,000 per mile of track, and I am pleased to say at present, after ten years of operation, they have grown to $7,000 per track-mile, and are steadily but not greatly increasing for the present year. At the time of the construction the two competing steam roads, which were then in the hands of a receiver, were charging $1.20 one way between Cleveland and Akron. The Akron, Bedford & Cleveland inaugurated a charge of $1 for the round trip, or 60 cents one way. Then the steam roads commenced the sale of excursion tickets at the rate of 75 cents per round trip, good on their high-speed trains, but the trolley business showed a constant and steady increase. Undoubtedly a considerable part of the electric traffic was due to the abominable location of all of the steam railroad passenger stations in Cleveland. The total traffic of both steam roads is now as great as it ever was, and the Akron, Bedford & Cleveland division earnings are fourteen times greater than the passenger earnings between these two cities of the steam competing railroad companies.

After the construction of the Akron, Bedford & Cleveland Railway we built the Cleveland, Painesville & Eastern, which has earned its fixed charges each year since construction, but hardly any surplus for the stock, as it was constructed at a time when prices were very high, and a large amount of money was expended in eliminating dangerous steam railroad crossings. This line is one that serves a very desirable residence district, and naturally requires very careful attention.

When operation is commenced on our lines an account is started during the first month called "Injuries and Damages Account," and each succeeding month a percentage of the gross receipts is charged to this account. During ten years of experience we have found that from 2 per cent to 4 per cent is amply sufficient for all claims of this kind, and that this plan avoids great variations in the operating expense account.

Since the construction of the earlier roads we have developed the Lorain & Cleveland, the Sandusky & Interurban, and have purchased the Toledo, Fremont & Norwalk, all of which have been consolidated into the present Lake Shore Electric Railway, operating from Cleveland to Toledo. This latter road is one of the longest through electric roads in this country, and we are much gratified with the number of through passengers carried on it. There is, of course, a very material difference in the running time between the steam roads and the electrics, but we find that a number of our patrons prefer the trolley because of the frequency of the cars, which enables them in many cases to reach their destination more quickly than if they waited for a steam train. The Lake Shore Electric track-mile earnings were originally not as large as we expected, but since we put in the connecting link from Lorain to Norwalk there has been a decided increase.

We also built the electric line between Detroit and Toledo complete except the power house, but we found it necessary to dispose of this road before it was put in operation electrically. It is now owned by the Grand Trunk Railway.

We have also been interested in the syndicates which built the Southern Ohio, now called the Cincinnati, Dayton & Toledo; the Aurora, Wheaton & Chicago, the Washington & Annapolis, the New York & Long Island Traction Company, the Springfield & Xenia Traction Company, the Scioto Valley Traction Company, the Richmond & Petersburg Traction Company, and were associated in combining the properties in and about Detroit, now comprising the Detroit United Railway.

The present hold up in the money market will probably prove to be very beneficial to the ultimate success of all interurban trolley properties, as their promotion in the past has often been induced by real estate or other local interests in the territory to be developed rather than on the direct return from the capital invested.

We have found that a combination of an electric lighting service with an electric railway system possesses a very decided advantage to both interests, and believe that the future of suburban trolley roads is an assured success. The recent acquisitions in New York and Connecticut by steam railroads of competing trolley systems will undoubtedly prove of great value to the electric railway transportation interests, as it will undoubtedly give an important impetus to electrical construction.

THE DEVELOPMENT OF STREET RAILWAY ACCOUNTING DURING THE PAST TWENTY YEARS

BY C. NESBITT DUFFY

FROM the time the "bob-tail" car with its fare-box attachment was supplanted by the double-platform car equipped with a fare register, through the evolution of the construction and operation of cable, electric and interurban roads, giving to the world the modern transportation methods now enjoyed, street railway accounting has kept pace with and abreast of every improvement in the art, and played its part in the development thereof.

In the transition from the use of animal to mechanical traction, many accounting problems presented themselves. In solving these problems, the development of accounting work and its importance and value was first accorded recognition and appreciation. The record of the cost of the different items that entered into the construction and equipment of cable and electric roads, the work of keeping the details of construction so that any information desired in connection therewith could be readily supplied, and the presentation of results of operation under the new conditions, taxed the skill and ingenuity of the accountant to the utmost. Not only was it of vital importance to know and compare results with old conditions, but also as to specific conditions with respect to the economy and efficiency of the use of different types of apparatus, of which there were many, in the early days of electric railways. It was these facts that enabled managements to decide as to whether or not roads should be converted from animal to mechanical traction, and if converted, what should be the character of the track and line construction, power plant apparatus and car equipment.

In the development of street railway accounting during the past twenty years, the "Standard System of Electric Railway Accounting," covering classification of construction and equipment accounts, classification of operating expense accounts, and the "Standard Form of Report," including balance sheet with classification of assets and liabilities, description of road and equipment, together with mileage, traffic and miscellaneous statistics, has been formulated and put in practice. This system has become the standard, not only of the railways, but of the National Association of Railroad Commissioners and the United States Census Bureau.

Under the "Standard System" the items of cost representing the investment of a street railway company's capital in road and equipment, the items of income and expense in connection with the operation of the property, the financial condition, and the results of operation, are clearly and comprehensively shown, establishing a fixed uniform basis that admits of analysis and comparison, alike for the management, the investor and the public, where before there was no fixed uniform basis, bringing about confusion, results that were not only unsatisfactory, but misleading.

To fully appreciate the force of this statement it is only necessary to examine the published reports of the street and interurban railways in the leading financial manuals, such as "American Street Railway Investments," "Poor's Manual of Railroads" and other publications of similar character, the annual reports of the State Boards of Railroad Commissioners, who exercise supervision over the books and accounts of railways and use the standard system, or the published report of the United States Census Bureau, of statistics gathered concerning the street railways of the United States for the 1900 census, and compare that report with the report of the 1890 census.

The importance and value of the accounting department of a railway property is to-day recognized and appreciated; this is one of the marked features of the development of the work during the past twenty years. The result has been that the operating and accounting departments of railways have been brought in closer touch with each other, to the mutual advantage and benefit of both departments, and the distinct betterment of the railways.

The "bookkeeper" of the days of horse railways has given way to the "accountant" of the present day, upon whom rests the responsibility of not only "accounting" for the assets and liabilities, the earnings and expenses, but of being able to give the reasons therefor, and of upholding the principles involved and the methods followed. An eminent philosopher has said: "The skill of keeping accounts is a business of reason more than arithmetic." "Reason" must of necessity be the foundation and enter into the application of accounting principles, the analysis of accounts, the preparation and presentation of statements, or in explanations of cause and effect in connection with accounts.

The "accountant" of the present day must needs be thoroughly posted on the affairs of the company, have a general knowledge of the operation of the railway in all its departments, closely study the special local conditions which are a part of the operation of every road, so that the accounting problems involved may be correctly solved and the conditions of operation clearly and comprehensively set forth.

The development of street railway accounting work has reached such a scope and extent that the grasp of the affairs of the company, as well as the operation of the property, is at all times within the hands of the accounting officer in charge, and he is usually able to furnish any information that may be required or desired promptly, or readily answer any question which may be asked.

The sphere of usefulness and the value of accounting work has greatly expanded under these conditions, resulting in methods and systems that are practical and thorough in application, as well as economical in operation. The advantages of modern methods of commercial business and the introduction of labor-saving devices have been made use of to a large extent. Duplication of work and expenditure of labor that is unnecessary or that yields no returns is a thing of the past. Although not a producer of "gross earnings," a properly organized and efficient accounting department becomes an increaser of "net earnings."

To the Street Railway Accountants' Association of America, especially to those who were instrumental in organizing the association in the year 1897, who unsparingly and unselfishly gave to the association, the calling it represents and the interests it stands for, their time, energy, best thought and whatever ability they may have possessed, to the broad-minded and liberal managers of the American Street Railway Association for their support and encouragement, to the Association of Railroad Commissioners for their hearty co-operation, and to the representative street railway publications for their valued assistance, all credit is due for what has been accomplished in the development of street railway accounting during the past twenty years.

THE NEW CRAFTSMAN

BY H. H. VREELAND

ASTONISHING as is the story of the physical growth of the industry of which this periodical is the blue-book, and marvelous as are the inventions it has provoked and made useful, they are, to me, less interesting than the little thin thread of human interest that is woven into the story of the growth and transformation of the last twenty years. I hope that, in a moment like this, devoted to the proclamation of purely material achievements, this human interest may not be lost sight of.

Even to those of us intimately associated with the daily routine of street-passenger transportation during the last twenty years, the results accomplished (now that they are massed for inspection) read like a romance. No other purely American activity makes any such showing. I say "purely American" advisedly, for one may in truth claim that in this particular art we have shown the way; our devices and methods are the standard for the world outside. We conceived the idea and invented the means of making it safe, expeditious and profitable. All the topics relating to how this was done and how it grew are, I am informed, to be treated elsewhere by others. They have arranged the data showing the fabulous physical growth during the past twenty years. The pleasant duty that has been assigned to me of writing a few words in the strange eventful history of which this number of the Journal is to be the record, will not, unfortunately, submit to exact tabulation, since, unhappily, the subject has not as yet received the attention devoted to "car mileage," "passengers carried," "cost of maintenance," "kilowatt-hours," "possible speed" and all the rest of it.

My topic, as I have intimated, concerns a thin, fine skein worked into this wonderful carpet of achievement; here quite plain; there invisible, but always inextricably woven into the beautiful pattern and, to my way of thinking, by no means the least beautiful thread of them all. It relates to the class of craftsmen which this wonderful physical creation called into existence and developed by selection. We called to our aid a great army of "miscellaneous labor" and have welded it into a distinct craft, which compares favorably, in our great cities, in intelligence, public spirit and utility, with its brothers, the Fire and Police Departments. Like these two armies of public servants, our men perform (not occasionally as emergency demands, but daily and hourly) a public service of far-reaching consequence. The class for which I speak has become an essential reliance of the citizens of every great center of population in America, and on its sobriety and integrity daily depend the lives of millions of people and the security of millions of property. On its efficiency and promptness, without other guarantee than the public faith in it, the orderly conduct of the business of our great army of bread-winners is based. With the same confidence that one turns on the bath faucet in the morning or the gas key at night, men regulate their presence here or there, at given hours, in implicit confidence that our men are at their posts performing their appointed duty. This highly disciplined army is larger to-day than the United States army, numbering 133,000 men, and the vast majority of its members are in a fixed employment, enabling them to marry and raise families in decency and comfort. When one contemplates the establishment of a class of workers as large as this, secure in decent employment, it shows the beneficent work of street railway development from a new angle. I wish it could be matched by the sowers of discontent, whether it be in printed appeal or whispered promises of impossible conditions. The steadying of a self-supporting army of citizens like the street railway employees of the United States is a civic contribution to the life of the State that the managers of the industry throughout America should be prouder of than all the money they have amassed.

All this seems very significant to me, because I remember a different state of affairs. When I was drafted from a steam road and took charge of what was then the Metropolitan system, I found that so far as the men were concerned it was a system in name alone. Unification had gone on in all other respects than this. Here was chaos. The employees were an unorganized rabble, without status or pride, or the security which makes for both, recruited at haphazard, depending for their employment on political influence or the whimsical power of petty superiors deficient in moral sense or any regard for justice and right.

The demoralization consequent on this condition of affairs can be imagined and some idea had of the morale. When the idea was fixed fast that the abolition of this system was no temporary shift the results were marvelous. To abolish the system was the act of an hour. To drive home and fix in the consciences of the men that it was a permanent reform has been from that day to this a daily duty, because all those active elements that make for cynicism and doubt in the minds of working men require a daily antidote. The means to create a class feeling and pride did not then exist, and it was necessary to invent them. To supply this want my men, numbering then some 4000 and odd, formed an association, for the purpose of social intercourse and mutual aid. That little mustard seed has grown into a towering tree, and year by year has spread its branches far, until now under its shade not only the opportunity of social intercourse but life insurance and old-age pensions have come to rest. The success of these men in this little social and economic effort has had the effect of stimulating similar efforts among their widely scattered brothers, and while it is true that imitation has not kept pace with the slowly realized benefits, the work is still on the way, and it is my hope, which must be shared by every one who has had the good of his fellow-workers at heart, that it will go on spreading and growing until the example furnished by the street railway employees of New York City is copied everywhere.

In the brief space allotted to generalizations of this kind, it is, of course, impossible to give in detail all the results of a work of this kind, but no opportunity should be lost of bringing home to the minds of those who have our great street railway properties in charge, the realization that the reflex influences on their property of such efforts are in some respects often greater in their beneficence than those secured to the men themselves. Without loyalty and pride of class there can be no true co-operation, and to my mind co-operation can only be secured by enlightened insistence that anything that benefits a property and elevates it in the public mind also contributes to the dignity and distinction of the labor it employs. As showing the recent steadying influence of class pride among the men I am most familiar with, it can be stated that as the personnel quadrupled in numbers, dismissals diminished even more rapidly. It is a fact that to-day, with 15,000 employees, the dismissals for breaches of rule and incompetence are actually less in number than they were when New York City roads employed a little over 2000 men. They have gone down from as high as 300 a month to, in one instance, less than 30.

I plead this individual instance in proof of the fact that when the employment is elevated and the conditions of labor dignified and made secure, it attracts from the community at large a class of honest wage-earners who are in times of stress a reliance to be depended on. The New York men since they have been together have collected over $200,000; they have paid out in sick benefits $90,000; they have paid death claims of $43,000. They have invested $27,000 of their surplus money in the bonds of the property which they operate, and all this they have accomplished without the demoralizing patronage of their employer.

As I look back over the past twenty years, fully cognizant of the great physical change they record, I am still unconvinced that in that alone is there cause for pride. The growing necessities of the great public duty we have to perform have brought into being a new class of workingmen, yearly becoming more distinguished. When one stops to think of the demands made to-day on the intelligence and physical alertness of the motorman or conductor of a public vehicle, having under his control a force and the mechanism for its manipulation unknown twenty years ago, amazement over the physical development is replaced by wonder at the sudden development of this new and efficient guild of craftsmen.

DEVELOPMENT OF RAILWAY MOTOR DESIGN

BY S. T. DODD

WITHIN the limits of such an article as this it would be impossible to sketch, historically, the rise and the characteristics of the many types of railway motors which have appeared on the market in the last twenty years; therefore, the writer does not propose to do more than to comment on the various features which characterize the railway motor of to-day, and to trace, as far as possible, their first use and the necessities which developed them. The course of this development divides itself, naturally, into two main periods. The first period, prior to 1895, during which the rough mechanical characteristics of the modern railway motor were worked out. The changes in design during this period are bold, prominent and easily identified. The series winding, spur gearing, the carbon brush, the multi-polar field, the iron-clad armature, were developed in this period, and were developments which demanded the taste and skill of the mechanical engineer rather than the application of electrical formula or refinements of mathematical calculation. The second period, covering the last ten years, introduces many men of specialized training, whose education in university and shop had taken place during the early development of the electrical industry. The changes in this period are, if anything, more interesting than those in the former, but consist rather in refinements of design and economy of space, material and labor, in the introduction of devices for getting greater output from the same size of motor, and in a more intimate study of the problems related to the calculation and predetermination of service characteristics.

It must be borne in mind that the early attempts at the application of electricity to the transportation problem were based

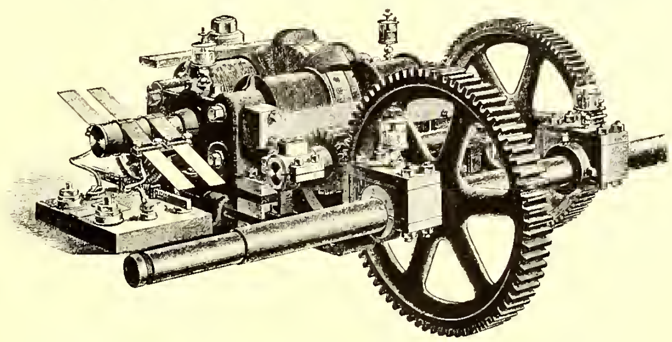


FIG. 1.—BRUSH RAILWAY MOTOR—1884-86

on the application of existing stationary motors and dynamos to railway service, and while the work of Edison, Field, Daft and Van Depoele were of value in the development of the problem, the writer has always considered that the work of Bentley & Knight, in Cleveland, Ohio, in 1884, introduced one of the first permanent characteristics of the modern railway motor, in the series connection of armature and field, which gives the drooping characteristic, demanded by railway work.

On July 26, 1884, Bentley & Knight put into operation their first electric car on Central Avenue, Cleveland, Ohio. The motor was suspended under the car and was a Brush No. 6 machine, with armature and field connected in series, similar to that shown in Fig. 1, with the exception that the first connection to the car axles was by coiled steel-wired belts instead of by gearing. The generator was a Brush No. 7 machine, of the open-coil armature type, about 500 volts and 20 amps., full-load capacity. The troubles developed during the next year in gearing, conduit and generator and motor, caused them to make a decided change in most of the characteristics of their next installation, but it is to be noted that the motor suspension under the car and the series connection were features which were never abandoned, and must be considered permanent from this time.

To appreciate the conditions of the art at that time, we would note that Field and Edison, in 1883, were operating a locomotive with a shunt-wound motor, geared by bevel gearing and belting, and taking current from an exposed third rail at 75 volts. Leo Daft, upon his locomotive "Morse," in 1885, on the Baltimore Union Passenger Railway Company, was using a compound-wound 8-hp motor at 125 volts, with exposed third rail for conductor. Frank J. Sprague, in 1885, was experimenting with electric traction on the elevated railways in New York, and we would note again that he was using a shunt-wound motor, with a compound coil at right angles to the field for neutralizing the armature reaction. Two permanent features, however, were introduced by Mr. Sprague in these experiments in 1885. One was the flexible suspension of the motor, carrying the weight of the motor directly upon the axle on one side and spring suspended to the truck frame on the

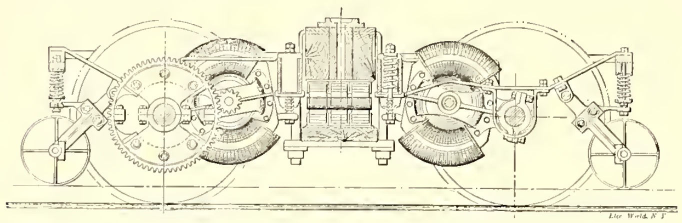


FIG. 2.—SPRAGUE SHUNT-WOUND ELEVATED RAILWAY MOTOR—1885-86

other. The other permanent feature was the introduction of spur gearing. As a matter of fact, the single-reduction spur gear used in these experiments, as well as upon the later Sprague No. 5, or Richmond motor, in 1888, was premature, and had later to be replaced by double-reduction gearing.

To Sidney H. Short should probably be given the credit of seeing that for motors of the speed common at that day, double-reduction spur gearing should be used. The motor shown in Fig. 1 is a motor built by the Brush Electric Company in 1886 for Mr. Short's Denver road, and was in service at least as early as March, 1887.

In 1888 both the Sprague Company on the Richmond road, and the Bentley-Knight Company on the Observatory Hill road, at Allegheny, are operating motors built especially for railway work rather than adopting stationary motors for this service. While there are certain differences in the design of the motors and the methods of control, both companies agree upon the adoption of the characteristics whose origin we have sketched above. Both types of motors are series connected, hinged on the axle and drive by double-reduction gearing. That the design of the motors or the predetermination of motor

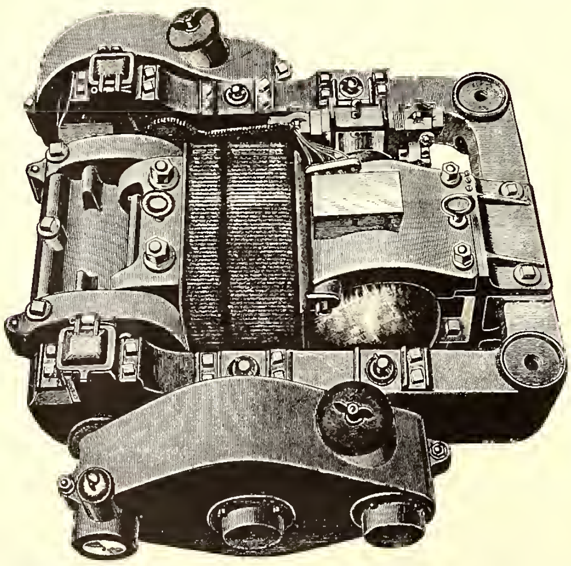


FIG. 3.—WESTINGHOUSE DOUBLE REDUCTION MOTOR—1890

characteristics had not reached a very advanced stage, may be inferred from the fact that the first Richmond motors designed for single-reduction gearing were finally made successful by changing them to double-reduction gearing, a change which shows that as originally designed the motors had about half the capacity necessary for the service.

The following extract from the New York "World" of February, 1889, shows that it was realized at that time that several very important changes must be made in motor design before the railway motor could be commercially successful. The author says:

"The criticisms of Mr. Lawless (engineer of the Kansas City System of Cable Roads), that on his visit to ——— in September, twenty-eight cars out of forty were disabled, and the cars running on a headway of from fifteen to ninety minutes apart, and of Mr. Hendree (an officer of the Detroit City Street Railway System) that eighteen mechanics were at work on repairs of a road having only forty cars, shows what happens when a stationary motor is forced to do the work required by a street railway. The "Plain Dealer," of Dec. 31, concerning the system at Cleveland, Ohio, is far from complimentary, that a road operating on a test, five or six cars should burn out $1,500 worth of field magnets in a week, speaks for itself."

One of the most serious sources of the troubles, referred to above, lay in the commutation. It can easily be realized that the use of a metallic brush on a motor subject to the overloads

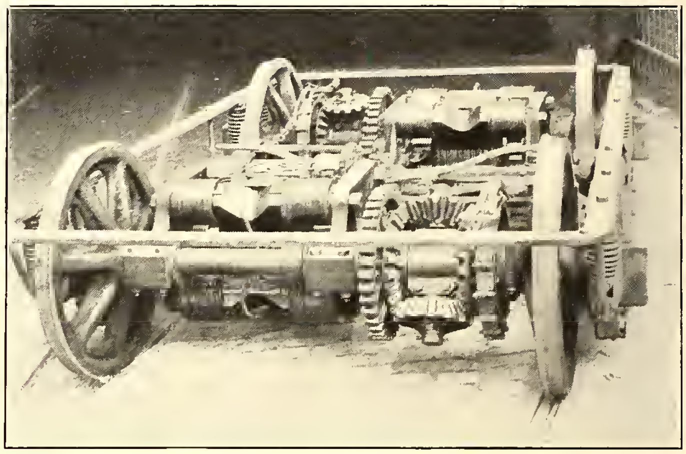


FIG. 4.—MAILLOUX MOTOR—1889

of railway service, as well as to reversal in direction of rotation, was a most prolific source of trouble. It is questionable whether the railway motor would ever have been made a commercial success if this had not been eliminated. In October, 1888, Mr. Van Depoele proposed to use a carbon brush upon a Thomson-Houston railway motor. By December of that year several Thomson-Houston railways were experimenting with carbon brushes instead of copper, and reporting very successful results. By March, 1889, we find it stated that the carbon brush was in general use on all railways using the T.-H. system, and by this substitution a vital and serious difficulty was removed.

Another striking advance in design was introduced in 1890, in the Westinghouse double-reduction motor. This motor had a very poor magnetic circuit, and the electrical features possibly accounted for the fact that it never attained any very marked commercial importance. The mechanical features, however, deserve some consideration; it had an external frame, protecting the working parts; the gears were protected by neat and convenient gear cases; the pole pieces were hinged to the frame and gave accessibility to the armature, a construction which was in marked contrast to the Sprague and Bentley-Knight motors, or to their successors, the Edison and Thomson-Houston motors.

The high speed of all these double-reduction motors presented a serious source of trouble. E. M. Bentley has said that one of the reasons which prevented him from employing spur gearing in 1884 was that he could find no precedent for spur gearing at speeds of 1500 r. p. m., which were ordinary motor speeds from 1884 to 1889. Although by the latter date spur gearing had been generally adopted, the mechanical difficulties encountered in the high-speed gear and pinion had not been overcome, so that the next logical step lay in the development of a slow-speed motor which would eliminate one set of gears. The first example of this type of railway motor was designed by C. O. Mailloux for a storage-battery road in Washington, D. C., in 1889. Several permanent characteristics were contributed to the art by this motor. It had a four-pole field, thus having twice the ordinary number of poles. The armature was built of slotted laminations, with the windings placed in the slots. The commutator was cross connected, so that a single pair of brushes would serve for a multipolar motor, a characteristic which was still further modified in a subsequent motor of the same type built in 1890 by the introduction of the series winding of the armature. It is unnecessary to comment on these improvements, further than to point out that each of these characteristics contributed to the reduction of the motor speed, and every manufacturing concern started at once

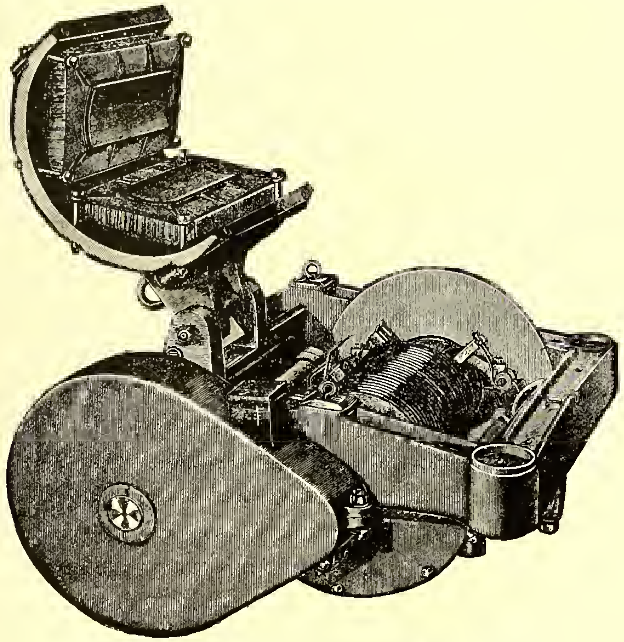


FIG. 5.—WESTINGHOUSE NO. 3 MOTOR—1891

on the development of a line of single-reduction motors, adopting one or all of these features.

In 1891 the Westinghouse No. 3 motor appeared on the market. This was the first permanently successful railway motor, and was so rather because it embodied the successful features of previous types than because it introduced new features. Two features are, however, worthy of remark. One of these is that the hinged field of the double-reduction motor, Fig. 3, has been made multipolar, following the design of the Mailloux motor, and has been extended to embrace and protect the working parts; the other is that this motor introduces the first form of machine-wound armature coils. The coils, however, were of different sizes and were not symmetrically laid around the armature as has since become a common practice.

In 1891, almost simultaneously with the appearance of the single-reduction motor, the design of slow-speed motors was pushed to an extreme in the gearless type. Recent developments have made this motor a step in the history of the art, although at the time it was premature and did not mark an advance. The objections to which the motor was subject at that period were its extreme weight, due to the slow speed of equipments, its lack of flexibility, the inaccessibility of its parts for inspection or repair, and the impossibility of changing its speed for various conditions of service. None of these objections could be considered vital in a locomotive shop with ample facilities for removing wheels and handling heavy machinery. They were, however, very serious objections for street railway service with the repair facilities which we had in car houses

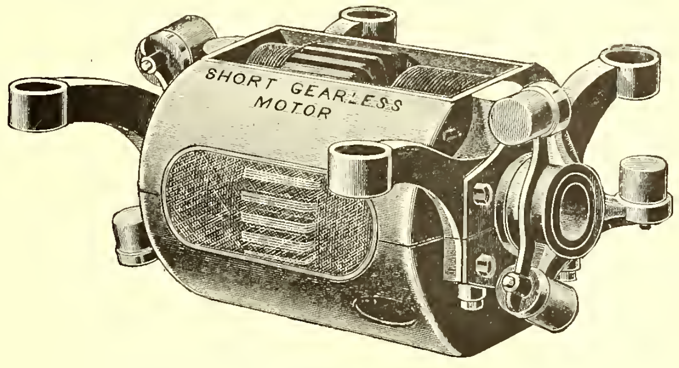


FIG. 6.—SHORT GEARLESS MOTOR—1891

in 1891 and 1892. But the developments of the last year or so —the Berlin-Zossen experiments and the still more recent New York Central locomotive—demonstrate that there is still a field in the future for the gearless motor.

Steel castings for motor frames were introduced in 1891 on the T-H. W. P. motor.

The GE 800 motor of 1893 presents some interesting features; the frame, made of steel casting, entirely enclosed the working parts of the motor. Gaskets under the covers and sealed joints protected the motor to such an extent that it was hoped it would be absolutely waterproof. This feature, however, never was a marked success, as the lack of ventilation and drainage was the source of troubles which soon caused a reaction from this type of motor toward a more open type and one more capable of long-time service. Another feature which was introduced in the motor was the Eickemeyer coil, all the

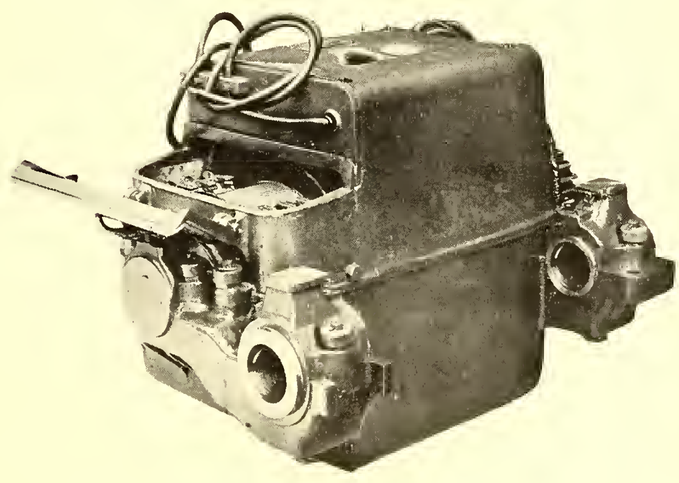


FIG. 7.—GE 2000A MOTOR—1899

armature coils being symmetrical and interchangeable around the circumference of the armature.

The name GE 800 was based on the fact that at its normal horse-power the motor would develop a draw-bar pull of 800 lbs. when running at 10 miles an hour, and marks the first attempt to establish an accurate commercial rating for railway motors, a subject which had been more or less indefinite up to this time.

In 1894 the GE 2000 introduced a still further improvement in symmetrical armature windings; the coils of this motor were made of solid strap copper, one turn per bar, carried straight out on the back end of the motor and the corresponding coils soldered together with clips, thus making a "barrel" winding with an approximately flat diamond shaped coil. Directly after this the Westinghouse 12-A and Walker motors appeared with coils of this diamond shape, wound of several turns of continuous wire, a characteristic which has been standard for railway motors since that time.

Thus by 1895 the chief mechanical characteristics of the railway motor had been settled, and, as said above, the developments of the ten years since that time have been in the direction of refinements of design and economy of material and cost of manufacture. One of the best illustrations of this is to be found in the Lorain-34 of 1897, a motor in which by careful designing the weight was reduced to less than 80 per cent of that of any of its contemporaries of equal output, while its rugged construction and excellent electrical design made a large demand for it for certain classes of service.

Since 1896 it has been realized that the all-day service capacity of motors was a matter that demanded serious consideration; to this is due the increased size of armature bearings, as well as improved methods of lubrication. As an illustration

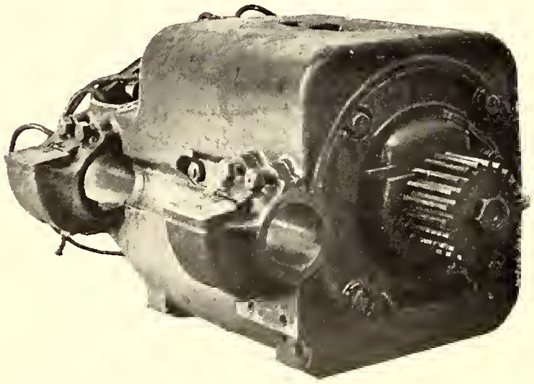


FIG. 8.—GE 55 MOTOR—1897

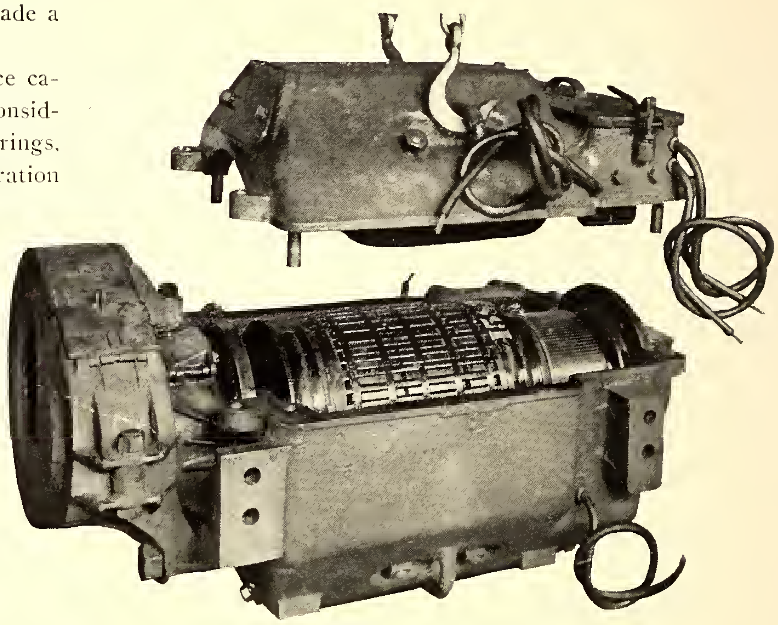


FIG. 9.—GE 74 RAILWAY MOTOR—1903

of this tendency the GE 55, in 1897, introduced armature bearings extending in under the armature windings and commutator, and carried in solid unsplit housings, packed with waste, and lubricated with oil.

Another point that has demanded attention is the accessibility of motor parts and their convenience for repairs. An instance of this has been referred to in the Westinghouse motor of 1890, and still more recently the GE 74 of 1903 affords a good illustration. The new features incorporated in this motor were introduced according to the specifications of the customer, especially with the point in view of making the motor accessible for inspection and convenient for replacal of repair parts.

In 1896 the Westinghouse No. 38 motor introduced laminated pole pieces to reduce the eddy current losses in the pole face. In the next year, 1897, the GE 52 motor introduced the ventilated armature, decreasing thereby the amount of iron in the armature and increasing the core loss per unit of iron, but increasing in a greater proportion the ventilation and the radiating surface of this core so as to reduce the temperature of the armature. Still more recently the "SKC" line of motors show a further development in this direction by opening ventilating ducts in the field laminations to correspond with those in the armature, and thus further increasing the circulation of air through the armature. The cars of the Berlin-Zossen experiments in 1902 and 1903 were equipped with separate air compressors for forced ventilation of the motors. All these instances illustrate the fact that one of the recent tendencies is toward a reduction to a minimum of magnetic and electrical material and an increased ventilation of these working parts to maintain a normal temperature.

One of the most interesting developments of recent years has been the effect on motor design of the study of service characteristics. The speed and power variations developed in operating electric motors in service could never be clearly understood till a study was made of the speed and power curves involved in such operation. As far as the writer is aware, the first published use of speed-time curves illustrating the operation of electric railway motors was made by himself in an article in the STREET RAILWAY JOURNAL of September, 1897, during a discussion of the variations of power and speed produced in accelerating a car. Since 1897 the application of such curves has been developed by several prominent engineers, and they are now a recognized instrument in the discussion of motor problems.

Another discussion of recent years has been the controversy over railway motor rating, and the attempt to arrive at a basis of rating which would be valuable as a comparison of different motors, and, at the same time, a statement of the service characteristics. The rating of the GE 800 type of motors has already been mentioned. This rating was unsatisfactory, for the reason that it was based upon the characteristics of the motor at a certain predetermined speed, which, in any particular case, was generally fictitious. It amounted, therefore, to a horse-power rating upon an indefinite basis. This has given place to an arbitrary numbering of motor types and to a definite commercial rating, which was first proposed by W. B. Potter and commercially introduced with the GE 50 of 1895. On this basis the motor is rated upon the horse-power which it will develop for one hour, with a rise of temperature of 75 degs. C., as measured by thermometer. With this rating we have here an accurate definition of motor rating, and one upon which different types of motors can be compared with each other; the rating, however, is unsatisfactory, as it practically only defines the short-time commutation limit of the motor and does not define its characteristics for long-time service. This fact was pointed out in an article by

N. W. Storer in the Street Railway Journal, January, 1901, in which he claimed that on account of the operation of railway motors on reduced voltage in starting, the average voltage in service was 60 per cent to 80 per cent of the full line voltage. As a consequence, he advocated the rating of motors on their all-day capacity at 300 volts for city service and 400 volts for interurban service. The matter, however, goes deeper than this, as has been pointed out by A. H. Armstrong in a series of valuable articles, the first of which appeared in the Street Railway Journal, April 6, 1901. The heating of railway motors in service depends upon a multiplicity of data, including the weight to be moved per motor, the number of stops per mile, the acceleration, coasting, braking and schedule speed, and the capacity of the motor can be determined for any particular service from a series of curves which can be derived from tests of each type of motor. Of two motors of the same horse-power rating one may have a greater capacity for one type of service and the other for another. The influence of this discussion can be seen in the design of the motors of the last few years. To-day a railway motor is designed with a proportion of core loss and copper loss, and with commutating limits which will fit it for the particular service expected of it. The details of these features of design are too technical to follow in an article of this character, but the discussion of railway-motor rating is not yet ended, and we are still in need of a brief and accurate method of rating of motors which will express the characteristics of a motor and at the same time indicate its capacity for railway service.

I have tried to summarize the course of investigations upon the railway motor. The problem that was faced twenty years ago was one concerning which we were ignorant of the mechanical requirements and of the theoretical method of attack; in fact, to a great degree, the problem itself did not exist at that time, as the necessity for handling electric railway traffic as we know it to-day is a necessity which has developed itself as we have showed our ability to meet it. To-day the d. c. railway motor has twenty years of history and experimentation behind it, but the a. c. motor and the electric locomotive are presenting new phases of the transportation problem upon which we are just entering. The writer does not believe that either of these will in any reasonable time displace the d. c. motor from the particular field it has developed for itself, but that rather they will in their turn develop their own peculiar traffic conditions and demands, but we are sure their development will be more speedy because the general conditions of the problem are known and the methods of investigation have already been outlined, while the work of their investigators will be more accurate because of the failures as well as the successes of the last twenty years.

"And we face that last and greatest discovery of the century, the application of which bears more directly upon our immediate interests than any other, namely, electricity as a motive power. So long as purely brute strength and endurance enter so largely as a factor in our enterprise, there must ever be perplexing and annoying obstacles that the ingenuity of man will be taxed to overcome. Any invention looking toward the abolition of these, thus simplifying our methods of locomotion, will be eagerly welcomed and thoroughly discussed in our deliberative councils. I see in the recent subjugation of the subtile and hitherto illusive force of electricity to the needs of man, boundless possibilities for the world's three greatest requisites for advancement—heat, light and motion."—*From Chicago Meeting, 1883.*

THE EVOLUTION OF THE MODERN POWER STATION

BY J. G. WHITE

YOUR twentieth anniversary number has some special personal interest, because of the fact that it is just twenty years since I first came into contact with electrical machinery outside a laboratory. This was at the Electrical Exhibition in Philadelphia in 1884, after which I had still a year to spend at Cornell. There is perhaps no more forceful way of illustrating "The Evolution of the Modern Power Station" than to recall to mind two or three of the exhibits which attracted special attention at that exhibition.

One of these was the Thomson-Houston ball-armature arc light machine, which was then entirely new to many of the best informed men of the country, like Prof. William A. Anthony. The construction of the machine, the regulator and other details elicited much comment and discussion. Although Brush and other arc lamps were exhibited, the new Thomson-Houston light was much admired. If I remember correctly, only small sized Thomson-Houston Company dynamos were exhibited, and until then the Thomson-Houston Company was almost unknown commercially. It seems truly remarkable that the entire growth of the Thomson-Houston Company, its incursion into the fields of incandescent lighting, street railway equipment and other sections of the electrical field, its amalgamation with the Edison interests into the General Electric Company, and the many years of successful development of the General Electric Company, can all have taken place within the brief period of twenty years.

Another exhibit which attracted considerable attention was that of the Westinghouse Company, this being the first important exhibit of that company as well. As far as I can recall, the exhibit consisted principally of some Westinghouse single-acting engines, and of some direct-current generators, these being of the two-pole double-magnet type, very similar to the then well-known Weston generators. The Westinghouse generators, however, were intended to be of cheaper construction, cast iron being used to a considerably greater extent. It was a year or two later that Mr. Westinghouse went boldly into the alternating field, and energetically pushed the development and use of alternating apparatus. It naturally follows that the entire development of the great business of the Westinghouse Electric & Manufacturing Company has taken place within this same twenty years.

There were, of course, other important exhibits, notably those of the Edison Company, the United States Electric Lighting Company and others.

In these days of 3-amp. and 5-amp. arc lights, it seems strange to think that in this same exhibition the majority of the arc lamps were of the "short-arc" type, consuming about 20 amps., and that there is almost no arc light apparatus in use to-day which was shown at that time. The only exceptions are the then new Thomson-Houston and the Brush 9.6-amp. arc lamps, which are still in use in many places where an enclosed arc or alternating arc system has not been adopted.

As to the power station itself, a 50-kw dynamo was, twenty years ago, considered quite large. The usual rating of dynamos at that time was not in kilowatts capacity, but in capacity of 16-cp incandescent lamps, and a dynamo with a capacity of 1000 lamps, which we would now rate at about 25 kw, was considered an important piece of machinery.

Three years later, in the autumn of 1887, the writer and associates were interested in the installation of what then seemed to us quite a large and important electric lighting station at Lincoln, Neb. This consisted of one 750-light and one 1500-light Westinghouse alternating machine, running at about 1650 r. p. m., and direct belted to two New York Safety engines.

During the five years, 1884 to 1889, the usual power station installation consisted of two or more engines of the high-speed type, frequently of different manufacture, driving directly, by single belts, dynamos of various types, these including at times arc light machines, alternators and direct-current generators of small sizes. The most prominent of all the engines of those days was the Armington & Sims high-speed single-cylinder, from 50 hp to 100 hp each, engines of the same type and of 150 hp being unusual. Other prominent engines of the same period were the Ball, the Ide, New York Safety and the Westinghouse single cylinder. At a little later period, compound engines of the same general types and of the same manufacture came into vogue, and other manufacturers came prominently forward, among these being McIntosh & Seymour, the Harrisburg Machine Works and Ball & Wood.

In 1887 electric railways, which had been previously confined to a few small roads, largely of experimental type, and operating at most only a few cars, received a great commercial impetus by the equipment of the street railway of Richmond by the Sprague Electric Railway & Motor Company. This contract, which included an equipment of forty cars, was perhaps the most notable event in the electric field during the six years —1884 to 1890—and has been followed by the enormous development in electric railways so well known to all.

As electric current came into more general use for electric railway, power and lighting purposes, stations gradually increased in size, and to secure greater economy a number of engineers began to use Corliss engines of sizes from 100 hp to 300 hp each. In order to drive satisfactorily the small high-speed dynamos then in vogue, it was usual to belt from the engine to the dynamo through countershafting, although the latter was obviated in some cases by using "idlers" to force the belts closer together near the dynamo pulley, thus giving contact with a larger surface of the dynamo pulley and a better "grip."

At a little later period there were also a number of installations where larger Corliss engines were used, each operating a number of the small high-speed dynamos then still prevalent. These machines were driven from a long countershaft on which were mounted friction-clutch pulleys, one for each of the generators, so that any generator could be started or stopped without interfering with the others or the main driving engine. The most prominent of these installations was the original West End Station at Boston.

In the period of 1887 to 1890, when the electric railway was developing rapidly, we considered 80-kw generators as being the largest which it was advisable to use. Although the Sprague Company at that time sold some generators of 150-kw capacity, its 80-kw machine was considered by most of the sales agents a better machine, and, consequently, the one to be recommended to customers.

In the summer of 1889 I secured my first big order for electric railway apparatus, selling to the Omaha Street Railway, Omaha, Neb., twenty Sprague car equipments and two 80-kw generators. That these two dynamos were considered an important sale illustrates the development of the power station during the last seventeen years.

During the early nineties, the four, or more, pole dynamo came gradually into use, and for a time many of the power houses installed Corliss engines directly belted to multipolar direct-current dynamos of from 100 kw to 300 kw each, although during this same period many high-speed engines were still used direct belted to generators.

With the improvement in design of generators and the reduction in their speed, came the period of direct driving, and, when after a time we were able to secure dynamos running at not more than 150 r. p. m., it seemed that great progress had been made. Then came the period covering a number of years of direct-connected units, of speeds from 150 r. p. m. to 300 r. p. m. for small units, and 70 r. p. m. to 150 r. p. m. for the larger units, the latter gradually increasing up to 1500 kw, which only a few years ago seemed a tremendous sized unit. The next stage of progress was the building of the larger vertical Corliss engines, which gradually increased to such units as are now employed by the Manhattan, the Interborough and Edison companies in New York, of about 5000 kw each.

As we all know, while there has been some improvement in gas engines during the last few years, the great development has been that of the turbine unit, and to-day the points which interest us most are the merits of the turbine unit as compared to the direct-connected Corliss, or other high-grade engines. Data are not yet available to show conclusively what may be expected in the way of steam economy from the large turbine units. As much as five years ago I knew of a splendidly finished Swiss (Sulzer) engine of 1500 hp, triple expansion, condensing, sold for driving a cotton mill in Russia, which the purchaser told me was guaranteed to show economy at full load of 9½ lbs. of dry steam per ihp-hour. This engine cost what seemed an enormous sum—about $250,000, or about $50 per hp, against from $15 to $25 ordinarily assumed as the cost of a Corliss engine, and reported costs of complete engine and generator, turbo units, of $25 to $30 per kw capacity.[1]

Results have been published[2] of a test of a 4000-hp Brown-Boveri-Parsons turbo-generator at Frankfurt-a-M, which, with a load of 2518 kw, and a vacuum of 91.8 per cent, showed a steam consumption of 15.75 lbs. per kw-hour, and with a load of 2985 kw, steam pressure 152 lbs., superheat 312 degs. and vacuum 90 per cent, a steam consumption of 15.1 lbs. per kw-hour. While this steam consumption is about 10 per cent higher than that guaranteed for the Sulzer engine above mentioned (which was equivalent to about 13¾ lbs. steam per kw-hour), yet the fact that the complete engine and generator can be purchased at about one-third the cost per ihp of the Sulzer engine alone, is of itself a sufficient reason for the installation of the turbo unit under ordinary conditions, besides which the latter has many other advantages. Any Corliss engine, which costs no more than the combined turbo-generator unit, could scarcely be expected to show any better economy than the test just above mntioned.

A. M. Mattice, in an article on "Efficiency Test of 1250-kw Steam Turbine for the Interborough Rapid Transit Company, of New York,"[3] states that the turbine had an efficiency with 150 lbs. steam pressure, 28-in. vacuum, and steam superheat

[1] See discussion on Mr. Emmet's paper, at the Saratoga meeting of the American Street Railway Association, STREET RAILWAY JOURNAL, Sept. 12, 1903.

[2] "The Electrical Review" (New York), Jan. 23, 1904, page 158.

[3] See "Electrical World and Engineer," Feb. 20, 1904, page 356.

75 degs. F., of 13.2 lbs. per ehp-hour at full load, and 139 lbs. at three-quarter load, and 15.4 lbs. of half load. He also reports a regulation test showing only 2 per cent increase in speed by suddenly throwing off a load of 1309 kw, and a decrease in speed of only 2.2 per cent by suddenly throwing on a load of 1340 kw. These economies are about what might be expected under good conditions from a good compound condensing Corliss, or other high-grade unit.

J. A. Seymour, in an article entitled "The Economy of Reciprocating Engines at Light Loads, as Compared With That of Steam Turbines,"[4] shows that tests conducted on three McIntosh and Seymour engines, direct-driving 1600-kw generators, gave economies for all loads somewhat better than those reported by Mr. Mattice for the 1250-kw turbo units. This also shown by the diagram, Fig. 1, which was given with Mr. Seymour's article.

Emile Guarini, in an article entitled "Steam Turbines in Europe,"[5] reports the efficiency tests made on two turbo-generators at Elberfeld. These were of 1000 kw each, and a speed of 1500 r. p. m. The actual steam consumption with only 14 degs. (probably Centigrade) superheat was as follows:

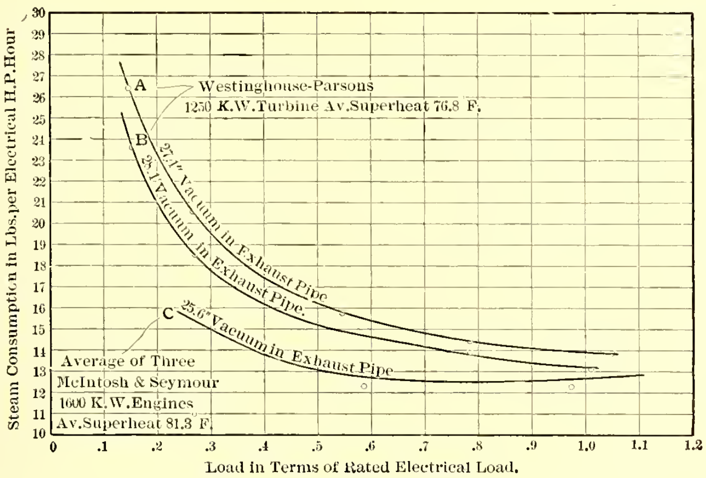


FIG. 1.—CURVES OF STEAM CONSUMPTION

Load in Kw	Actual Consumption 14 deg. superheat Kg per Kw-hour	Actual Consumption 14 deg. Superheat Lbs. per Kw-hour
1,250	8.63	19.03
1,000	9.19	20.26
750	9.99	22.02
500	11.41	25.16

"The Electrical World and Engineer," New York (June 18, 1904, page 1162), contains an article entitled "A Recent Brake Test of 400-kw Westinghouse-Parsons Steam Turbine." This test was carried out by Dean & Main, of Boston, and shows steam consumption with 100 degs. F. superheat, in pounds of steam per B. H. P., as follows:

POUNDS OF STEAM PER B. H. P.

31 per cent Overload	Full Load	77 per cent Load	41 per cent Load
12.07	12.41	12.86	14.62

The above-mentioned tests for both 1000-kw and 400-kw sets compare favorably with what might be expected from good Corliss, or other high type engines of the same capacity.

Mr. Seymour's article seems to prove that, under some circumstances, the economy of the steam turbine at light loads may be less than that of the reciprocating engine; yet, under ordinary conditions, the general impression that the turbine unit will show better economy at light loads, seems justified.

[4] See "Electrical World and Engineer," April 2, 1904, page 651.
[5] See "Power," December, 1903, page 676.

The governing mechanism employed on turbines, by which steam is admitted in puffs as frequently as may be required to maintain speed, permits of the steam going into the turbine at practically full boiler pressure, and without being wire drawn at the throttle valve. The arrangement of the best design of turbines is now such that the steam may expand in such way as to very closely follow an adiabatic curve. In addition to the above, there is no alternate heating and cooling of cylinders, no loss of energy due to stopping and starting of reciprocating parts, and much less friction, due to lighter weight and lack of reciprocating parts.

Considering all the above, it is fair to assume that, when the design of the turbine has been worked out to such high perfection as is shown in the reciprocating engines mentioned in the article of Mr. Seymour, the turbine economy is likely to surpass that of the reciprocating engine for all loads, but more especially for light loads.

The commercial development of the turbine has been remarkable. The first Westinghouse-Parsons turbine was put into commercial use in the last six months of 1899. The first Curtis turbine, according to Mr. Emmet, of 600-kw capacity and horizontal type, was put into operation the latter part of 1901. The second Curtis turbine, 500 kw and the first of the vertical type, was put into regular operation at Newport about June, 1903, and the second vertical Curtis turbine, 5000 kw, was put into operation in Chicago about Oct. 1, 1903. In the short time since these first machines were started, many thousands of horse-power of both Westinghouse-Parsons and Curtis turbines have been put into operation. The General Electric Company has now on order several hundred thousand horse-power of Curtis turbines, many of them being 5000-kw units, and the Westinghouse interests are building 5500-kw turbine units for the proposed large stations of the Pennsylvania Railroad of New York, eight units of the same size for the London Underground Railways, and have on order many other large turbine units.

The largest turbine unit ordered to date, so far as noted by the writer, is one being built for the Electricity Company at Essen, Germany, by Brown, Boveri & Company, of about 10,000 hp, which is to drive an alternator of 5000-kw capacity and a continuous current generator of 600 volts, 1500-kw capacity. The total height of this unit will be 9½ ft., and the total length 55 ft., the length of the turbine itself being about 22 ft. The manufacturers guarantee a consumption of less than 7 kg of steam per kw-hour, or about 9 lbs. per ihp-hour.

The rapid adoption of the turbine unit has been largely facilitated by the rapid growth in size of central stations, and the tendency to use alternating current for general distribution, installing sub-stations wherever direct current is required, even at the central station itself. With improved alternating motors, adapted to traction as well as other purposes, there will perhaps be a tendency to restrict the installation of sub-stations, but this will in no way interfere with the continued and increasing use of the turbo-alternating units. On the other hand, the development of steam turbines has helped to make more general the use of alternating generators, because of the difficulty of constructing armatures, and particularly commutators, with large capacity adapted to the high speeds of the turbines.

During the last few years the development of the gas engine for power house uses has been much discussed, and in design and operation has been greatly improved. Where gas can be had at less than 20 cents per 1000 cu. ft., the actual fuel cost for gas engines would be probably less than steam engines of either turbine or reciprocating types. The gas engine, however, has, as compared to turbo-generators, numerous disadvantages, the most important perhaps of which are:

(1) Very much higher first cost.

(2) A multiplicity of reciprocating parts, with many wearing surfaces, requiring constant attention and increased repair accounts.

(3) Complicated valve gear likely to become clogged with residuum from the gas consumption, requiring constant care and watchfulness.

(4) Increased space required, much more expensive foundations, etc.

The mere fact that the turbo-generator units have come so rapidly into use, and that so many thousand horse-power are now on order, is of itself practically conclusive proof that the turbine-generator unit has inherent advantages. Abraham Lincoln's oft-quoted remark that "You cannot fool all of the people all the time," is still apt, and the mere fact that so many prominent engineers have ordered turbo-generator units is conclusive evidence of their merits.

The chief advantages of the steam-turbine units apparently are as follows:

(1) Lower first cost of turbine unit, including dynamo. Although the selling prices of these units are still high in proportion to their cost of manufacture, it seems certain that competition will ultimately, as processes of manufacture become standardized, bring the selling prices of the turbo units much below those now prevailing, and within reasonable margin of the actual cost of manufacture.

(2) Economy at rated load about equal to the best economy ordinarily obtainable from reciprocating engines of usual types, with relatively somewhat better economy under light loads and ordinary operating conditions.

(3) Very satisfactory momentary regulation under sudden variations of load.

(4) Generators can be more easily synchronized, operated in parallel, and adjustment of governor can be more easily made during operation, so that each unit shall take its proper proportion of total load.

(5) Smaller space occupied, necessiating less investment in land, as well as in building.

(6) Cheaper and simpler foundations required.

(7) Easier lubrication.

(8) The simple compact construction makes all parts easily accessible, and the absence of reciprocating parts considerably reduces frictional losses, wear, danger of hot wearing surfaces, and the attendance required.

(9) Reduction in repair accounts. This may not apply at present, but is sure to follow as the natural consequence from the simple construction after standard types of turbines have been developed and the "bugs" eliminated.

(10) Lack of oil in condensed steam permits of the condensed water being pumped hot directly to the boilers without danger of injuring them, thus saving fuel, and almost entirely eliminating cost of feed water, and minimizing boiler repairs.

(11) Ability to secure increased economy by use of steam much more highly superheated than is practicable with reciprocating engines.

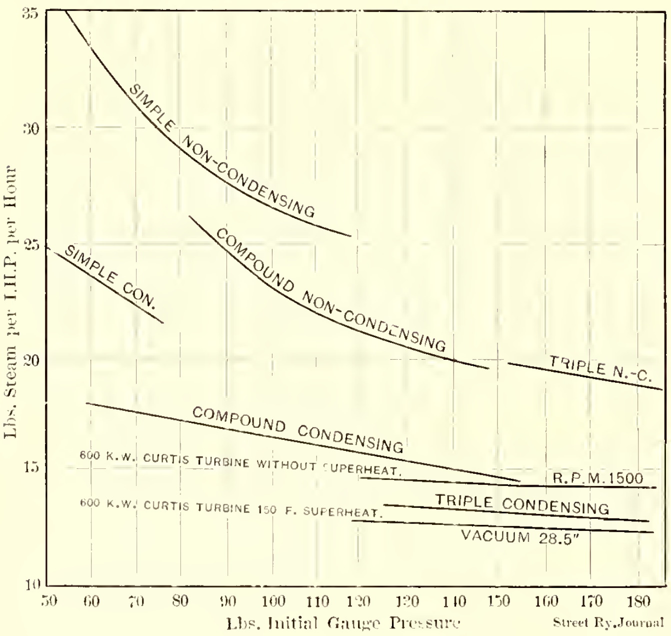


FIG. 2.—ENGINE AND TURBINE PERFORMANCE—STEAM CONSUMPTION

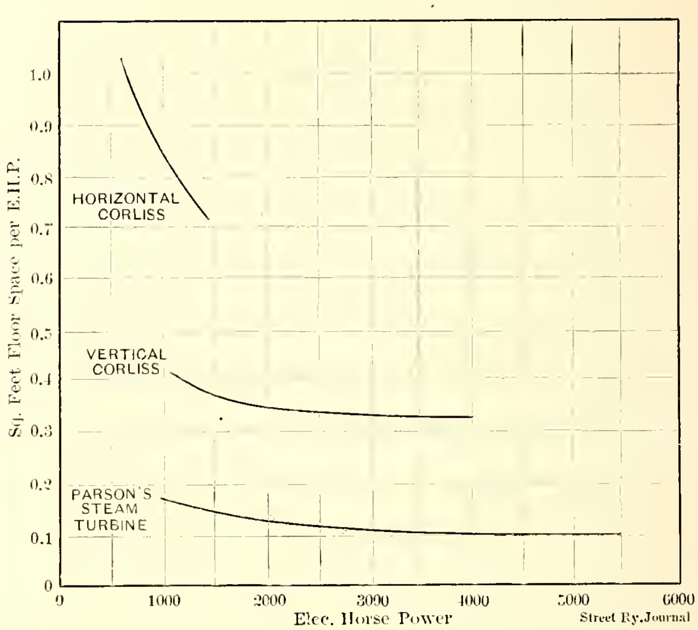


FIG. 3.—COMPARATIVE FLOOR SPACE REQUIRED FOR THREE TYPES OF PRIME MOVERS, ALL OPERATING CONDENSING

Some of these advantages are shown graphically in the accompanying diagrams, Figs. 2 and 3, taken from articles previously published.

Ten years ago many of the power stations, especially the smaller ones, showed steam consumption of from 50 lbs. to 100 lbs. per ehp-hour, and coal consumption from 7 lbs. to 15 lbs. per ehp-hour. Some stations are still showing similar poor results. It should, however, now be possible to install a station of 1000 hp, or over, which should show average economy of better than 20 lbs. of steam per ehp-hour, and full load economy better than 15 lbs. of steam per ehp-hour.

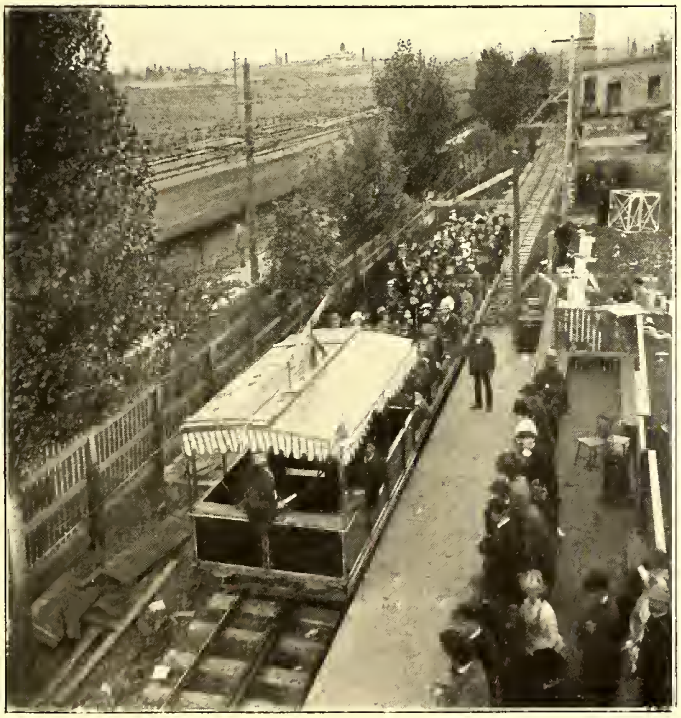
The development of switchboard apparatus and minor details has been quite as marked during the past twenty years as has been the development of engines and generators, and while undoubtedly improvements will continue, the progress already made has been so great that similar rapid improvement can no longer be expected. One may consequently now invest in securities of electrical undertakings, feeling confident that machinery now purchased is not likely to become antiquated within reasonable time, or to be seriously handicapped in competition with machinery of greatly improved types.

ELECTRIC RAILWAY WORK IN AMERICA PRIOR TO 1888

OUTSIDE of the early work of Davenport, electric railway work in America dates from 1880, when Thomas A. Edison, whose genius has illuminated practically every field of electrical research, ran an electric locomotive over a track, less than half a mile in length, at Menlo Park, N. J. Since that time the development has been rapid and has called into service an immense number of men, many of whom know little about the trials and hardships experienced by the pioneers in the electric railway field. Yet it is their work, courage and energy which has developed the electric railway of to-day. Among those to whom the world is indebted for the success of electric transportation and who have passed away are Charles J. Van Depoele, John C. Henry and Sydney H. Short. Others, however, are living, and several, like Sprague, have remained prominent factors in the electric railway field.

The readers of this issue are fortunate in being able to read the story of a considerable part of the early work as told by the inventors themselves, or by others who were closely associated with them. It is not the intention of this article to repeat the facts which are described in more interesting detail at first hand, but to mention briefly some of the other important events in the very early work of electric railroading.

The motor on the Edison electric locomotive, already mentioned, consisted of a dynamo of the "Z" or sixty-light type, wound for 125 volts, and took power from the track rails which were insulated from each other. In prosecuting his claims for patents soon after building this road, Mr. Edison found two other inventors, Siemens and Field, whose claims covered largely the features for which his applications were filed. The claims of the first named were denied by the courts, and Edison united with Field and organized, about 1882, the Electric Railway Company of the United States. Soon after this, Mr. Edison's attention being attracted to other fields of electrical development, the promotion of the new company was left to Mr. Field, and at the Chicago Exposition of 1883 an electric locomotive called "The Judge" was exhibited. This locomotive weighed about 3 tons and was operated by a third rail. It was put in operation June 19, 1883, drawing a trail car, and carried over 26,000 passengers during the two weeks in which it ran.

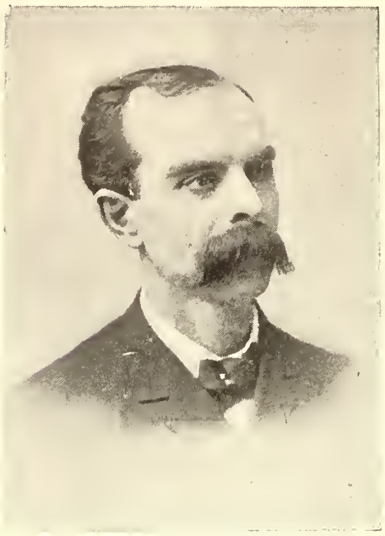


THE TORONTO EXHIBITION RAILWAY—1885

About the same year, Walter H. Knight and Edward M. Bentley organized the Bentley-Knight Railway Company, which in the fall of 1883 built an electric railway line in the yards of the Brush Company. The first public line equipped by the Bentley-Knight Railway Company was on a section of the East Cleveland Street Railway, where a car was put in service on July 27, 1884. About a mile of track had been equipped with a wooden conduit, built up of cast-iron yokes set on the ties. Outside of the yokes were 2-in. planks to form the sides of the conduit, while similar planks formed the top. The slot had an original width of ¾ in. The conductors were mounted about 4 ins. apart within the conduit, and were supported on insulators projecting from the wooden side walls. The first car was equipped with a Brush arc light dynamo suspended underneath the center of the car body and connected by coiled steel-wire belts to countershafts, which in turn were similarly belted to the axles. Another road was constructed later at Woonsocket, R. I., and a combined trolley and conduit road at Allegheny, Pa. A section of conduit line in Boston was completed in 1888, and soon after that time the company was absorbed by the Thomson-Houston Electric Company.

VAN DEPOELE ELECTRIC RAILWAY IN APPLETON—1886

Charles J. Van Depoele seems to have been the first to have adopted the under-running trolley, although the value of this invention did not immediately appeal to him, and a number of his later roads used the over-running trolley. Mr. Van Depoele was a Belgian by birth and moved to this country in 1869, settling in Detroit. In 1880 he organized the Van Depoele Electric Light Company in Chicago, and in the winter of 1882-1883 he equipped an electric elevated railway in an exposition building in that city. The line was 400 ft. long, and the rails were used as one side of the circuit, while a copper wire suspended in the center of the track was utilized as the other side of the circuit. The wire was supported on a number of boards which were cut with V-slots at their upper end. On the bottom of the car were placed two wheels over which the wire ran, so that as the car traveled the wire was lifted out of the V-shaped slots and dropped into them again after passing. This arrangement had been substituted for an overhead conductor, which was first proposed. The car was equipped with a 3-hp motor and could accommodate about five people. This plant ran for several weeks with perfect success. The same year, during the month of August, Mr. Van Depoele equipped an elevated railway car at the Chicago Institute Fair. The cars were suspended from the elevated structure instead of running upon it.

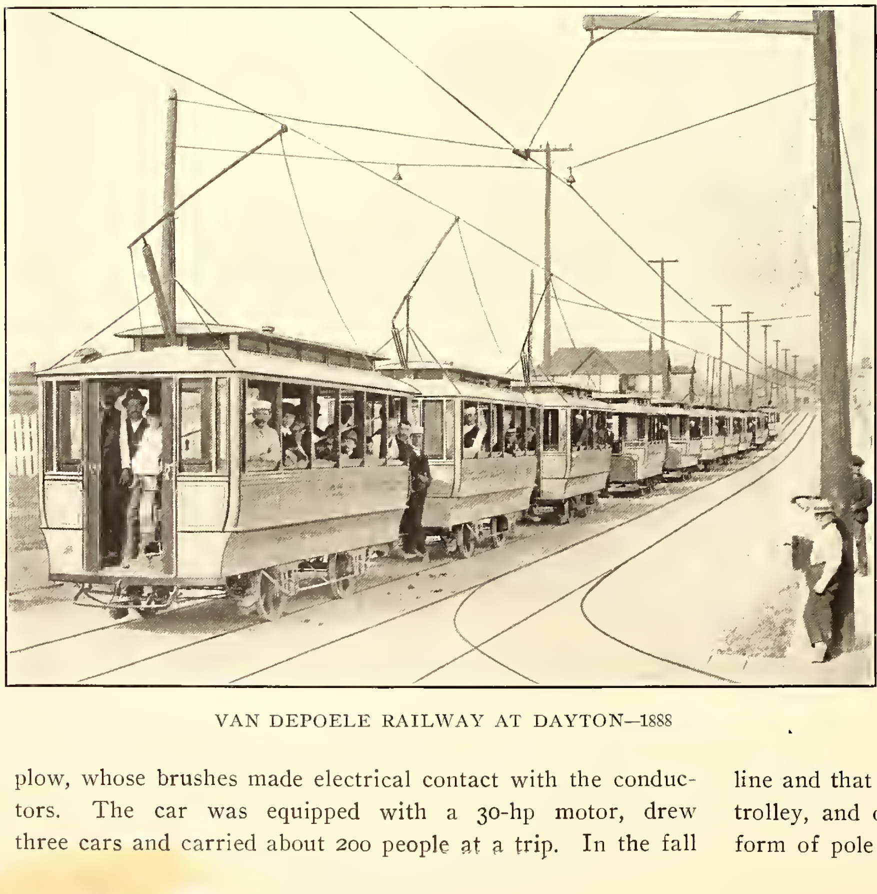


J. C. HENRY

C. J. VAN DEPOELE

The motor was consequently on top of the car, and by means of belting was connected with the car axles. The conductors, of which there were two, one for each side of the circuit, were carried directly over the car, and contact was made by brass rollers pressing upward against the conductors. This line was run for fifty days, or as long as the Exposition lasted.

In July, 1884, Mr. Van Depoele installed an exhibition line about 3000 ft. in length at the Toronto Annual Exhibition, where an underground conduit, consisting of a wooden box fixed to the center of the track by means of iron brackets, was used. The top of this box was slotted, and the edges of the slot were protected by iron strips running its entire length to prevent the wear of the wood. Inside and outside the wood of the box was painted with asphalt. The conductors were carried on opposite sides of the box, and current was taken by a



VAN DEPOELE RAILWAY AT DAYTON—1888

plow, whose brushes made electrical contact with the conductors. The car was equipped with a 30-hp motor, drew three cars and carried about 200 people at a trip. In the fall of the following year the overhead trolley line, illustrated in the accompanying engraving, was built. This line was 1 mile in length, and the trolley pole, which was arranged very similar to an old well sweep, was carried on top of the car, the rails being used as a return. The round trip was made in eight minutes, and during the last five days of the Fair 50,000 people were carried.

The first road operating several independent cars built by Mr. Van Depoele was at South Bend, Ind., where four ordinary cars, each equipped with a 5-hp motor, and one large car equipped with a 10-hp motor, were put in operation on Nov. 14, 1885. The track rails were bonded by copper plates 3 ins. x 12 ins., placed under the joints, and the rails were then spiked down over the plates. The trolley wire was ¼ in. in diameter, and the over-running trolley was used, as in most of Mr. Van Depoele's work during the following three or four years. The motors were placed under the cars between the wheels and were

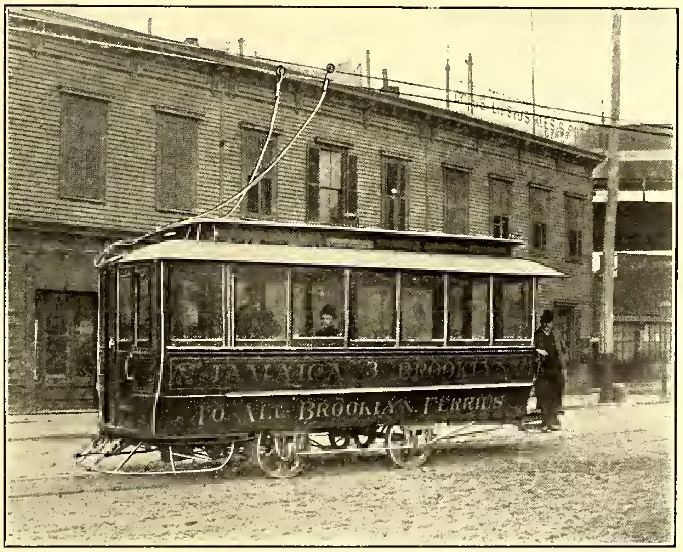
CAR AT LIMA IN 1887, SHOWING MOTOR ON FRONT PLATFORM

connected to the axles by link belting. This road was about 2½ miles in length. The latter part of the year a line three-quarters of a mile in length and with two cars was put in operation at the New Orleans Exposition. During the following winter a 50-hp locomotive was put in service on the Minneapolis, Lyndale & Minnetonka Railway. This railroad was operated by steam and the electric locomotive was installed to haul the passenger cars through the streets where the use of steam power was not permitted. As many as eight loaded cars were hauled at one time up a grade of 3½ per cent, making a total estimated weight of 91 tons. Other lines built about this time were the Windsor Electric Railway, of Windsor, Ont., in the spring of 1886; the Detroit line, 1¾ miles in length, put in operation on Sept. 1, 1886, and the Montgomery, Ala., line, 1½ miles in length, was put in operation early in 1887. Lines were also built at Appleton, Wis.; Port Huron, Mich.; Scranton, Pa.; Ansonia, Conn.; Dayton, Ohio, and other cities. The Ansonia line and that at Dayton were equipped with the under-running trolley, and one of the accompanying illustrations shows the form of pole used. The chief objection to this form of trolley in the early days was the difficulty in making it stay on the wire.

Associated with Mr. Van Depoele in a great deal of his early work were several gentlemen who have ever since been connected with the industry and are well known in electrical circles; among them W. J. Clark, Elmer P. Morris and W. N. Sheaff.

John C. Henry was another of the early inventors. In 1884-5, Mr. Henry, who was then a resident of Kansas City, constructed there an electric railway, using overhead wires. In the fall of 1885 he made some experiments in heavy electric railroading on a branch of the Fort Scott Steam Railroad, where heavy freight cars were operated. Mr. Henry later, in 1886, equipped the Kansas City Fifth Street Railroad with his street railway system. Here he employed, it is claimed, for the first time the following features, which are still in common use: The trolley wires were of No. 1 hard-drawn copper, and were supported centrally over the street from the insulators and span wires to poles placed along the curb lines; the trolley engaged the sides and bottom of the wires, and was so held by spring pressure; the current was supplied by compound-wound, constant-potential dynamos; the motors were series-wound and were journaled on the car axles at one end, the other end being spring supported; the gearing was encased and ran in oil; the practice of using two pairs of tapering brushes was discarded and a single pair which abutted the commutator was substituted. An independent switch was added to reverse the motor instead of shifting the brushes. In 1887 Mr. Henry removed to San Diego, Cal., and constructed a number of electric roads, one of which contained 9 per cent grades, which were surmounted by his motors and trail cars with success. The system of underground feeders was first introduced on one of those roads.

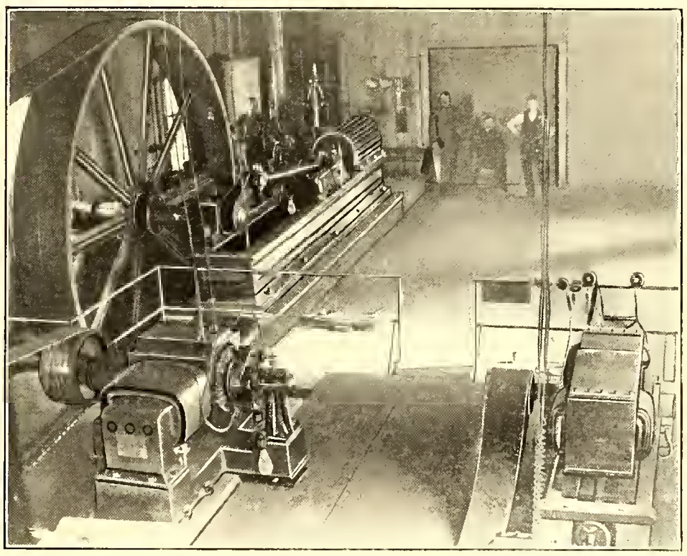
S. H. SHORT



VAN DEPOELE RAILWAY IN JAMAICA, N. Y.—1887

The pioneer work of Sidney H. Short should also be mentioned in this connection. Prof. Short, while vice-president of the Denver University and professor of physics in that institution, became interested in electrical work, and in the spring of 1885 constructed a short electric railway in Denver. The track was made of T-rails laid on crossties, the two conductors being supported on insulators between the rails. The car had four wheels and a rigid truck; the motor was geared with one pinion and one gear to the axle. The car body was 8 ft. long, and fitted with a rheostat lever and reversing lever. The success of the road was so great that a party of capitalists induced Mr. Short to give up his professorship and develop a street railway system. The conduit system was adopted and 5 miles of track were laid on Fifteenth Street in Denver, and operated with considerable success. The difficulties with insulation in the conduit in wet weather, and the imperfections of the early types of motors and generators, led to electricity being finally abandoned and the cable substituted. This was in turn given up, and the road is again equipped with electricity, the overhead trolley system being used.

ONE OF THE EARLY SHORT-SERIES ROADS



POWER STATION AT JAMAICA—1887

Later, Mr. Short returned to Columbus, where, under the firm name of S. H. Short & Company, a short line about 2½ miles in length, using the overhead system and series motors, with the series system of distribution, was built. In 1888 Mr.

Short constructed another line on the overhead series system in St. Louis. In June, 1889, he made Cleveland his home, and organized the Short Electric Railway Company, with a capital of $5,000,000. He was later chief engineer of the Walker Company, and some few years before his death moved to London, where he became technical director of the English Electric Manufacturing Company.

TWENTY YEARS OF CAR BUILDING

BY JOHN A. BRILL

TWENTY years ago—that takes us back to the final days of the horse car and short era then commencing of the cable car. Types and methods of construction of the horse car had long been established and the minimum weight of cars for the maximum loads determined. The art of car building was so completely developed by the genius and energy of the fathers of the industry, chief of whom were John Stephenson, J. M. Jones, F. W. Brownell and J. G. Brill, that practically nothing has since been added to it. The reduction of weight of the standard closed 16-ft. horse car and gear and brake complete from 5700 lbs. to 4280 lbs., which was accomplished by Mr. Brill, well illustrates the remarkable degree of excellence to which building was brought,

A TYPICAL HORSE CAR OF TWENTY YEARS AGO

for these cars frequently carried from seventy-five to one hundred passengers, and were equal in durability to the heavier cars.

Lightness was obtained by careful selection of material and the placing of it together with the accuracy of the highest class of carriage work. The posts were cut from wood selected on account of the direction of the grain, and every particle of strength used to the best advantage. This was necessary because of the almost complete absence of bracing. The influence of this careful construction was altogether beneficial in its effect upon building, developing habits of thoroughness and care in details, which still obtains, and lightness of construction is as important as ever, for any unnecessary weight increases the operating cost per car-mile. There is a fallacious idea current among street railway men that cars should be as heavy as possible to increase tractive force. That is entirely a matter of motor equipment, the rating of which is figured on the maximum load and not on the car running light.

With the introduction of longer cars for cable and electric roads, the size of framing material was increased about 25 per cent. In the horse car the strains brought upon the upper framing by stopping and starting were comparatively small, while on cable and electric lines the strains are violent and tend to loosen the whole upper structure.

In the first cars that were operated by electricity early in the

ONE OF THE FIRST ELECTRIC MOTOR CARS—MOTOR ON PLATFORM

80's, the motors were placed on the car floor, but that method had to be abandoned, as the vibration racked the car severely. The suspension of the motor from the car body by different methods was also found to be impracticable, and eventually it was supported upon an independent frame work connected with the truck. The writer was the inventor and first constructor of a truck of this character. The idea was not at once accepted, but after many costly experiments, street railway men realized that it was the only logical method of carrying the motor.

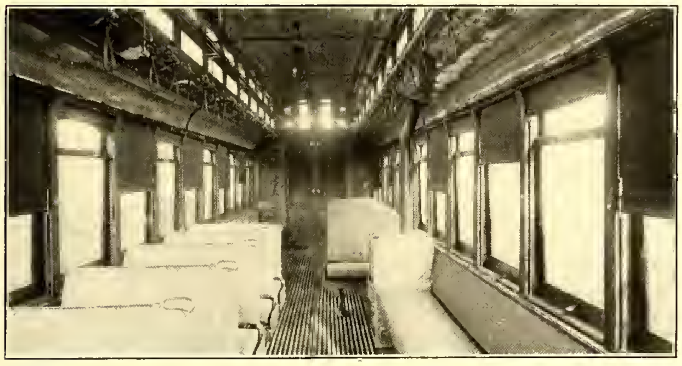
During the first years of electrical operation many of the old

HORSE CAR TRANSFORMED FOR ELECTRIC SERVICE

horse cars were placed on motor trucks, traps cut in the floor and the roofs strengthened for trolley poles. The new cars were built 18 ft. over the bodies, and that was considered very long. It was several years before they were again increased a couple of feet, and 22-ft. bodies are of comparatively recent date. The length of the bodies waited on the development of the trucks. The discovery that the bounding motion, common to single trucks, was the result of a rhythm set up in the coil springs, led to the introduction of plate springs, which by their slower action prevented, in a large measure, the oscillation and permitted longer bodies to be used. With the lengthening of cars the bottom framing required additional cross joists and metal reinforcing, and still plates soon came to be a regular part of the construction.

When longer cars requiring double trucks came into use, the difficulty of carrying the bodies low enough to have the steps of a convenient height confronted builders. After a long series of experiments the maximum-traction truck, invented by the writer, was perfected, carrying the car body as low as a single truck, and bringing the long city car into general use, so that for a number of years comparatively few single-truck cars have been used in city work. Many short cars were spliced together and mounted on maximum-traction trucks—the trucks made this possible. A large number of small roads went in for double-truck cars when four-wheeled cars would have saved much of the original outlay and reduced the cost of maintenance.

Coincident with the coming into vogue of the double-truck



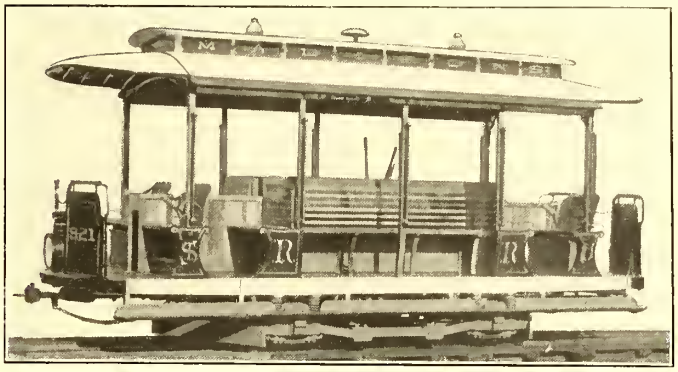
A MODERN TRANSVERSE AND LONGITUDINAL SEATING ARRANGEMENT

car was the demand for a transverse seating arrangement—not always wise when applied to the cars of busy city systems, for such an arrangement, although providing a larger seating capacity and more comfortable seat, lessens the total capacity by limiting the standing room and retarding the movement of passengers in and out. Longitudinal seats for four or six passengers each at the car corners are used to much advantage with the transverse seating arrangement. With the view of obtaining more aisle space a plan adopted on several large roads has the transverse seats on one side and the longitudinal seats running the full length of the car on the other side; but as passengers prefer the transverse seats, these cars often run with the load all on one side. A better arrangement is to have the longitudinal seats extend half the length of the car, with the transverse seats opposite, and the other half of the car with

A TYPE OF DOUBLE-DECK TRAILER CAR, FORMERLY USED IN THIS COUNTRY

the same arrangement transposed; this balances the load and accomplishes the same object.

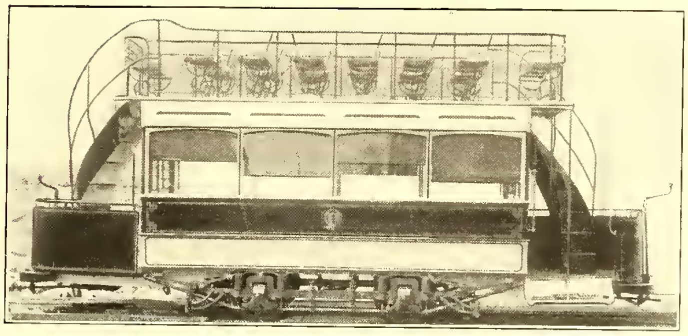
Interurban traffic, which commenced seven or eight years ago, enlarged the scope of electric car building, introducing a number of features and methods of steam car construction. This class of building, however, was developed from former types of electric cars rather than adaptations from steam car practice. There has been and still continues a tendency to construct the bottom framing of interurban cars for a greater horizontal strength than conditions require, adding an unnecessary amount of weight, and not infrequently there has been insufficient provision for vertical strain. This has been shown by the early need of repairs, and in some cases the bottom framing has required additional bracing and trussing. The upper framing of the larger straight-sided cars is braced and



A GRIP CAR FOR CABLE SERVICE

trussed in the same manner as in steam car practice. Plates are usually placed on the inside of the sills, and latterly, on account of the long and heavy cars being built, a large amount of reinforcing of the other members of the bottom framing by plates and angle irons has been introduced. Many companies have learned to their sorrow, and others are failing to profit by their experience, that the cost of operating extremely large and heavy cars is more than the business warrants, or that the service is limited by using a few large cars when the same outlay for smaller cars would provide for a more frequent schedule. There are many disastrous results of small roads emulating the example of the few extensive systems whose conditions require large cars.

For cable traction, grip cars with trailers were chiefly used. The grip cars were usually open and the operating mechanism



ENGLISH DOUBLE-DECK MOTOR CAR OF THE PRESENT

placed in the center of the car and direct connected with the grip device. These cars commonly had longitudinal seats placed back to back with space for the operator between and transversely placed seats at either end. At first horse cars were used as trailers, then followed cars of various types and sizes to suit conditions, among them double-deckers, open cars with seats facing outwardly, center vestibuled types and the ordinary forms; usually these cars were mounted on double trucks. The latter types for cable service carried their own grip device, which was connected to operating mechanism placed in the ends of the car. The center vestibule car continued to be considerably used, and another type which found much favor was a car having open sections at either ends, with seats facing outwardly and a place for the operator between the backs.

When the electric car commenced to displace horse and cable cars at the end of the 80's, the types that came into general use closely followed the closed and open standard forms of horse cars. The double-decker that was formerly somewhat used has gone entirely out of use in this country. Its continued use in foreign countries is due to regulations requiring every passenger to be seated, and also to speed restrictions. It will pass out of use everywhere eventually on account of its slow-

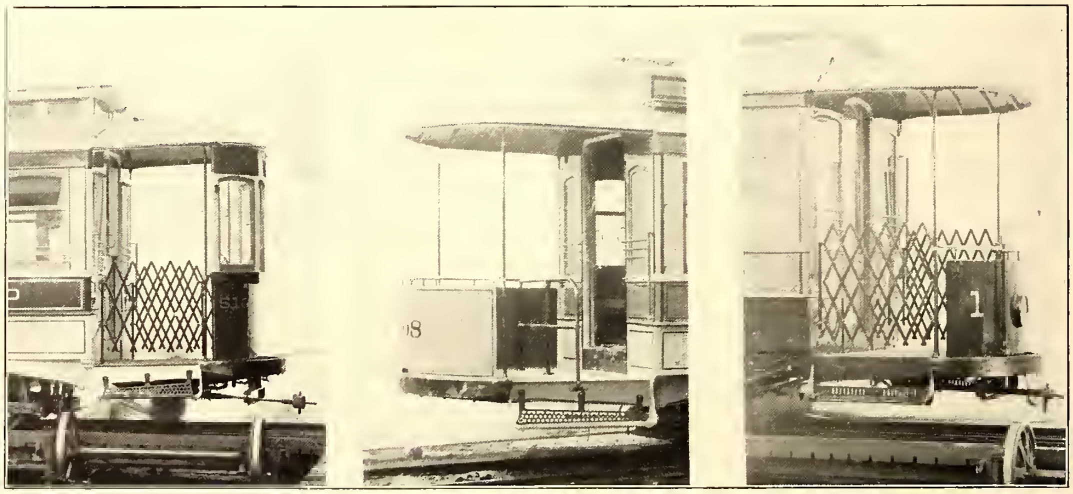
INTERIOR OF A MODERN INTERURBAN CAR

ness. Cable service developed a few types which were suitable for use on double trucks, and therefore were held in abeyance until double-truck motor cars should be built. The first important additions made to closed cars were folding gates, and in many cases vestibules with or without doors. The arrangement of platforms has been given very careful attention by builders and railway men, and every conceivable type thoroughly tried. For city service, vestibules with open sides have been invariably used where the conditions permit. The protection which they afford increases the efficiency of motormen and conductors. Passengers are also protected when entering and leaving the car, and while the doors are open the car is made less drafty. In cold climates the completely enclosed vestibule early came into use, and with the growth of suburban traffic in all climates this form of vestibule was universally adopted. In interurban cars the vestibule has been frequently divided by a partition, which formed a cab for the motorman at one side. In some cases the partition has been extended diagonally from the corner post of the vestibule to the inside post of the door, and the triangular corner thus formed occupied by the hand brake.

The standard size of platforms is 4 ft. 8½ ins., measured from the body over the crown piece. Of late years, however, longer platforms have come into vogue for city and suburban service, some being even as long as 6 ft. As a rule, long platforms are divided transversely by a rail, which, in a large measure, prevents the passengers who are standing on the platform obstructing the passage from the door to the step. This style is commonly known as the "Detroit" platform, and is intended to increase the standing space of the car. Formerly there was a good deal of criticism upon the method of supporting dropped platforms, and much of it was just. The best method includes the use of angle-iron center knees extending well back of the body bolster, and outside knees reinforced with angle iron. By this arrangement ample support is given to vestibules and long platforms.

Cars for interurban service have been usually built with a baggage compartment fitted with folding seats for the use of smokers, or with a smoking compartment. Extra long cars occasionally have both baggage and smoking compartments, and toilet rooms of standard steam car character are also generally included in cars for this form of service.

Except that it is longer and stronger, the open summer car of to-day is identical with the open car formerly drawn by horses. As a rule, open cars are built with bulkheads having seats at either side, and occasionally light vestibules are included. One variation from this type omits bulkheads and uses heavy corner posts instead; another has bulkheads, but omits seats on the outside of the bulkheads, reserving this space for the motorman. Open cars with center aisles and with or without running boards date back to the horse car days and continue to be used in a number of cities. The old longitudinal-seated open car—the seats facing outwardly—has entirely gone out of use because of its limited seating capacity and lack of standing space. Except on maximum-traction trucks, long double-truck open cars have been used to a very limited extent. Mounting on maximum-traction trucks having 30-in. driving wheels, brings the tread of the running board 18 ins. from the rails, and the distance from running board to car floor, 15 ins. Heights greater than these are manifestly unsafe, unless platforms are used. The growth of amusement-park service, and of summer-excursion service generally, has created a demand for large open cars requiring double trucks capable of a four-motor equipment per car. To meet this, the car known as the "Narragansett" type was designed, which has a pair of steps on either side, so arranged as not to exceed the width of a standard single-step open car. The upper step is upon the middle web of Z-irons, which constitute the sills.



MODERN TYPES OF PLATFORMS

Cars having long platforms with seats thereon were considerably used on cable roads, and have since been most widely used on electric roads on the Pacific Coast. A form of this car, known as the "California" type, is constructed with angle-iron side sills, offset and prolonged to carry the platforms 8½ ins. lower than the floor of the closed part. This arrangement relieves the body of the strain of the long platforms, and by carrying the platforms low, the step heights are 14½ ins. from the rails to the running boards, and 12 ins. from running boards to platforms. Large double-truck cars of this type, with platforms flush with the floor of the body, have been used for many years in the far West. They have been usually provided with vestibuled ends, and the seats in the open parts are properly guarded at the sides to prevent accidents. The "Metropolitan" combination car, so called because first designed and largely used by the Metropolitan Street Railway of New York City, is simply a closed car at one end and open at the other. In New York every fourth car is one of this type, so that in summer those who desire to ride in a closed car may be accommodated, and in winter the open part is usually well filled with smokers.

From the early horse car days endeavors were made to adapt cars for both summer and winter use, but, because of the awkwardness of handling, lack of durability and unsightly appearance, none were successful. The nearest approach to success in such a car was one having the windows and the upper section of the side panels removable; this system came into favor in spite of several objectionable features. In 1898 the Brill convertible car was put on the market, and has grown into considerable favor. It is a genuinely convertible car, because side entrances are provided, and also because it is self-contained and capable of being rapidly converted by inexperienced persons.

The most important type of all is the semi-convertible car, because of its large field and adaptability to various conditions. It is simply a car with the window spaces capable of being made entirely free of the sashes. There are four methods of accomplishing this: in the first the sashes are removed bodily from the car, the second has pockets for the sashes in the side walls, the third has wall pockets for the large sash and the small upper sash is raised into a recess back of the latter board, and the fourth arrangement is the storage of both sashes in pockets in the side roofs.

A combination of the convertible and semi-convertible roof window storage types has recently been built for systems where the cars run in one direction. The arrangement provides more transverse seating space than is obtainable in a convertible car, and by closing one side entirely reduces the liability to accidents. One of the cars of this type was built for trailer service and furnished with a center vestibule. The advantage of the center vestibule are such that it will probably be considerably used in the future, especially in the trailer service, which is coming into vogue again. A larger seating area is provided, and by dividing the car, one compartment may be used for smokers, and the car is less subject to drafts in winter than the ordinary style.

TWENTY YEARS' DEVELOPMENT IN STEAM-ENGINE PRACTICE

With Special Reference to Electric Traction

BY EDWIN H. SNIFFIN

In a retrospect of two decades, we discern in the steam-engine practice of that period a constructive growth great in its proportions and far-reaching in its effect; a growth dominated throughout by commercial considerations, and in this sense symbolical of the contemporary advance of a distinctively material age.

The development during this period has been confined for the most part to mechanical improvements, refinements of design and construction; in a word, to the adaptation on a vast scale of pioneer thought and achievement to modern exacting demands. If we except the steam turbine, to which reference will be made later, there have been, within the time of which we are treating, no discoveries or inventions to mark a radical departure either in the engine itself or in its method of utilizing the heat energy of steam. The engine has grown bigger and better, but fundamentally remains unchanged.

The period of 100 years precedent to 1884 had yielded the heritage of established laws and mechanical principles. Watt had, in 1784, converted the atmospheric engine into the double-acting engine, with steam-jacketed cylinder, separate boiler, individual condenser and air pump, fly-wheel, governor, throttle valve and automatic cut-off valve gear. Twenty years later the principle of compounding was introduced by Wolff. The names of Davy (1812), Joule (1843), and Rowland (1880), mark the determination of the mechanical equivalent of heat. Carnot and Clausius (1850) elucidated the theory of heat. Regnault (1847) determined the physical properties of saturated and superheated steam. Hirn (1870) gave us the thermodynamic analysis of the engine, and Rankine from 1849 contributed his prolific work. The nineteenth century witnessed in succession the Wolff or non-receiver type, later the receiver type, the application of the steam engine to locomotive and marine work, the slide valve, the Corliss and the so-called high-speed types, both simple and double-acting.

Watt's original simple D slide valve had been successively modified into the balanced valve, the double-ported balanced valve, single and double-ported piston valves; the Meyer adjustable cut-off; the various forms of riding cut-off valves; the detachable or drop cut-off, applied by Sickles to marine work, and later by Corliss; the rocking valve and wrist motion gear of Corliss, and the various four-valve arrangements. The original unweighted fly-ball or pendulum governor of Watt's invention had been modified into the weighted fly-ball governor, and later into the spring-weighted governor, generally adopted with slow-speed Corliss gears. With the high-speed engine came the centrifugal shaft governor, and later the inertia type. These successive discoveries and developments resulted in the types of engine which had come into use for general power work and later for electric lighting.

The inauguration of electric traction service, therefore, found available engines fairly well suited to its initial demands and imposed no immediate conditions which they could not meet. Steam pressures were low. Units were small and refinements of economy and regulation were not yet understood or sought. The adaptation of electric apparatus to the new service was at this time the subject of transcendent importance, the engine being of comparatively minor concern. The generators were direct current, high speed and universally belt driven.

The first distinguishing step toward improvement lay in establishing a closer relationship between engine and generator, and the elimination of belts and shafting, with their attending objections. This led to the direct-connected generator, first of the high speed and later of the moderate speed type. Engine construction was modified to meet it, various ingenious methods of flexible connection being first devised, and later, with improved shaft and bearing construction, the engine shaft was extended to accommodate the revolving generator element. The sudden and wide fluctuations of load required engines of heavier proportions, resulting in many improvements in mechanical detail and engines of better general design. During the ensuing period of urban service the problems were less those of design than of application. The relation of engine indicated horse-power to boiler horse-power, and to kilowatt rating, all in turn relating to the character of station output, were among the more imperative considerations. Engineering inquiry was directed less critically, perhaps, to the individual feature of steam plant design than to the harmonizing of the component parts, bringing each factor into its proper relative proportion. The lesson was learned that a plant composed of good units was not necessarily a good plant; that the misapplication of unrelated features—however meritorious in themselves—produced poor results. Out of this experience came the systematic correlation of the various elements into well-balanced unity and the establishment of the principles of station design. Meanwhile, simple engines had grown into the multiple expansion types. Steam pressure had risen, vacuum came into more general use and economy was more definitely and insistently sought.

The era of consolidation brought new standards. Sizes increased by leaps and bounds. Long-distance transmission established alternating current, and the engine builder was confronted with the perplexities of operating enormous reciprocating and revolving masses, not only with safety, but with extreme nicety. Apart from the problems of size alone, still higher pressures and greater temperatures were to be met; the maximum uniformity of crank effort was required; compactness was necessary; efficiency of great importance, and the general service conditions more exacting and arduous than ever before. Withal, there seems to have been, in the growth of the steam engine, prompt response to the successive demands upon it, even if it to-day seem to have reached its functional maturity. The problems have softened into those of selection.

Contributary to this progress have been the marked advance in metallurgical processes and methods and the great improvements in machine tools. The one has produced the proper character and requisite uniformity of materials; the other has rendered possible the working of these materials. The strides of twenty years in engine building had not been possible without the development of these co-ordinate branches.

With the appearance of the steam turbine, we find the first radical departure in the character of our prime mover, and with it the departure of many limitations previously insurmountable. Under the refining influence of extended practice, steam plant wastes have been, by every known device and expedient, reduced to the mimimum point. But with all care and ingenuity there remain the abnormal interest and maintenance charges inherently attributable not to the defects but to the character of our reciprocating units. The marked interest which the turbine has created, and its prompt adoption, are evidently due, not to its high steam efficiency, but to its evident commercial efficiency. We see the cost of land, building and foundations reduced. We note in contrast its great simplicity and evident small cost of repair and attendance. We find its first cost comparatively low. We discover its economy to be less dependent upon size or upon character of load, and therefore giving greater flexibility of operation. We observe that it takes but little oil, and that, with no cylinder lubrication, its exhaust is pure and available for reuse. We conclude, in a word, that within its general character are comprehended a number of attributes that will mark new commercial standards in power plant design and operation.

The steam engine is a subject of intense practicality, and its growth and success have drawn from its votaries the most that human effort could yield. But if the path has been devious and the barriers high, achievement has been the recompense. We may be privileged to suppose that the prime mover, whatever its form, will in the future, as in the past, be equal to the demands upon it.

SOME PERSONAL EXPERIENCES

BY FRANK J. SPRAGUE

A REMINISCENT period is that when a paper celebrates the completion of its first score of years, especially when it has done yeoman's work for the promotion of an industry it so fitly represents —that of electric transportation. And so we, whose hands it has upheld, must respond when called upon to tell of some of the milestones we have passed. But I will go back to an earlier date than the birth of the Street Railway Journal, and I find myself, in June, 1878, on my way from the United States Naval Academy at Annapolis, where, under the late Admiral Sampson, I had imbibed some of my earlier scientific training and love for electricity, my head filled with many ideas which I thought might bring fame and fortune. Menlo Park was my immediate destination, and my object to see Mr. Edison and show him a new invention in telephony. Despite the fact that I was a stranger, a kindly reception immediately put me at ease, and a candid criticism, illustrated by a sketch of an alternative scheme, was emphasized when, to more fully satisfy me, I was told to go to the laboratory and experiment for myself.

Before long I was diverted from the paths of invention and suddenly recalled to the duties of my profession by orders to the U. S. S. "Richmond," shortly to sail for the Asiatic squadron, that cruise taking me around the world. For a part of the time I acted as special correspondent for the Boston "Herald," to record the doings of Gen. Grant and the receptions given to him after he had joined our flagship in Eastern waters. But electricity had taken such a hold of my fancy that all during the cruise my messmates were made unwilling victims to listen to explanations of various inventions and to subscribe as witnesses to their understanding of them. Orders for home for examination in the spring of 1880 were very welcome, and the short interval of leave was occupied with attempts to have built a possibly ingenious but impossible sort of motor, the cost of which was prohibitive to my slender income.

Ordered in the fall to the training ship "Minnesota," I found teaching the young idea how to shoot, reef sails and tie knots anything but agreeable work, and both at the Navy Yard in Brooklyn, and later at Newport, I improved every opportunity to put my ideas in metal.

About this time Edison's work with the incandescent lamp was becoming prominent, and with a great aversion to the antiquated methods of lighting aboard our men-of-war, I essayed to make a demonstration of the advantages of the use of electricity on board ship. To that end I proposed to appropriate an old single-cylinder fly-wheel pump, apparently but little used, and to belt it to an Edison "Z" dynamo. When I sought the loan of the machine Edison's answer was very characteristic and illustrative of his hard practical sense, for his refusal was accompanied with the explanation that the motion of the pump engine would be so irregular as to cause flickering of the lights and their certain rejection, thus retarding instead of advancing the introduction of the light on board men-of-war.

At the Stevens Institute shops and the Navy Yard machine shop arc lamps and continuous current machines without commutators were among my earlier and more hopeful attempts at construction, and equally disastrous; but by the time I had arrived in Newport, and had the benefit of association with Prof. Moses G. Farmer, then Government electrician, my ideas had crystallized into something more tangible and possible, and a double-wound armature, with internal field, the several circuits connected to a switch to give various series and parallel combinations, was constructed.

It was at this time, early in 1881, that while watching the action of a large induction coil I conceived the idea of its reversibility, and suggested connecting the high-tension coil to a balloon and the ground, and in case of discharge to get larger currents of low potential from the primary without the circuit breaker. Impractical? Yes, but how near the modern transformer when the oscillating character of the discharge is remembered.

About this time the Paris Exhibition was being organized, and always believing that it was worth while to ask for anything one much wanted (if it be right), I sought orders as assistant to the officer detailed for duty there, only to be refused, but to have, by chance, an alternative pointed out—to get orders to the "Lancaster," soon then to leave for duty as flagship on the Mediterranean squadron, with leave, at my own expense, upon my arrival abroad.

Armed with a letter from Prof. Farmer and Lieut.-Commander Caldwell, in charge of the equipment at Newport, I obtained the coveted orders, the beginning of the end of my naval career. There being the usual delay in getting away, I soon occupied myself with schemes for installing a system of bells on board ship, and this kept me busy until our arrival out. Candor compels me to admit that neither material nor workmanship was up to modern standards, and before long it was a question whether the captain was calling the first lieutenant or the cook.

Owing to our delay in arriving I found the exhibition closed, but another was to be opened the beginning of the following year at the Crystal Palace at Sydenham, England, so I applied, with whatever eloquence I could command, for orders there. After a long period of suspense, approaching the end of my leave as well as my pocketbook, I was finally made happy by their receipt, and landed in England with a capital of $20 and a fund of youthful confidence. The kindly offices of the United States despatch agent saved me from my embarrassment of riches, and presenting myself to the necessary officials, I was made a member of the Jury of Awards, being at my request put on that section having to do with dynamo-electric machinery. Among my confreres were many men of science whose names have become of world renown, among them Prof. Fleming Jenkin, of Edinburgh University, inventor of telpherage; Capt. Abney, the great photographic expert; Prof. Adams, of the Wheatstone Laboratory, King's College, brother of Charles Adams, one of the mathematical discoverers of Neptune; Horace Darwin, son of the great naturalist; Prof. Frankland, C. E. Spagnoletti and others. On motion of Prof. Jenkin, I—being the youngest member present—was made secretary. I promptly decided to improve the occasion by getting my orders extended, and organized a series of tests of dynamos, incandescent lamps and gas engines, the most comprehensive which had up to that time been undertaken.

In the entire exhibition there was nothing which so impressed me as Edison's work, and in connection with this I was brought into contact with E. H. Johnson, whose buoyant belief in the work of his principal, coupled with my admiration for what had been accomplished, made me an ardent convert to the Edison system. My interest in this, the conducting of the experimental work for the jury, extending as it did after the close of the exhibition, and the preparation of a report led to a very liberal interpretation of my orders, and it was with something of a shock that I received a sharp reminder from the Navy Department, with imperative orders to at once rejoin my ship at Naples, where I went with visions of court-martial and possible ultimate disgrace. Fortunately, however, the explanation which I had sent to the department, supported by a letter from Prof. Adams, proved satisfactory, and I received permission to remain in London, but as funds were still anything but plentiful, I decided to complete my work on board ship. The filing of the report was followed by a letter of commendation from the Secretary, and its publication by the Bureau of Naval Intelligence.

It was evident, however, that ship life in time of peace would always prove irksome, and my love for electricity was growing apace. So when the cruise took us back to the English Channel in the spring of 1883, I passed my examination for ensign on board ship, and having received an offer from Johnson to go into Mr. Edison's employ, I applied for a year's leave and resigned.

I almost immediately reported upon the three-wire system of distribution, invented independently and almost simultaneously by Edison and Dr. John Hopkinson, and also tested the "Manchester" dynamo, the first machine built under the direction of Hopkinson to improve upon the old Edison long core "Z."

It was while thus abroad, in 1882, that I was required to travel much upon the underground railway in London, and my attention having been called to the possibilities of electric railways, I was so greatly impressed with the special desirability of operating that particular road that I seriously contemplated resigning from the navy and remaining in London to see if it were not possible to effect this result. The plan of distribution which ultimately seemed most feasible, especially in view of the multiplicity of tracks and switches at stations like the Kensington, was to consider a train as traveling between two planes, making upper and lower contact with them, these planes being the termini of a constant potential system of distribution, one to be replaced, in practice, by the running tracks, switches and sidings, and the other by a center overhead rail following the central lines of all tracks and switches, contact being made on the one by the wheels and with the other by a universal spring supported device. This may be fairly considered as one of the early forerunners of the modern trolley.

May of 1883 found me back in the United States, and my first interview with Mr. Edison as my employer. I was soon sent with W. S. Andrews to Sunbury, Pa., to get ready the first overhead three-wire plant. To me getting ready meant trial as well, and so the night before the Fourth of July an Armington-Sims high-speed engine was started and current was delivered to the line. Sight feed oil cups were then something of a novelty, and having run some hours with little or no oil, we managed to burn out the babbitts, and despite diligent scraping by a local machinist, Mr. Edison when he arrived the next morning with his secretary and chief engineer found a badly pounding engine. I pass by the comments excited by my assumption of responsibility, but the plant continued to run.

For a time, however, I was not in entire favor with the "construction department," which was then busily engaged in laying out small models of the assumed lighting requirements of various towns and trying to determine the proper size of mains and feeders. It was tedious and unsatisfactory work, and at the instance of Johnson, I took up the question of the mathematical determination of the necessary elements. My

Naval Academy training stood me in good stead here, and I had soon found a plan by means of which all the determinations could be made in a few hours, and although the summer was spent in charge of the first underground three-wire station at Brockton, Mass., I was still employed in distribution calculations.

By this time I began to foresee the possibilities of stationary motor work, and began the construction of a sectional field motor. Some time after, Mr. Edison asked me to take up calculations in the matter of long distance transmission of power. I declined in a long letter citing my personal ambitions which was replied to by a short note to the effect that as the construction department was about to be given up I would better resign. So I did, and with Mr. Johnson's encouragement organized the Sprague Electric Railway & Motor Company. A curious company this—purely a paper one for a long time, of $100,000 nominal capital, of which sixteen shares

EARLY SPRAGUE ROAD AT LAFAYETTE

were sold for cash and the balance issued to me under a contract by which I undertook to turn over inventions, and also to be vice-president and general manager, and about everything else that a company can employ. My self-imposed duties made me treasurer, salesman, electrician, wireman and bookkeeper, and, in addition, I was to pay myself $2,500 per year salary. To meet the requirements of this contract I promptly agreed with Johnson that he was to advance a certain amount of money for a certain percentage of my interest, and for a further advance to receive an additional interest. This latter agreement, although never signed, was faithfully lived up to by both parties.

The Philadelphia Exhibition in the fall of 1884 was an opportunity to exhibit quite a variety of motors, among others constant-speed motors with differential fields and fixed points of commutation, concerning the principles of which I was shortly involved in a discussion with English scientists. The business of the company for the first two years was the construction and installation of stationary motors, principally for use on Edison constant-potential circuits, 250 of them being in that time put in operation. Prior to this, with the exception of the pioneer work which had been done by Mr. Daft, there were few motors applied to industrial purposes other than the small ones used for sewing machines and similar work, and so necessary was public education that in the first catalogues published by the Sprague Company, the number, owner, locality and duty, followed by statements from the users, identified every machine which had been put out.

Meanwhile my interest in the electric railway problem had become active, and after a study of the movement of trains and the conditions of operation upon the Manhattan Elevated, I schemed out a system, and in December of 1885 read a paper before the Society of Arts in Boston, advocating an equipment with motors under each car, and using shunt-wound machines to enable current to be returned to the line when decreasing from the higher to more moderate speeds. The construction of motors was also begun at the Brown & Sharpe Company in Providence, and at the Edison Machine Works in New York.

About this time the Electric Railway Company of the United States, representing the combination of the Field and Edison interests, had leased a portion of the Durant Sugar Refinery in East Twenty-Fourth Street, New York, and installed a battery of five or six Edison machines, coupled up in series to get 600 volts potential, and laid a track between the walls of two adjacent buildings. The work of that company for the time being suspended, Mr. Johnson made arrangements for the prosecution of my own experiments in the same place. I soon had two motors mounted on an elevated railway truck and put under a flat-bottomed car, with which a number of demonstrations were made—visited at various times by the Field and Gould interests and others connected with the elevated railway. Too much confidence may have been the indirect cause of subsequent lack of interest by the owners of that road, for on one occasion when Mr. Jay Gould was standing on the car I attempted a somewhat unusual rapidity of control, with the result of failure of the safety catch, much to his alarm, and the explanation of its purpose apparently was not sufficient to reconcile in his mind the idea of safety and a small electric volcano. At least, neither then, nor in the experiments which followed, was he apparently ever again interested.

Somewhat satisfied with the results achieved, however, I was one day sitting in the office at 65 Fifth Avenue when Superintendent Chinnock, of the Edison station in New York, brought a proposition to buy a sixth of my interest for $30,000; his arguments were unanswerable, but his surprise and methods of criticism somewhat uncomplimentary when I declined the offer, although at the time I probably did not have enough to pay my board bill for a month. Having gone off for a short rest, I was one Friday summoned to New York by a telegram from Johnson saying that he had promised Cyrus Field that on the following Tuesday he would show an electric car in operation on the elevated railroad. How we got together car body, truck and machines and completed a regulator, in face of a strike, and assembled them all by Monday night on the elevated railroad, is more than I can at present tell, but that night found me with my faithful assistants, McPherson and Crawford, by candle light making all the connections necessary to operate two machines at 600 volts potential by duplicate switches at each end of the car, and to brake the car as well, with no way way of testing the apparatus or to ascertain the correctness of any connection. At 1 o'clock the next day there was an expectant crowd on the Thirty-Fourth Street platform, among whom were many men of prominence. While waiting for current half an hour passed with no evidence of "anything doing," save under my breath, and there Johnson was the object of many an earnest anathema for his strenuosity, for I did not know whether either machine would turn over, or whether, if they did so, they would operate alike—in short, everything was in the air. Finally, when current was put on the line I first tried one machine and then the other, but with no movement in response. Finally, in sheer desperation, I threw both machines into circuit, moved the regulator, and the car responded perfectly. For two hours every feat which could be tried with the machines was attempted without a failure. It was with something of relief that I finally saw the car deserted, and, exhausted by the exciting experiences through which I had passed, I sat pondering over the day's results, when Chinnock again came to me, apparently much impressed with what he had seen, and this time offered $25,000 for a one-twelfth interest. I did not much care one way or the other, but he finally got it, and a few weeks later the other twelfth went to some one else for $26,250.

The result of the day's work determined Johnson and me to continue the experiments, and they were not terminated until December of that year; but in all those months, so far as I remember, not a director or stockholder of the Manhattan road ever took the slightest interest in what was being done.

During the summer the first pair of motors was supplemented by a second set, and in addition to metal resistances water rheostats were also tried.

The machines used on these experiments may be termed the parent models of the modern railway motor. They were centered through brackets on the driving axles and suspended at the free end by springs from the transom, the elliptic springs being interposed between this support and the car body. The motors were single-geared to the axles, had one set of tilting brushes, were run open, and they were used not only for propelling the car but for braking it. At first shunt wound, increase of speed being first accomplished by cutting out armature resistance and then inserting the resistance in the field, there was added later a correcting coil in series with the armature at right angles to the normal field to prevent shifting at the neutral point.

One of the motors was put into service at the East Boston Sugar Refinery, the current being supplied from a trolley carried on an overhead wire, and is, or at least was a few months ago, still in existence. Two others, with Pat O'Shaughnessy and me at the helm, operated a snow sweeper and ice cutter on the Alston division of the West End Railway Company in Boston, in 1888, but have gone the ultimate way of all good motors.

THE FIRST SPRAGUE ROAD IN NEW ENGLAND, AT THE BOSTON SUGAR REFINERY

Like the others who had attempted work on the Manhattan, I was evidently ahead of the times, although I was not sufficiently discouraged but that I immediately began the construction, on the suggestion of J. H. Vail, of a locomotive car to be equipped with four 75-hp motors, each with double armatures. But the elevated field offering little of promise, I soon turned my attention to tramway work, and began the development of the type of motor finally used in Richmond, one earlier form being used in Julien storage-battery experiments in Philadelphia, and others in New York and Boston.

A paragraph in the New York "Sun" about August, 1887, seems curious reading to-day. It was in part as follows:

"ELECTRICITY ON WHEELS

They tried an electric car on Fourth Avenue yesterday. It created an amount of surprise and consternation from Thirty-Second Street to 117th Street that was something like that caused by the first steamboat on the Hudson. Small boys yelled 'dynamite' and 'rats,' and made similar appreciative remarks until they were hoarse. Newly appointed policemen debated arresting it, but went no further. The car horses which were met on the other track kicked without exception, as was natural, over an invention which threatens to relegate them to a sausage factory."

EARLY SPRAGUE ROAD AT SALEM, MASS.

In the calendar of the electric railway 1887 marked an epoch, for although in 1879, at the Berlin Exposition, Messrs. Siemens & Halske had constructed a short line, which was followed by other exhibitions, and a one-car line at Lichterfelde in 1881, the succeeding six years found the art still essentially in an experimental and chaotic condition, while throughout the world, including every kind of equipment, there were fewer than a score of installations, three-score miles of track, and about one hundred motors and motor cars. The roads, however, were limited in character, varied in motor equipment and power distribution, and presented no acceptable type or comprehensiveness of design sufficient to overcome the prejudices of those interested in transportation, or to command the confidence of capital. But the work of many inventors — Siemens, Edison, Field, Daft, Van Depoele and others—as well as the developments taking place in the distribution of power and the application of electricity to stationary motor works and the recognized needs of transportation had brought about a condition ripe for a great development. The interest of my associates and myself was keenly aroused, and the actual success of the experiments on the elevated railroad and with storage-battery equipments, and in the installation of stationary motors, had begot a confidence in undertaking the larger problem.

The first tramway contract by the Sprague Company was one at St. Joseph, Mo., which was followed almost immediately by one with the New York syndicate which had secured the rights for installing an electric railway in the city of Richmond, Va. This latter contract was for a road the rails of which were not yet laid, and included a complete generating station, the erection of overhead lines and feeders, and the equipment of forty cars each with two 7½-hp motors, on plans largely new and untried. The road presented conditions of length, curves, character of roadbed and number of cars to be operated, which, if

EARLY SPRAGUE ROAD AT EAST CLEVELAND

successfully overcome, would mark a new era in electric traction, and hence our ambition. There were 12 miles of track, twenty-nine curves, with a maximum grade of 10 per cent, and a foundation of Virginia clay. The contract was one which ordinarily no sane man would make, for we undertook to erect the complete equipment in a period of ninety days, for which we were to receive $110,000 in cash, "if satisfactory." The Sprague Company had managed to fortify itself with some capital, and I was fortunate enough to have the hearty co-operation of Mr. Johnson and Mr. Harding, as well as the technical assistance of Lieut. Oscar T. Crosby and Ensign S. Dana Greene, who resigned, respectively, from the army and navy to cast their lot with the new development. Typhoid fever took me out of the active direction of the work for a period of two months, and left the brunt of it upon my associates, but on my return I had the satisfaction of seeing Dave Mason run a car on the track at St. Joseph, Mo., in August, 1887, and soon thereafter active progress toward equipment at Richmond. Experimental running was begun there toward the latter part of the year, and in February, 1888, the road was put into commercial operation. The trials and disappointments, the alternate successes and failures, the hopes and fears which went with this road have been often told. This original equipment long ago served its purpose, and was replaced by more modern and powerful apparatus, but Richmond, by common consent, stands as that pioneer road which more than any other was influential in creating the industry of the electric railway as it stands to-day.

Briefly summarized, its general features were as follows: Distribution by single overhead line over the center of the track, reinforced by a continuous main conductor, supplied in turn at distributing centers by feeders from a constant potential plant operated at about 450 volts. The tracks were reinforced and grounded, and constituted the return. The current was taken from the overhead line, at first by contacts pressed vertically upwards, and subsequently by a trolley wheel carried on a polé over the center of the car and having universal movement. There were two motors on each car, centered on the axles, and flexibly supported at their free ends. The gearing was at first single, and then double reduction. The motors were therefore individually free to follow variations of axle movements, and yet maintain at all times absolute parallelism of armature shafts with car axles and a yielding touch upon the gears. All the weight of the car was available for traction, and it could be operated in either direction from either end. The controlling system was at first by graded resistances through variation of field coils, and also by series-parallel control of armatures with a separate switch. Fixed brushes were used for both directions of movement—at first laminated ones at an angle, and later solid end-on metallic ones, replaced on the new equipments by carbon, as originally adopted by Van Depoele.

The fate of the Richmond road, both technically and financially, lay for a long time in the balance. The road cost at least $150,000, and the company got in the end about $80,000, all essentials being time and again rebuilt. During the progress of this installation the Van Depoele Company was offered to me by William J. Clark, but partly because of confidence in my own work, as well as lack of appreciation of what Van Depoele was doing—to say nothing of the need for every dollar we had to carry out work already taxing our resources to the limit—it was not long considered, and shortly afterward fell into the hands of the Thomson-Houston Company, which had only a short time previously entered the railway field. The rivalry of these two companies is something well remembered by all engaged in active work at that time, but it had one good result in that it put the engineers of the companies on their mettle to build the best they knew, and the virtues of the electric railway were sounded in the ears of every transportation man alive. Few industrial developments have been so rapid and have had results so marked as that of the electric railway, and it would be idle to predict its ultimate limitations.

The Sprague Electric Railway & Motor Company, although operating a small factory, depended largely upon the contracts made with the Edison General Electric Company for its equipments, a result hardly satisfactory to either party; but for the time being this seemed to be the only possible arrangement because of certain official relations which existed, and because the growth of the business was so rapid that even the increased capital of the Sprague Company was not able to take care of it, even without the additional burden of maintaining a large factory. This need of capital continued, and a considerable sum was supplied by the Edison Company when it saw the great future of the electric railway. The natural consequence, in a short time, was the absorption of the Sprague Company, and the end of its independent existence.

Looking back, I cannot even now think that this was the best outcome for those identified with it or for the art, for soon afterward it was given out that the overhead system, especially in the larger towns and cities, would largely be supplanted by a system of supply through the running rails at very low potential, on a plan devised by Mr. Edison, and radical departures were attempted in motor construction. For personal reasons the Sprague name was drastically wiped off from every piece of apparatus and another substituted for it, while men who had been largely active in the creation of the industry were thrust aside. A wiser policy and better management on the part of the Thomson-Houston Company, and activity on the part of the Westinghouse Company through some of the men who had helped create the commercial business of the Sprague Company, quickly won a foothold which made the fight for business a keen and bitter one, and to a certain extent for the Edison Company a losing one. The position of the latter company in the incandescent lighting field, however, was strong, and there soon followed a combination by which the Thomson-Houston interests became more influential in a new company, the General Electric.

The experience was for me a bitter one, but I soon undertook, with Charles Pratt, the experimental development of a high-speed screw electric elevator, and then of the elevator in various forms. Hard as was the Richmond work, I was not quite prepared for the variety of difficulties, both technical and business, that confronted me when I undertook to overturn the hydraulic elevator industry, firmly established as it had become in the minds of conservative capital, and promoted by what was practically a number of close corporations working in harmony—or, if not in harmony, at least all against the development which I undertook.

But a new organization, the Sprague Electric Elevator Company, took up the work after I had made an experimental demonstration in a loft in New York City, and at a small hotel, where the first installation, somewhat modified, is still in operation. But it was some time after that I made the really first important contract—that for six elevators at the Postal Telegraph Building, where in George Harding, the architect, and John Mackay, the owner, I found liberality of view and courage of conviction enough to accept my offer to install the plant on condition that if it should prove unsuccessful I would replace it with any type of hydraulic equipment which they might select. This Postal Telegraph experience was a somewhat wakeful one also, for every machine had to be rebuilt while in operation, and for weeks it was doubtful whether the outcome would be a success. It was really the beginning, on any scale, of pilot control of large electrical apparatus now so widely used, and in one sense the beginning of the multiple-unit system, for having interconnected the controlling circuits in the basement, with provision to throw any or all machines on to a common master switch, I undertook one day to run a number of elevators simultaneously from one controller. The result may be imagined, for on account of the lack of automatic control of current input or speed of main controllers, I soon had the battery of elevators executing a series of terpsichorean feats the like of which has probably never been seen.

The elevator contest with the Otis, Crane, Whittier and other companies was carried on with a vigor worthy perhaps of a better cause, and extended from one end of the country to the other, until the whole business was in a more or less demoralized condition, boding no good to any one. The result was the usual one—the separation of the elevator business and the turning of it over to an alliance of interests.

Meanwhile, although out of electric railway manufacturing, and having no voice in its management, my interest was by no means ended, and I took up cudgels in favor of underground rapid transit in New York City, based upon electric operation. About this time (1890-91) the Board of Rapid Transit Commissioners of New York was considering tentatively various plans, but it seemed to me more than anything else possible extensions of privileges to the Manhattan Elevated, or the construction of other elevated or viaduct lines. I was a believer in the Greathead system of tunneling, but more than anything else in the ultimate supremacy of electric operation, and the vital necessity of determining the element of motive power before any other affirmative conclusion whatever was reached. This conviction I voiced in a long interview in the "Commercial Advertiser," Feb. 16, 1891, in which I advocated a four-track independent way and express tunnel service, and added that the use of electricity as a motive should be a *sine qua non*, and that this agent being capable of satisfying in the highest degree the most exacting demands of service, the system should be planned with special reference to its use.

On March 15, in the same year, I addressed a letter to the Rapid Transit Commission, of which Wm. Steinway was then chairman, setting forth my views on the requirements for underground electric traction for New York City, advocating first, an underground system of tubular construction, and second, the adoption of electricity as a motive power. In order to emphasize my views, I closed with the following statement:

EARLY SPRAGUE ROAD AT CINCINNATI

"I repeat, there need be no hesitation on the part of your Board on the question of electric traction because of any apprehension that the electric motor development will be found wanting when demanded.

"On the City & South London Road the entire central station and electric equipment was finished before the tunnel was ready for use, notwithstanding the fact that when the tunnel was originally designed a cable was intended for the motive power.

"But I will go further than mere assertion that the required development will take place, and I will, so far as may be, determine the matter by reference to that criterion which alone governs almost all decisions of this character, the possibly hard, but the entirely just one, of dollars and cents, for I am ready, if a rapid transit system be adopted requiring the use of the electric motor, to undertake the entire contract for the necessary steam and electrical equipment for not less than fifty way and express trains operated as I have outlined, under satisfactory guarantees of efficiency and cost of operation as compared with steam practice."

This was followed in May by a paper before the American Institute of Electrical Engineers, reviewing the considerations which should govern the selection of a rapid transit system for the city.

For a long time Mr. Gould, who was the controlling owner of the Manhattan, and other interests connecting with it had been opposing any grants whatever except in the nature of extensions of the elevated, and then only under such conditions as were satisfactory to themselves. One of the most serious proposals, and one for some time seriously considered, was for a main line directly up Broadway and the Boulevard for a good portion of their length. I could not but view this desecration of the city with alarm, and as the New York "Sun" was voicing the views of the opponents of an underground road, and ridiculing its construction, to clinch the argument which I had made to the Rapid Transit Commission, which had now expressed itself as favoring an underground railway with electrical equipment, in February, 1893, I published in the "Evening Post" a communication which is here reproduced in full:

"DEEP TUNNEL ELECTRIC MOTORS

The Rapid Transit Commission of New York recently announced a decision in regard to route, construction and motive power which was founded on extensive investigation, provided well for the future growth of the city, and met with general commendation.

Since this decision was made, its wisdom has in certain quarters, presumably representing existing corporate interests, been most industriously attacked, and one of the principal criticisms has been that upon motive power. So far as these relate to any form of propulsion other than electric they are sound, but when directed against that particular method they are not so.

These criticisms are unquestionably dictated by one of two reasons; either they are intended to make the raising of capital for the new enterprise difficult by assailing the soundness of facts, in which case all argument is useless, or they are founded on a real belief in the inability of electric motors to do the work required.

The form that this comment has taken is that there is no electric motor yet "invented" which can propel even one loaded elevated car 30 miles an hour. The objection thus embodied can be easily disposed of if those making it are firm enough in their belief to put it to practical test. It is, of course, essential before money is subscribed for the new road that confidence should exist that electric motors can do what is claimed for them, and it may be necessary to make an actual demonstration on a large scale without committing the construction company to be subsequently formed to any particular system.

Having been somewhat actively identified with the development of electric railways in this country, and having urged upon the Commission the necessity of electric propulsion, I am entirely ready to make a demonstration as follows:

Let a section 2 miles long be provided on the Second Avenue, the Suburban, or the New York & Northern Railway, which shall fairly represent a station section of the express track on the proposed underground road, for use at night when not required for regular traffic.

Set apart a train of six standard elevated cars. These will weigh when empty 71 tons, and can carry when crowded to the utmost about 500 passengers weighing 37 tons, making a net weight of train without motive power of 108 tons.

Let this loaded six-car train be propelled in two ways:

1. By a separate electric locomotive.

2. By a system of motors, one on each track, all controlled from a pilot locomotive.

Let the condition of operation be:

1. A maximum speed of not less than 40 miles per hour on a level.

2. Power to stop the train without the use of brake-shoes and independently of the main station current.

These requirements both as to weight and speed are double those now characterizing the operation of the London road, and represent a capacity of eight times that mentioned in the criticism.

I will undertake to make this demonstration prior to the formation of a construction company, with free subsequent competition for regular equipment under either of these conditions:

1. The Rapid Transit Commission to require the successful bidder for the franchise to pay the costs of the experiment to an amount not exceeding $50,000.

2. The forfeiture of a like sum in case I succeed within a specified time, by any person or newspaper that will take up my challenge.

3. On the other hand, entire loss to me if I fail.

4. The time to be four months from acceptance of this proposal, barring labor troubles, with one month leeway, at a forfeiture to me of $1,000 a day for each day of the month over four months, and premium of like amount for every day under four months. If the cost of the experiment be less than $50,000, the saving to go to the benefit of whoever pays for the demonstration.

It will be noted that this experiment is entirely at my personal risk, with time limitation, and without any direct pecuniary value to me, but is proposed to demonstrate the soundness of the decision made. As an evidence of my faith I am ready to deposit a sum which will guarantee the good faith of this proposal."

Whatever other effect, I think this proposal was of some service in brushing away the objections on the score of motive power, but the claims on behalf of Manhattan extensions were assiduously pushed, rapidity of construction being one of the most telling arguments in view of the congested condition of traffic. For a time it seemed that the difficulty in financing an underground road would prove insuperable, and action was taken which opened the way for the elevated if terms with the city could be agreed on. Meanwhile my interest in electric railroads had been reborn with a rush because of a sudden conception which was the direct result of the work which for five years I had been doing with indirect control in elevator work, and from that moment the "multiple-unit" system, fulfilling completely the idea of individual car equipments under a common control, became of absorbing interest.

The first experiment was made with a number of sidewalk elevator machines, which were assembled together in a quasi train arrangement, and their controllers connected by relays, secondary circuits and couplers, with master switches from any of which all the machines could be operated.

Although eight years had passed since the Richmond road had been put into commercial operation, and electric traction on tramways had become world wide, electric train operation was little known, and, then, as a rule, only where a locomotive car or electric locomotive performed the function of a steam locomotive and hauled a number of trailers, as on the Metropolitan and Lake Street Elevated in Chicago and the City & South London in England. No sooner was the new idea fairly matured in my mind than my ambition reverted to the early scene of my experimental work—the Manhattan, and on June 6, 1896, I addressed the special committee of the road in part as follows:

Gentlemen: Assuming that the recent decision of the Appellate Division of the Supreme Court in the matter of the report of the Commissioners makes certain a material extension of the Manhattan system, and that the adoption of a new motive power on the present, as well as on new lines is now open for consideration, I shall be glad to appear before your Board to make in a definite manner a proposition either in connection with the Manhattan Company, or entirely independent through myself and some associates, for a serious demonstration on the Ninth Avenue, or some other division of an electric equipment having the following general characteristics:

1. So much double track with sidings and switches, and selected as to grade as to give the severest test, will be supplied with current.

2. Five cars will be individually equipped with a reduced amount of standard apparatus without change in the cars except one truck on each.

3. The motors will have capacity to handle the cars at express speeds.

4. The electrical pressure, the character of current and the type of machines will be such as have been tested and found practicable on over 700 street railways.

5. Each car will be provided with a special control which permits of it being operated from either end at will, or for the operation at either end of a train composed of from one to five cars in any required combination and without regard to their sequence.

6. The cars will be provided with automatic control so that they will be self-braking in case of an accident to an operator or failure of current.

You will note that the system departs from the locomotive plan of operation and affords what is essential for the best results, namely: the opportunity to keep train intervals at the shortest possible limit, with train lengths varying at will in proportion to the traffic demands, and it will have the following results:

Train lengths of from one to any number of cars controlled at will from either end of any car, and made up at any section or branch of the road; reduction of train intervals at certain portions of the day and night to one-third or fourth the present intervals; a reduction of about $1,000 a day in the coal account compared with the present system; a far more even distribution of load than can be provided with any locomotive train system; a reduction of fully one-third in deflection and shearing strains; a material reduction in longitudinal vibration and in depreciation of sleepers and superstructure; the abolition of head and tail locomotive switching, giving material increase of rapidity in despatching trains, and greater effectiveness of sidings for car storage; a marked increase in the number of passengers carried; provision for lighting and for such elevator service as some stations may require from the same source of power.

In short, a very large return on the capital required for a change of motive power.

On completion of this demonstration I shall be prepared to make a bid for the electric equipment of any part or the whole of the present or extended system in its entirety.

This letter apparently fell on incredulous ears, for it met with no response, but eight months later, on Feb. 18, 1897, I addressed them another letter, giving further arguments, and repeating my proposals, except increasing the demonstration train length from five to eight cars.

This letter met with a similar fate, and finding my philanthropic efforts unappreciated, I desisted for a time from frontal attacks, and busied myself with the elevator business to which I was financially deeply committed.

Meanwhile, the Central London Railway had been projected for electrical operation—this road to run from the Bank to Shepherd's Bush in London. An essential of this equipment—for this was a deep tunnel scheme—was the installation of a large number of lifts of great carrying capacity and considerable extent of run. My attention being called to it by Mr. Mackay, I was requested to go to London to see if it were possible to get the contract—one amounting to nearly half a million dollars.

About this time I had met with a severe accident, and a fire threatened the shops of the company. After straightening out matters as well as I could, just as I was about to sail I received a communication requesting me to act as consulting engineer for the South Side Elevated Railway in Chicago, to revise the plans of its regular engineers. I was unwilling to burden myself with the additional work, but after returning what might have been called an evasive reply, I was surprised by a visit from an old friend, Fred Sargent, with the information that he and A. D. Lundy, formerly associated with me in Richmond, were the engineers, and it was their desire that I should go over the plans. A short inspection of the layout instantly showed a field ripe for multiple-unit application, which I briefly explained to Sargent and to Mr. Clark, of the General Electric. I hastily drew up a report, the main feature of which was an argument in favor of abandonment of locomotive car schemes and the adoption of individual equipments under common control—in short, the "multiple-unit" system. As an earnest of my sincerity and confidence, I supplemented the report by an offer to undertake the equipment on the general plan outlined, which met with the indorsement of the engineers. This was followed by a visit to Chicago, but the contract was not concluded before I was obliged to return to New York.

My plans being opposed to those which had been submitted by the General Electric, Westinghouse and Short companies, I found myself with a lively contest on hand, which was illuminated by some hours of engineering discussion over a private wire direct from the main operating rooms of the Postal Telegraph Company to that of its manager in Chicago.

The main contention which finally arose was in the matter of speed. I had guaranteed, among other things, a regular schedule of 15 miles, including stops, and the equipment I proposed averaged 100-hp per car, with 62 per cent of the total weight on the drivers. The Westinghouse Company's agent promptly undertook with the same horse-power, consolidated upon a single car, and with but 25 per cent of the total train weight on the drivers, to guarantee 18 miles. The difference was so marked that for a time I failed to convince President Carter, of the absurdity of the claim of being able to make the higher schedule under the conditions named, and I declined to make it even under the more favorable conditions of distributed motors and with the increased percentage of driver weight offered by the multiple-unit system. But time was pressing, and I called one of my assistants, Mr. McKay, loaded him with data on accelerations, motor capacities and what not, and despatched him to Chicago with orders to kill that 18-mile schedule beyond resurrection. I believe he left on a Sunday, and I was booked to sail for Europe on Thursday. On Wednesday night I received a telegram from Mr. Carter, saying that he would accept the schedule which I had guaranteed and make a contract based upon my proposal, but that he wanted a $100,000 bond to guarantee performance. I wired back that I was leaving for Europe in the morning, but that I would give the bond on my return.

The contract itself, although based on my original proposal, I never saw until it was finally executed under power of attorney by McKay, but as it was drawn up by the engineers of the company, under the able supervision of its president and counsel, it can be well imagined that the technical conditions were no less severe than I had myself proposed, and the financial and other requirements governing the execution of the contract were somewhat in favor of the company. The contract was a personal one with me, and among other things, I was to immediately begin work on the entire equipment, and to have six cars ready for operation by July 15, 1897, on a standard track supplied by me, the manner of making the test to be prescribed by the officers and engineers of the road, and to be to their entire satisfaction. Should the test be not concluded by the date set, or be unsatisfactory, the contract could be canceled. Satisfactory further tests could be called for elsewhere, and the remaining equipments were to be completed by specified dates. As soon as the power house and road were ready there was to be another test of not less than twenty equipments under severe conditions for a period of not less than ten days. Should these equipments prove unsatisfactory to the officers and engineers the right still remained to cancel the contract, and to require a waiver of all claims against the company. Under existing conditions it was necessary to accept the contract in the form offered, and while the installation, from the contractor's standpoint, was similar to Richmond in the immediate outcome, the results in the art were of almost equal importance.

It was impossible before leaving to do much to forward the work, and I was detained in London on the elevator contract, which I only received finally after offering to guarantee the cost per thousand trips, and staking the entire contract upon the successful outcome of trial elevators erected in place, the engineer, Sir Benjamin Baker, to be the sole judge of performance—all under a heavy weekly forfeiture.

I did not return to New York until the middle of June, so that most of my instructions for the trial equipments were by cable, and the actual preparation was made within thirty days despite a wholesale strike of the machinists in the shops of the Sprague Company, which soon took over the contract.

On July 16 two cars were put into operation on the tracks of the General Electric Company at Schenectady, and on the 26th, the half-century anniversary of Prof. Farmer's test of a model electric railway at Dover, N. H., my ten-year-old son, D'Esmonde, operated a six-car train in the presence of the officers and engineers of the South Side Elevated Road.

In November, a test train of five cars was put in operation in Chicago, and on the 20th of April following, twenty cars were put into initial operation, seventeen of which, one in flames, were taken off by me during the day because of defective rheostats, but I had the satisfaction with the last three-car train of pushing a steam train around a curve. Three months later, a year after the Schenectady test, locomotives had been entirely abandoned, the local work being largely supervised by my assistant, Frank Shepard.

No sooner had the test train in Chicago established the multiple-unit idea than I returned to the attack on the Manhattan Elevated and renewed the campaign of education. On Dec. 13, 1897, I addressed a letter to President George Gould, calling attention to the published accounts of the Chicago work and, requesting an interview, asked "if, after investigation of what has been done, the Manhattan Company will be inclined to entertain a proposition for the entire electrical equipment of its system, from power house to motors, for a price based in part upon a capitalization of the actual saving accomplished in coal and depreciation, or cost per passenger carried."

This excited no particular interest, and a week later I requested a visit to Chicago of officials, engineers or experts, but I went back alone.

About this time the newspapers were filled with various accounts of what the Manhattan was going to do, the plans being apparently based upon the locomotive car idea. It seemed necessary that I should at least again put myself on record, and so on Jan. 12, 1898, I sent them another letter in which I entered at length into a general discussion of the Manhattan needs, especially directing my arguments against the plan under consideration. Following my practice of backing settled conviction to the limit of my capacity, the letter closed with the following proposition:

Whatever your decision, however, in the matter of consultation, selection of dynamos or make of motors, and without unnecessary argument, we are prepared to install any part or the whole of an individualized equipment, and as against any possible locomotive car plan, on the same rails and with the same dynamos back of us, and using your present cars modified to meet the conditions, operate in any combination of from one to eight or ten cars, and with any condition of rails, under the following guarantees:

1. The lowest maximum speed with a given schedule.
2. The highest schedule speed with any given maximum.
3. The lowest expenditure of coal per car-mile.
4. The lowest cost per car-mile, all things considered.
5. The least shearing and deflection strains on the structure.
6. The quickest acceleration for any train combination.
7. The most effective and powerful braking system.
8. Equal acceleration, speed, smoothness of movement and equality of work, whatever the number of cars in a train.
9. The installation of such an equipment in the shortest possible time.

But the Manhattan Company was evidently far more concerned in efforts to obtain increased privileges than they were in the electric equipment of the road, and were actively flirting with both the Rapid Transit Commission and the political powers that were, in the hope of securing its extension and delaying the construction of an underground road, with the result that on April 1, 1898, I addressed the following latter to John H. Starin, the chairman of the contract committee of the Rapid Transit Commission:

Dear Sir: In all the published accounts on the subject of the negotiations between the Commission and the Manhatan Elevated Company, as well as with anyone else, one of the most important essentials seems to be entirely ignored. Routes, structures, rights of way and penalties are all considered, but the one thing which would do more to relieve congestion does not seem to be insisted upon, and that is the question of motive power.

The time has passed when there could be any question as to the advisability of adandoning steam and adopting electricity, and by this agent, and this alone, can the essentials of cleanliness, reduction of noise, smoothness of operation, and what is most important of all, increase of schedule speed, be obtained.

The elevated railroads now make on way trains a schedule speed of not exceeding 12 miles an hour, including stops, when running with loaded trains. It is possible to increase this to 18 miles or about 18½ miles, although that is the absolute maximum with station stops as they now exist, but 16½ miles is within the range of practical, reasonable demand.

It would seem, therefore, perfectly proper that the following conditions should be introduced in the granting of any franchise of any kind whatsoever, and to whatsoever company:

1. That there shall be a change from steam to electricity.
2. That there shall be a schedule speed, including stops at each station, of not less than 16½ miles, whatever the length of the train.
3. That there shall be a schedule speed, including stops at limited stations, of express trains of not less than 30 miles an hour.

The above conditions can be met, and it is only reasonable to expect that these increased speeds should be supplied by the railway company if they receive additional privileges.

It is worthy of note that the schedules suggested in this letter were those adopted when the underground speeifications were issued, although on account of the length of trains and sharp curves the express schedule will probably not be maintained above 25 miles.

Meanwhile the Brooklyn and Boston elevated roads had adopted the multiple-unit system, the latter under most difficult conditions, the stock of the South Side had trebled in value and the logic of events compelled action on the part of the Manhattan Company. Eighteen million dollars was provided for betterments and equipment, but by some curious obduracy certain influences were, however, effective for the time being in blocking the adoption of the multiple-unit system, and the first actual trials for an electric equipment, based upon the approval of the officers of the road and its engineers, was that of a train having two locomotive cars, one at each end, the motor equipments on the two cars as a whole being thrown in series and parallel relation, and governed by hand controllers supplemented by electrically operated reversers. A short trial proved the inefficacy of this scheme, and led to the final adoption of the multiple-unit system as developed in a modified form by the General Electric Company, and now known as the Sprague-General Electric system.

The operative and financial results attained by the adoption of electricity are sufficient commentary upon the cynical attitude of unbelief with which all claims on behalf of electric operation were received, and it is a matter of some satisfaction to see the growth of the multiple-unit idea and its adoption on the Manhattan, the Interborough, and the Metropolitan District of London, as well as other roads where I had for years advocated it in face of the most determined opposition and ridicule, as well as the substitution of the system where locomotive cars have been used.

It is also gratifying that the largest present enterprise effecting steam operation is likewise dependent upon this system. The whirligig of time has for the moment put me in the position of critic and engineer instead of inventor and constructor, as one of the commission in charge of the electrification of the New York Central terminals and a portion of its main line, the other members being Fifth Vice-President Wilgus, chairman; Superintendent of Motive Power Deems, Mr. Arnold and Mr. Gibbs, the general work being undertaken after a comprehensive and careful report by Arnold, supplementing an earlier crude investigation by myself.

It is too soon to go much into the details of this equipment other than as already known, or the character of the contracts. Much, of course, will be a duplication of the best practices elsewhere, but in one particular, that of the locomotive equipments, the departure is radical, and of such character that the contracting company is proceeding under very exacting conditions, required on the one hand by the railroad company and on the other willingly undertaken in its confidence of the outcome by the General Electric Company. The 2200-hp locomotive units of 85 tons weight, with over 65 tons on the drivers, are to be controlled on the multiple-unit plan, so that two or even three locomotives, representing an aggregate of several thousand horse-power under simultaneous control, can be put at the head of the heaviest train which can be made up.

One of the results sought, and which will be accomplished, is to replace the dozen types and sizes of locomotives now used within the territory determined for electric operation by a single type and size of locomotive of such a capacity and capable of such control and aggregation as to meet all the requirements of speed and power, whether for switching in the yards or hauling the heaviest trains at schedule speeds.

In view of the developments which are taking place in the alternating-current application, it may be proper for me to say here that the decision finally made in behalf of continuous motors, and a zone of operation bounded by North White Plains on the Harlem division and Croton on the main line was the only one then, or even now, possible or wise under existing limiting conditions, and that the operation of this particular area is not affected by, nor will it necessarily determine what shall be the future developments affecting trunk-line operation.

THE BEGINNINGS OF THE ELECTRIC RAILWAY MOTOR

BY BRIG.-GEN. EUGENE GRIFFIN, U. S. V.

IN 1888 electric lighting was nearly ten years old. The Edison incandescent lamp, invented in 1879, had given tremendous impetus to the lighting industry, which, before that date, represented but feeble and unsatisfactory efforts to make commercially useful the inventions of numerous pioneers in the lighting field. Edison lighting companies were being organized in all of the principal cities, and the incandescent lamp, while still expensive, was being generally recognized as a necessity of modern life. The arc light of Brush and Thomson had been so perfected that municipalities all over the country were lighting their streets by the arcs, and while commercial lighting was practically unknown, the arc light industry was advancing by leaps and bounds.

Electric welding had been invented by Elihu Thomson, and the public was beginning to appreciate the vast importance of this contribution to commercial industry.

Stationary motors were being used to a small extent by those who appreciated the value of such a ready source of power.

Electric railways were indeed in their infancy. Sprague was building the Richmond road. Daft had a two-car road in the outskirts of Baltimore, and four others in other cities. Bentley & Knight had abandoned their Cleveland experiment, but had built roads in Woonsocket, R. I., and Allegheny City, Pa. Van Depoele had some ten small roads running in various small cities. Each road differed from every other road, not only in small, but in essential details. Van Depoele placed his motor on the front platform and connected it with the axle by a sprocket chain and gear.

Such was the condition in 1888, when the Thomson-Houston Electric Company, of Boston, entered the railway field. That company, prior to 1888, was an arc lighting company. Basing its work on the patents of Professors Thomson and Houston, by able management and unusual energy it had achieved a leading position in the electrical manufacturing field and had surpassed its older rival, the Brush Company. The arc light business had absorbed all of the energy of its management, but having attained the first place, it was looking for new worlds to conquer. The Bentley-Knight Company, having no factory of its own, had purchased electric motors from the Thomson-Houston Company for the Woonsocket and Allegheny City roads. In this way the Thomson-Houston engineers had secured some experience in electric railway work.

In the spring of 1888 it was determined that the Thomson-Houston Company should take up the electric railway business. The first step was the purchase of the Van Depoele patents. The wisdom of this move was proven by subsequent results. The courts have repeatedly held that Van Depoele was a pioneer in the railway art, and his patents have been repeatedly sustained by the Federal courts in all parts of the country. We owe to Van Depoele the carbon brush, without which the electric railway motor, and I might even say the direct-current dynamo, would have been a comparative failure. We owe to Van Depoele the under-running trolley, which was an essential to the early roads, and is an essential to-day.

The purchase of the Van Depoele patents carried with it the employment of Van Depoele, and from that time the Thomson-Houston Company had the advice, counsel and active assistance of that great inventor.

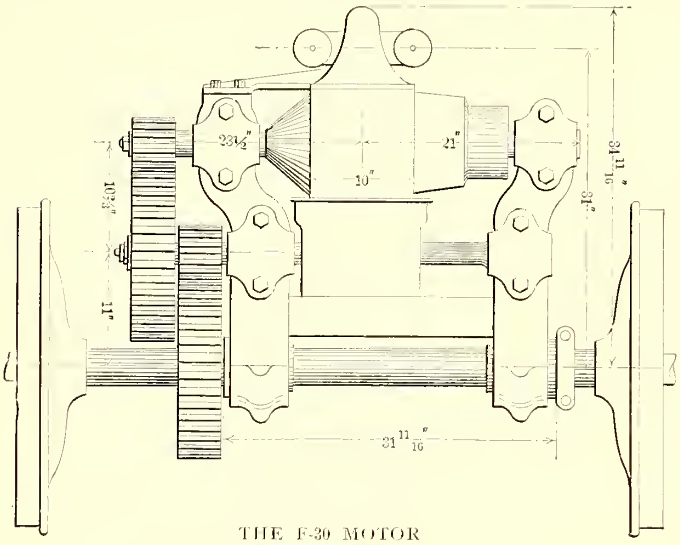
Experiments were at once undertaken to develop the best possible form of motor. These resulted in the F-30 motor—the old double-reduction, 15-hp so-called F-30 motor. Two motors were furnished with every car. These motors were flexibly suspended from the axles, and the armature speed of 1500 r. p. m. was reduced to the desired car-axle speed by means of an intermediate axle and a second gearing. It will be seen, therefore, that the difficulty at the outset with electric railway motors was not to attain high speed, but rather to attain low speed, and for several years the improvements in railway motors were all in the direction of bringing down the speed and ultimately eliminating the intermediate axle and secondary gearing.

The F-30 motor is shown on the following page. The motors of this type were characterized by flat fields. The frame consisted of a strong iron casting, comprising side arms and magnet yoke, while the field cores were wrought iron forgings, of flat, rectangular cross section, firmly bolted to this yoke. The field coils were wound upon sheet-iron spools with brass flanges, and the ends of the windings were joined by means of copper strips to the connection board, which is placed in a position of easy access for examination. The armature in the type F motor was of the Siemens or drum type, having continuous coils wound with the most careful attention to insulation.

The bearing linings were all of gun metal. On the armature and intermediate shafts the boxes were provided with the ordinary oil cups, as a means of lubrication, while on the axle shaft the boxes had an oil reservoir and a spring feeder. The gear ratio was 9.4, and the motor was rated at 15 hp. The weight of the motor was 2096 lbs. Four thousand six hundred and twenty-one of these motors were sold by the Thomson-Houston Company during the years 1888-1891, and went into operation in all parts of the habitable globe. It is no exaggeration to say that the F-30 motor made the success of electric railways.

Carbon brushes were first used on the F-30 motors. Some of the serious troubles with copper brushes encountered by Sprague on his Richmond road were rapid consumption and difficulty in reversal, and this invention of Van Depoele's was a long step in advance.

The first commercial road equipped by the Thomson-Houston Company was at Crescent Beach, Mass. Two cars were



THE F-30 MOTOR

equipped and put into regular operation on the Fourth of July, 1888. The pinions were made of alternate plates of steel and rawhide, a method of construction highly praised at the time, and from which much was expected. It is needless to say that it was but a short time before the rawhide was eliminated.

The success of the Crescent Beach road led to the contract for the Eckington & Soldiers' Home road in Washington. This road ran from Mt. Vernon Square on Seventh Street to and beyond the boundary. The straight line of New York Avenue offered unusually excellent facilities for good construction; steel poles were used, placed between the tracks with one cross arm extending out over both tracks. It was opened to traffic in the fall of 1888. This line was well constructed and was a model road in its day. Its position in the capitol city, where it was examined and commented upon daily by Senators and Representatives from all parts of the United States, justifies us in asserting that no one road did more to advance and make permanent the electric railway industry than did the Eckington & Soldiers' Home road.

Great fears were expressed as to the danger to life and limb, and as to the fire risk from such "high-tension" wires stretched over the public highway. These fears found voice in the United States Senate, and the construction of the Eckington road was considerably delayed, pending a hearing before the district committee, based upon a petition of the Thomson-Houston Company, praying for relief from the action of the Senate, which, in passing a resolution introduced by Senator Edmunds, of Vermont, indicated an intention of annulling all contracts and permits, and making impossible and unlawful the construction of the road. The evidence introduced at this hearing satisfied the committee, and the report of the committee satisfied the Senate, and work was resumed.

The telephone companies protested against the use of the ground return by the electric railways, as it interfered with their use of the ground return. Much litigation resulted, but the courts held that the telephone companies had no monopoly of the earth, and the result was the introduction of metallic circuits for telephones, an improvement which the public owes to the electric railway, although it was an improvement which was sure to come sooner or later.

Henry M. Whitney, a brother of William C. Whitney (afterward Secretary of the Navy), was president of the West End Street Railway, of Boston. A courageous and progressive man, it was his intention to introduce the cable system in order that Boston might have a modern and up-to-date transportation system. Probably no city in the United States was less suited to the cable system than Boston. Nevertheless, it seemed the only system available as an improvement over the old horse car, and Mr. Whitney's cable plans were already far advanced when his attention was invited to the possible use of the electric motor. A visit to Allegheny City, to Richmond and to Washington convinced Mr. Whitney that the new system was what he desired; a contract was made for the equipment of the Cambridge line with the overhead trolley, and at the same time he contracted with the Bentley-Knight Company for an underground conduit on Boylston Street. The Cambridge trolley was a success; the Boylston Street conduit was a failure. The conduit was removed and authority secured for overhead wires over practically all of the Boston streets. The West End engineers were satisfied with their knowledge of power house work, of the cost of producing power, of the cost of maintenance of dynamos, and of the possibility of operating cars by overhead wires. They were without knowledge of the cost of maintaining the overhead lines and the apparatus on the cars. A contract was proposed wherein the Thomson-Houston Company would assume this risk by agreeing to keep the overhead line

THOMSON-HOUSTON CAR ON ECKINGTON & SOLDIERS' HOME RAILWAY, WASHINGTON

and the car equipment in operating condition for the sum of 3 cents per car-mile for a double-motor car, and 1½ cents per mile for a single-motor car; this agreement to run for five years. It was a bold step for the Thomson-Houston directors to take, but on the advice of their engineers they did take it, and the contract was signed. At the end of two years Mr. Whitney found that the Thomson-Houston Company was making a profit on the maintenance guarantee, and he took it over, as was his contract right. But those two years were far from pleasant ones for those engineers upon whom rested the responsibility for such an agreement, and few can appreciate the relief they felt when it was realized that they had no longer any direct interest in the question as to whether or no the cars could be kept running during a Boston winter blizzard. The securing of the West End contract by the Thomson-Houston Company against the severe competition of the Bentley-Knight, the Sprague and other electric companies, unquestionably placed the Thomson-Houston Company in the front rank of the electric railway equipment manufacturing companies—a position which it continued to hold until its amalgamation with the Edison Company to form the present General Electric Company in 1892.

It was interesting to meet and combat the objections of the street railway manager. His fears as to the reliability of electric cars were natural; his feeling of absolute helplessness in the handling of a power of which he knew nothing, and could learn nothing, was natural; but it was amusing to hear him seriously argue that it was impossible to make any change whatever in the 16-ft. horse car. The body could not be raised one inch; not only was it impossible to add another step to reach the platform, but the rise in the prescribed number of steps could not be increased even by one inch. Car builders had nearly attained perfection in the manufacture of the car body, and the springs and axles and boxes and all parts must be used just as they were used when the horse constituted the motive power.

The introduction of the independent truck in 1889 was a great step in advance, and it did more perhaps than any other improvement to bring home to the old-fashioned manager the fact that the horse car days were past and that we had entered a new era where his horse car experience counted for but little, in so far as it related to the construction of the car and the motive power therefor.

The F-30 motor was succeeded by the S. R. G. motor in 1890. This was the first single-reduction motor; it was short-lived; it was followed almost immediately by the W. P. motor (water-proof), and some 7638 of the W. P. motors were sold. These were succeeded by the GE 800, and as the cars were increased in size and greater speed demanded, by the 25-hp, the 35-hp, the 40-hp, the 50-hp, the 75-hp and even the 125-hp motors of the present day. The Interborough cars in New York are equipped with 200-hp motors.

The growth of the electrical railway has been rapid. Hardly seventeen years have elapsed since the first substantial road was constructed, and yet the growth has been so gradual that few realize what it has done for humanity. The crowded city has been expanded into the country; the area available for homes has been increased at least nine-fold; towns and cities have been brought into communication where before no communication existed; where communication did exist the high speed of electric interurban cars has effected great savings in time; the value of property has been enormously increased; our streets have been made cleaner and healthier; additional work has been found for many thousands of laborers, and the saving in time to all who travel by electric-driven vehicles has added years to the active life of every individual.

"I feel that the time has now come when some of the physical dimensions of electric cars may, with benefit to all, be standardized. As to how far such standardization should go, committees of this association can best determine. The guiding principle, it seems to me, should be this: That standardization of parts should be so directed as not to interfere with the progress of invention."—*From Pittsburg Meeting, 1891.*

THE DEVELOPMENT OF STREET RAILWAY TRACK CONSTRUCTION DURING THE PAST 20 YEARS

BY W. BOARDMAN REED

PREVIOUS to 1884 steam railroad engineers had practically agreed upon the proper section of rail and style of construction, and little or no change has since been made in the standards then in use. The use of heavier rolling stock has called for heavier steel and more solid roadbed, this demand being met by increasing proportionately the dimensions of the then standard rail sections, substituting, perhaps, broken stone ballast for sand or gravel, and reinforcing culverts and bridges. Even the joint fastenings most generally in use to-day are of the same general design as those used twenty years ago. Though many patent joints and fastenings have been tried and used, there is no single one of them so generally used as the angle splice, which is a modification of the old fish-plate pattern.

The action of the American Society of Civil Engineers doubtless had much to do with standardizing rail sections. The section recommended in 1893 by its "Committee on Standard Rail Sections" is the standard of most steam railroads to-day, though the Pennsylvania Railroad Company has a standard of its own and some other roads use a slightly modified form of the A. S. C. E. section.

With street railways, however, there has been during the past twenty years a complete change in everything relating to track construction, so that the standard street railway track of 1904 has no closer resemblance to the standard of 1884 than has the modern electric car at present running on Broadway, in Manhattan, to the horse car running on West Street in this same Borough.

From about 1831 for a period of more than fifty years, animal power was universally used for street car service. The cars were light, and so did not call for a rigid roadbed. The problems confronting the street railway track department of that period, however, were the same, aside from the strength of the track construction, as confront us to-day. Much time, thought and money were expended in an endeavor to get a perfect track. The definition of a perfect street railway track twenty years ago might be as follows, the sequence of the requirements given being according to their importance:

First—The head of the rail to be of such section as to offer the least resistance to the movement of cars.

Second—The shape to be such that mud, slush or snow carried on it by vehicles would be easily pushed off by wheels of the cars.

Third—The rail to be such that it could be solidly spiked to the wooden stringer.

Fourth—The rail to offer the least possible obstruction to vehicles.

Fifth—The sub-structure to be such as not to interfere with the pavement and to be of sufficient vertical and lateral stiffness as to resist the strain caused by heavy vehicles.

To accomplish these results many various sections were rolled to meet the ideas not only of street railway engineers and managers, but of city authorities as well.

The first street railway built for passenger traffic was on

Fourth Avenue, New York City, the rail used being a simple bar of iron, with a groove formed to receive the wheel flange, and this section came as near meeting the definition given above as any since made. It was quite similar to Fig. 1, the lower lip being omitted, Figs. 2, 3 and 4 being other sections tried. Fig. 5, known as the "Philadelphia Section," was also extensively used.

The center-bearing rail, shown in Fig. 3, undoubtedly more nearly complies with the first, second, third and fifth require-

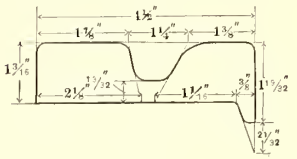


FIG. 1

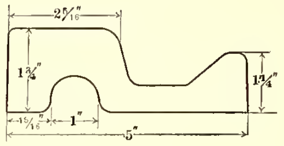


FIG. 2

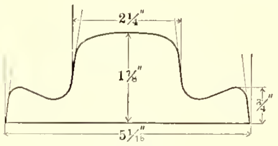


FIG. 3

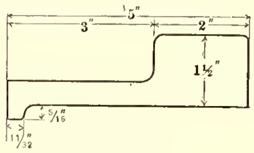


FIG. 4

ments of the above definition than any other, but much objection was made to it by drivers of vehicles, and so great was the objection that the Legislature of the State of New York enacted a law in 1892 against its further use. This section has rather an interesting history. The various street railway men, in their effort to obtain a proper rail, appealed to the late Hon. Abram S. Hewitt, of Cooper, Hewitt & Company. He personally designed for them this rail, and, as stated above, it was,

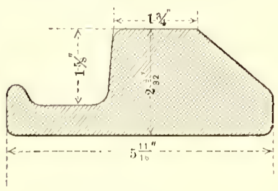


FIG. 5

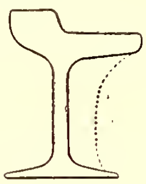


FIG. 6

to the street railway men, very satisfactory. The head being somewhat above the adjacent pavement and separated from it on either side by a flange, comparatively little dirt, mud or snow was drawn or pushed on it by vehicles. In light snow storms the wheels of cars would themselves clean the rails, and in heavy storms they would remain clean for a considerable period, especially if a small quantity of nocturnal sunshine or salt was sprinkled along the flanges. Some few years after the introduction of this rail, Mr. Hewitt was elected Mayor of the city of New York, and, being appealed to by the citizens, he refused to allow any permit to be granted for the further use of center-bearing rail, and, largely through his efforts, the statute above referred to was passed by the Legislature. When remonstrated with by the street railway men, he replied: "Yes, I designed this rail, but I was then employed in your interest. Now I am working in the interest of the public." I believe Kansas City, Mo., is the only city in the United States which permits the use of this rail-head.

With the flat sections of rail the method of construction was to spike the rails to a wooden stringer 5 ins. (equal to the width of the rail) in width and 7 ins. in depth. The rail being 1½ ins. or 2 ins. in thickness, this gave ample depth for paving blocks. The stringers were fastened to crossties placed from 4 ft. to 5 ft. apart with cast-iron knees or angles, one of which was placed either side of the stringer at each tie and fastened with spikes to both. Outside of the stringers, knees about 5 ins. x 5 ins. were used. Inside, the knees were 3 ins. x 3 ins. At joints of timbers a special shaped knee was used, arranged to engage both sticks. In laying this character of track care was used not to have a joint of the rail over a joint of the timber, and at rail joints a flat piece of steel or iron, shaped to receive the bottom of the rail, was placed, the timber being cut to receive it.

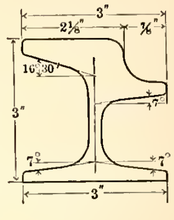


FIG. 7

Though the flat rail answered very well for the light cars of twenty years ago, some railway men, or it may have been rail manufacturers, thought that a rail with greater vertical strength would be better, so that, even for horse cars, many other sections were tried. Still clinging to the wooden stringer, sections were rolled with a channel base, the flanges tending to stiffen the rail, and the rail being fastened to the stringer with horizontal bolts. Later, the wooden stringer was abandoned and various sections supported on chairs were used. Though a patent was granted in 1859 to Sydney A. Beers for a girder rail very similar to those at present used, Fig. 6, owing to difficulties of rolling, no girder rails were manufactured until 1872. This rail, Fig. 7, was only 3 ins. in height and was supported on chairs. It was followed by girder rails, both with and without bottom flange, also by various other types of rails, such as Lewis & Fowler's box rail, Figs. 8, 9 and 10, and the Gibbon duplex rail, Figs. 11 and 12.

Each of these sections had some feature through which they were placed on the market, and answered fairly well for horse car service, though none of them, in the opinion of the author, was superior to the flat rail and wooden stringer. In 1894 and 1895, a considerable amount of the Lewis & Fowler and also of the Gibbon rail was removed from Sixth Avenue in New York City and the flat rail with stringer substituted. The Lewis & Fowler and Gibbon rails had been in service but a few years, while the flat rail and stringer adjacent to them had been in service over twenty years, during which time the rails had been renewed once, but the stringers had not been changed.

There is at present in the Borough of Manhattan something like 75 miles of flat rail and stringer construction, much of which has been in operation over twenty years, and it is to-day in better condition than is a line built about twelve years ago with 4-in. girder rail on chairs.

If the various box-girder, duplex, "Butterfly," shallow girder and so-called girder rails without lower flanges would not stand up under horse car service, it is not surprising that with the advent of electric service trouble was immediately experienced with the track. None of the rails in use when electric cars were introduced had sufficient vertical stiffness, and, though it would seem an easy matter to compute the best section of rail to carry a given load, yet we find one of the principal manufacturers of steel rails as late as 1890 recommending the use of so-called girder rails, with no lower flanges, set on chairs, though at that time regular girder rails 9 ins. high were rolled.

As late as 1895 few street railways were built with a stronger rail than a 7-in. girder, weighing from 75 lbs. to 80 lbs. per yard, and even yet 7-in. rail is extensively used, though 9-in. rail, weighing from 90 lbs. to 100 lbs. per yard, is fast becoming standard. Though the 7-in. rail, or even the 6-in. rail, weighing from 80 lbs. to 90 lbs. per yard, is sufficient with a proper foundation, the 9-in. rail has the advantage of giving sufficient depth for stone block paving, and, in addition, it gives a much more rigid joint. Rails as much as 10½ ins. in height have been used, but they do not meet with favor. The use of a girder rail with head from 4½ ins. to 5½ ins. in width, with a lower flange from 5 ins. to 6 ins. in width, and a total height of 9 ins., weighing from 90 lbs. to 110 lbs., is being adopted throughout the country as a standard, but, aside from this as a type, we are no nearer to a standard section than we were twenty years ago. In fact, we have retained all the heads used previously, except perhaps the center-bearing, and adopted many new ones. The general shape most used is the side-bearing, Fig. 13. Many cities, however, will not consent to its use, demanding a groove rail with inside flange approximately the same height as the head. The so-called "Trilby" rail, designed in 1895 by the engineers of the Metropolitan Street

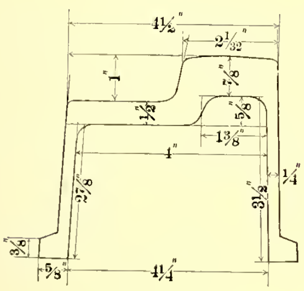


FIG. 8

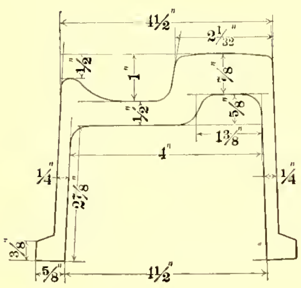


FIG. 9

Railway Company, of New York City, to meet the requirements of the city authorities, is being used quite extensively (see Fig. 14). It has probably less bad features than other grooved rails, but is more objectionable, especially in times of snow, than rails without a groove. A number of modifications have been made in this section since it was originally designed, and the present standard of Greater New York differs slightly from the original model.

In the foundation for rails there has been fully as great improvement during the past twenty years as in the rail. Whereas in horse car construction ties 5 ins. x 7 ins. x 7 ft., placed 4 ft., or even 5 ft., on centers, tamped up with the surrounding earth, were generally used, the better construction of to-day requires either metal ties, spaced 30 ins. on centers, with either

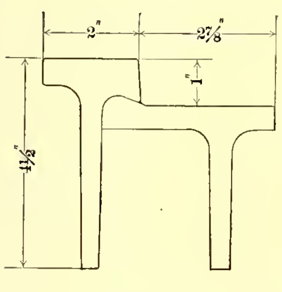


FIG. 11

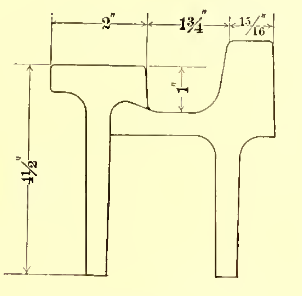


FIG. 12

a heavy beam of concrete under the rail or else a continuous bed of concrete not less than 6 ins. thick for pavement foundation, reinforced to 8 ins. or 10 ins. for 12 ins. either side of the gage lines. In this construction the tie simply serves as a tie rod to hold the track to gage and as a temporary support while the track is being lined and surfaced previous to the placing of the concrete. If wooden ties are used they are 6 ins. x 8 ins. x 8 ft., from 24 ins. to 30 ins. on centers, either broken stone or gravel being used for ballast. Often concrete is used in lieu of ballast, in which case it is not only tamped under and around the ties, but under the rail as well.

It might be claimed, however, that in thus using concrete there has been no development in the past fifty years except in that the concrete is a substitute for the natural stone, for on the first steam railroad built the rails were supported by stone blocks, and in the line built on Fourth Avenue, in New York City, stone ties, some of which were taken out in 1897, were used for at least a portion of the distance.

The underground trolley system of New York and Washington has been entirely developed in the past decade, though experimental lines quite similar in design were built even before the use of the overhead trolley. The principal mechanical development in this character of construction has been in the substitution of cast iron and concrete for wood in the supports for the rails and the conduits. This character of construction, however, is so expensive that it can never be used except in very populous cities where there is a large number of short riders.

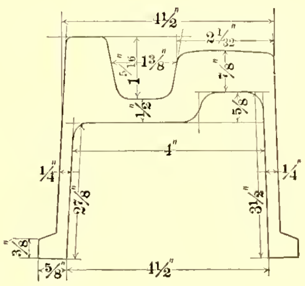


FIG. 10

In no branch of track construction has there been greater development than in the special work. Less than twenty years ago, when a turn-out was to be built, a pattern maker from an iron foundry would visit the ground with a wagon load of wooden strips, which he would proceed to lay out on the ground, bending them to form the necessary curves, nailing on pieces for crossings, etc. Having secured the model together, he would cut it into pieces that he could load onto the wagon and return to his shop. Patterns for cast-iron switches, mates, frogs and crossings would then be made and the rails bent to conform with the model. That work built this way would not always fit is not strange, for the wooden strips would often insist on warping out of shape before they were used. As late as 1895 the writer saw a piece

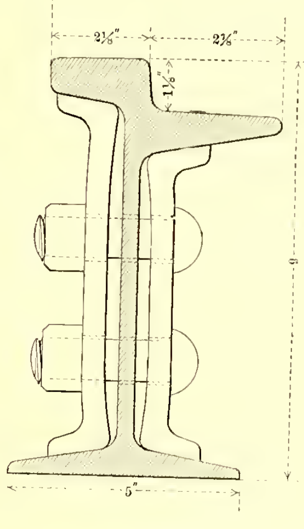


FIG. 13

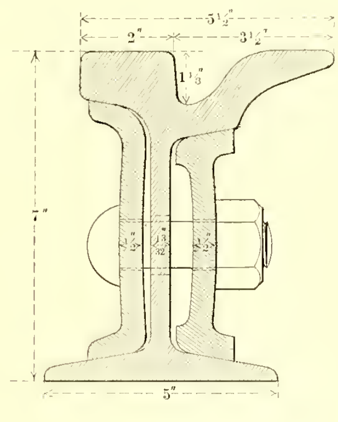


FIG. 14

of work built after this manner, causing a track gang and the pattern maker, who had been sent after, lots of trouble at First Avenue and Thirty-Fourth Street, New York City.

It is perhaps of interest to note that in the cast-iron work used nearly, if not quite, twenty years ago, hardened steel wearing plates were inserted in frogs and crossings.

The great improvement in the methods of manufacturing steel has enabled the manufacturers to make special work so that the parts of greatest wear will last as long as the rails adjoining, and all turn-outs, crossings, etc., being laid out by engineers instead of pattern makers, with wooden strips, there is very seldom any trouble with the fit. In special work for underground trolley lines, especially in renewal work, great care has to be taken in making the measurements and in its manufacture, for, unless the work is made mathematically correct, it will not fit and little or no fudging can be done. Even the holes in the castings must be in exactly the proper location or much extra work is required in the field, and gouging or redrilling of the holes weakens the structure.

ST. LOUIS STREET RAILWAYS IN 1884 AND 1904

BY ROBERT McCULLOCH

A VISITOR to St. Louis twenty years ago would have found a miscellaneous assortment of some fifteen horse and mule railway companies, the oldest of which dated from about 1859, at which time several roads were started. About half of the cars in service in 1884 were of the bob-tailed variety, with steps at the rear in lieu of a platform. The remainder had advanced to the stage where rear platforms and conductors were added, and these were consequently looked upon as being as much superior to the bob-tails as the present double-truck, cross-seat cars were a short time ago considered superior to the single-truck cars which preceded them. Grand Avenue, 2½ miles west of Broadway, was the terminus of the east and west lines. The company's central power station is now west of that thoroughfare, and Grand Avenue is occupied by a central cross-town line, which has very heavy traffic because it is so centrally located with reference to the system. In fact, Grand Avenue is not half way to the World's Fair grounds and the present lines radiate from 6 to 20 miles. The St. Louis Transit Company on World's Fair opening day operated 1000 cars, and the St. Louis & Suburban Railway Company 100 more. The St. Louis Transit Company's regular rush hour schedule now calls for about 1100 cars, which is perhaps as many as can be operated to advantage without causing congestion and defeating the object of carrying the greatest possible number of people per hour.

Mules were the favorite motive power with St. Louis street railway men. On the bob-tailed cars, although one horse or a large mule could have pulled them, experience proved "double-motor equipment" to be the best, the motors in this case being a team of small mules. One cannot refrain from enlarging a little on the superior qualities of these small mules for street car service. They were bred from mustang ponies, and seemed to combine the tough qualities of both the common mule and the mustang. A team of them would pull a bob-tailed car along at a lively trot, making a speed of 6 to 7 miles per hour when under full headway. They would get a car under way very rapidly, or perhaps we should say, in deference to modern methods of expression, the acceleration was very rapid. These little mules were usually bought right from the farms in Northern Missouri and Texas without any previous breaking in. Contrary to what might be supposed, these mustang mules were easily broken in to street car service, and proved very intelligent and quick to learn the requirements of the business as well as willing workers. They were not shirkers. To break them in, an untrained mule was put beside a trained one. The force of example was strong, and by the time the newcomer had made one round trip alongside a gentle mate he was usually considered broken in and would know how to act in street railway service from that time on. They soon learned that one bell meant stop at the next corner, that a person waiting at a corner meant stop, and that two bells meant go ahead. They were less susceptible to disease and less affected by hot weather than horses. About the only thing that took the vim out of them was a sleet-covered roadway in winter, which gave them an uncertain footing. Trouble from this cause was in those days overcome by sprinkling between the rails with fine cinders. Mules frequently averaged 20 miles per day with as much ease as horses would make 14 miles, and the mules lasted better. When unfit for street car service, they could be sold to advantage to traders further South, where they would be resold to negroes for farming small plantations.

So much for the mules. How about the men? Previous to 1884 the drivers alternated what were called long days and short days. The long days were sixteen to eighteen hours in length, and the short days twelve to fourteen hours. By 1884, however, this had been reduced. Drivers got from $2 to $2.50 per day. They stood all day on a small platform exposed to the weather, lines in one hand, brake handle in the other, looking out for passengers, making change, taking the entire responsibility for the car and its occupants. The fare box was used, and each passenger deposited his or her own fare in the box, unless the car was too crowded, and then the other passengers passed it up. The longer cars had conductors, but that was before the days of fare registers. The lot of the driver in those days was in striking contrast to the lot of the motorman of to-day, who has a comfortable cab in which he can stand and sit during his day's work and control his car with the air brake and controller handle. However, the added speeds have greatly added to the motorman's responsibilities, so that the greater physical comfort of the motorman is at the price of higher nervous tension. Taken altogether, however, the motorman's lot is much better than that of the old horse car driver.

It is hardly necessary to point out that the lot of the passengers in those days was little better as compared with to-day than was that of the men as compared with to-day. The distances covered were not great, but the speed was so slow that persons living at the terminals of the lines then were practically no better off than those living at the outer terminals of the lines to-day in point of time required to get to business, while the comfort in the old bob-tailed cars is not to be compared with that afforded by the present cars. Besides this, the fact that fifteen different companies, which did not issue free transfers to each other's lines, were operating within the small district then covered by street railways, speaks for itself as regards the limited transportation privileges that the payment of a nickel in those days carried as compared with to-day, when a passenger can go between any two points in the city limits for a 5-cent fare.

The first cable line in St. Louis was started by the St. Louis Cable & Western Railway in 1886. This is now the downtown end of the St. Louis & Suburban Railway. The outer end of this line was a steam road. The whole was, in 1891, changed to electric, being the first cable line so changed. Other cable roads in the order of their equipment were Olive Street, Franklin and Easton Avenues, Broadway and Fourth Street. In 1894 the era of change from cable to electric began, and since all cable lines have been changed to trolley.

Electric traction began in St. Louis with a couple of experimental lines—one a storage-battery line on the Lindell Railway in 1887 and the other a trial of the Short series system at the southern end of the old Broadway cable line. Both were failures. The real era of electrical operation began when one line of the Union Depot Railroad began to operate with a trolley in March, 1890, followed by one line of the Lindell Railway in September, 1890. The trolley spread rapidly, and within a few years had not only driven out horses, but the cables.

St. Louis has always been a progressive place in street railway matters. The general use of double-truck semi-convertible cross-seat cars is largely due to the example set by St. Louis roads, which took this type of car up before it was considered practical for city service elsewhere. The maximum traction truck was first generally used on these cars with car bodies about 28 ft. long. Later the regular double-truck car with four motors came in with car bodies 33 ft., this being the standard to-day. The first large railway generators in the world to be direct connected to Corliss engines were placed in service in the Cass Avenue & Fair Grounds Railway plant in 1893. The first cast welding of rail joints in the world was done on 2 miles of track in Chippewa Street in November, 1894, which was the beginning of great activity in cast welding. Incidentally, too, may be said that the joints in this track are good to-day. The first rail in 60-ft. lengths ever used for street railway service was laid on Franklin and Easton Avenues in 1895.

Perhaps the best illustration of what St. Louis street railways are to-day is the fact that on St. Louis Day, the greatest day of the Exposition, when the citizens of St. Louis and surrounding towns turned out en masse to attend the Fair, the St. Louis Transit Company carried in round numbers 1,151,785 people, including transfer passengers, in one day, and all this without the tremendous congestion of crowds that is commonly considered inseparable from such special holidays, when an exceptionally large number of people must be carried in an unusual direction. At no time did the crowds, either going or coming, collect faster than the street railways were able to transport them to their homes, and the people were delivered at the Exposition gates at times faster than the Exposition turnstiles could pass them through.

VERY EARLY WORK IN THE DEVELOPMENT OF ELECTRIC RAILWAYS

The following is a digest of the first portion of a paper presented by Frank J. Sprague at the International Electrical Congress at St. Louis, but received too late to allow the facts to be incorporated in other articles published earlier in this issue. Mr. Sprague's facts are so interesting that they should be inserted in this anniversary number:

Brandon, Vt., birthplace, and Thomas Davenport, blacksmith, father, are the names first on the genealogical tree of the electric railway, in the year 1834. A toy motor mounted on wheels, propelled on a few feet of circular railway by a primary battery, exhibited a year later at Springfield, and again at Boston, is the infant's photograph. This was only three years after Henry's invention of the motor, following Faraday's discovery ten years earlier that electricity could be used to produce continuous motion. From the records of Davenport's career, unearthed by the late Franklin Leonard Pope, this early inventor was undoubtedly a man of genius deserving a high place in the niche of fame, for in a period of six years he built more than 100 operative electric motors of various designs, many of which were put into actual service, an achievement, taking into account the times, well night incredible.

For nearly two-score years various inventors, handicapped with the limitations of the primary battery, and in utter ignorance of the principals of modern dynamo and motor construction, labored with small result. About 1838, a Scotchman, Robert Davidson, of Aberdeen, began the construction of a locomotive driven by a motor similar to that used by Jacobi in his experiments on the River Neva, which was tried upon the Edinboro-Glasgow Railway, and attained a speed of about 4 miles an hour. In an English patent issued to Henry Pinkus in 1840, the use of the rails for currents was indicated; also in a United States patent issued to Lilley & Colton, of Pittsburg, in 1847.

In 1847, Prof. Moses G. Farmer operated an experimental model car at Dover, N. H.; and about three years later one Thomas Hall exhibited in Boston an automatically reversing car mounted on rails through which current was supplied from a battery. These are said to be the first instances in which rails were actually used as carriers of the current, as well as the first time where there was a reduction by gear from the higher speed on the motor to the lower speed of the driven axle.

About the same time Prof. Page, of our Smithsonian Institute, aided by a special grant from Congress, constructed a locomotive in which he used a double solenoid motor with reciprocating plunger and fly-wheel, as well as some other forms. This locomotive, driven by a battery of 100 Grove elements, was tried April 29, 1851, upon a railroad running from Washington to Bladensburg, and attained a fair rate of speed.

Patents issued in 1855 to an Englishman named Swear and a Piemontais named Bessolo, indicated the possibility of conducting current from a conductor suspended above the ground, and in 1864 a Frenchman namel Cazal patented the application of an electric motor to the axle of the vehicle.

From 1850 to 1875 is a long period, relatively, and yet there seemed to have been practically an entire cessation in the United States of electric railway experimental work, until in the latter year George F. Greene, a poor mechanic of Kalamazoo, Mich., built a small model motor which was supplied from a battery through an overhead line, with track return, and three years later he constructed another model on a larger scale. Greene seemed to have realized that a dynamo was essential to success, but he did not know how to make one, and did not have the means to buy it.

Shortly afterward, in 1879, at the Berlin Exposition, Messrs. Siemens & Halske constructed a short line about a third of a mile in length, which was the beginning of much active work by this firm. The dynamo and motor were of the now well-known Siemens type, and the current was supplied through a central rail, with the running rails as a return, to a small locomotive on which the motor was carried longitudinally, motion being transmitted through spur and beveled gears to a central shaft from which connection was made to the wheels. The Siemens & Halske demonstration in Berlin was followed by others for exhibition purposes at Brussels, Dusseldorf and Frankfort, but no regular line was established until a short one with one motor car at Lichterfelde, near Berlin, the first in Europe, or in fact in the world. Shortly after, the same firm installed at the Paris Electrical Exposition of 1881, a small tramway about a third of a mile long, and used for the first time overhead distribution. In this case the conductors consisted of two tubes slotted on the under side, and supported by wooden insulators. In the tubes slid shoes which were held in good contact by an under-running wheel pressed up by springs carried on a framework supported by the conductors, and connected to the car by flexible conductors. The motor was placed between the wheels, and the power was transmitted by a chain. About the same time, Siemens constructed an experimental road near Meran in the Tyrol, with a view of demonstrating the possibilities of electric traction for the San Gothard tunnel, and later other small lines at Frankfort, Molding and elsewhere. These were followed by a comprehensive scheme for a combined elevated and underground road submitted to the city authorities at Vienna.

The invention about this time of accumulators directed attention to the possibilities of the self-contained car, and in 1880 a locomotive with accumulators was used at the establishment of Duchesne-Fournet at Breuil, and in the following year Raffard, with a large battery of Faure accumulators, made experiments on the tramway at Vincennes.

In 1880 Dr. John Hopkinson, in describing the application of motors to hoists, proposed both for them and for tramways the simple series-parallel control for speed, a principle which, combined with resistance variation, later became universal.

Meanwhile in the United States two inventors, Stephen D. Field and Thomas A. Edison, began electric experiments almost simultaneously. Perhaps more than to any other, the credit for the first serious proposal in the United States should be awarded to Field. In February, 1879, he made plans for an electric railway, the current to be delivered from a stationary source of power through a wire enclosed in a conduit, with rail return, and in 1880-81 he constructed and put in operation an electric locomotive in Stockbridge, Mass. (Field's later work is described elsewhere in this issue.)

In the summer of 1882, Dr. Joseph R. Finney operated in Allegheny, Pa., a car for which current was supplied through an overhead wire on which traveled a small trolley connected to the car with a flexible cable, and about the same time in England, Dr. Fleming Jenkin proposed a scheme of telpherage which was developed by Messrs. Ayrton & Perry.

THF FREIGHT PROPOSITION AS VIEWED FROM A PRACTICAL STANDPOINT

BY EDWARD C. SPRING

A DIVERSITY of opinion exists to-day among the managers of interurban electric railways whether it is more advantageous to handle merchandise at express or freight rates. Each manager has his own personal opinions and ideas along these lines, and in summing them up we cannot but see that each man's opinion is based upon the peculiar circumstances prevalent on his own property. The steam roads have the advantages over us in this respect, because their conditions are more of a universal nature.

It was the writer's fortune, or misfortune, to be on the committee which drew up and put into execution the interchangeable coupon book among various roads in the State of Ohio. In this position he has learned to appreciate fully the diversified conditions that exist at present among the various roads and the difficulties in harmonizing all these conditions so that they would meet the requirements. The situation as respects the adoption and operation of a successful freight or express business is even more varied.

The road that serves large manufacturing and commercial centers, where the consignee demands his goods at a given time and whose business warrants his paying well for their prompt delivery, can do an express business, charging express rates, upon a profitable basis, whereas to engage in a freight business, upon freight rates, would be suicidal to the company. On the other hand, another condition of affairs exists with the road that operates through a farming district and which caters to the demands of the farmer, to whom time is but of a very small consideration, and who wrangles with a Shylock modesty over the fraction of a cent. Here an express business would be entirely out of the question and only a freight traffic, with the lowest possible freight rates, could be maintained. The farmer has not yet realized the advantages which interurban freight facilities afford, and charges in excess of his present steam road rates are severely questioned. The merchants in the various farming towns, knowing that the farmer will not pay anything extra for a quick service, are equally unwilling to pay more than the present steam road charges; and the only way that the electric railway company can hope to obtain a local freight business under such conditions is to place its rates on a par with those of the steam roads. Nevertheless, there is no doubt that in many instances the hauling of heavy freight through these farming sections can be made to show a fair return if properly conducted.

The writer in this article will deal more particularly with the handling of freight under the conditions described. The road with which he is associated, on finding that an express service could not be operated with profit, devoted itself entirely to the freight traffic. In working up this business the company has been obliged to do constant missionary work, but by showing the farmer the advantages which the electric road affords in this class of transportation, has been able to develop a very profitable freight traffic. Tobacco, corn, wheat and oats, which are the principal farming products of the community through which the road runs, are carried in car lots to brokers in various cities. The most serious obstacle to be overcome has been the fact that the farmer does not, in any of his estimates, include his own time or that of his team. He will willingly drive 25 miles and consume an entire day rather than pay one cent more on the ton than he had previously paid to the steam road. We are able to deliver our cars at various points on the line, leaving them for the farmer to load during the day, and thereby shortening his haul to the steam road.

The matter of transporting live stock in carload lots has been demonstrated by this road to be a source of profit. It has also been shown to be an advantage to the stock itself, inasmuch as live stock will depreciate on the steam road from 5 lbs. to 6 lbs. per head during twenty-four hours transportation, while we have been able to deliver live stock to the stock yards in Dayton in from two to three hours time, with no perceptible depreciation. We have also been able to utilize flat cars by hauling them to the various sidings by our first passenger cars out in the morning, leaving them to be loaded during the day, and then bringing them in by our freight service later. I thoroughly believe that a freight business can be maintained through farming districts of this kind so as to show as great a percentage gain over operation, all things being equal, as the majority of the interurban express business; and I believe that the freight department bids fair to rival the passenger department in magnitude. Freight stations are being located in connection with passenger stations in the various cities and towns and traffic arrangements are being made with connecting lines, so that the interurban electric road can deliver its freight at the door of the merchant and the farmer with a frequency and rapidity with which the steam roads cannot think of competing.

Up to the present time steam road managers have been very slow in the matter of exchanging freight in carload lots with the interurban lines, but I believe that they are beginning to realize that in the latter they have a strong ally, whereby they can increase their own business in a way which they could never before do. The interchange of freight in carload lots and its delivery to the door of the merchant and the farmer in remote towns, not to the steam road lines, gives an added profit that they could not get from any other source. I believe that it is for the interest of all roads doing freight business to interest the steam roads in their section, not only to have an interchangeable freight traffic arrangement, but induce them as far as possible to pro rate with them in the handling of freight in carload lots. This has already been accomplished in certain parts of Ohio. It has taken the actual proof of these facts to convince officials of steam roads, who, in most cases, have been stubbornly blind to the true state of affairs.

In the conduct of our freight business the disposition has been to follow steam road methods, representing, as they do, the result of many years of experience, and I believe that we can do no better than to take advantage of this experience in the operation of our freight department.

The handling of garden truck is also fast becoming a source of revenue to interurban freight handlers on account of despatch in the carriage of perishable goods. The road with which the writer is connected has become interested in a proposition which is being put forward by the Ohio Cold Storage Company to bring about a higher development of the farms along the line in the production of staple commodities, such as corn, wheat and tobacco. If the farmer to-day receives $70 to $80 per acre for his yield, he considers he is getting a good revenue for his labor, but the possibility of raising vegetables, which will return him from $100 to $300 per acre, is interesting a great many at the present time. Farmers' meetings have been held in the various towns along the line and have been addressed by officers and experts of the Cold Storage Company, as well as by officers of the interurban company. Literature from the Department of Agriculture has also been freely distributed along the road among the farmers. The Cold Storage Company proposes to establish receiving stations and to collect from the farmer at his very door all vegetables, paying for them in cash at the current market price of the day. This will add a new source of revenue to the road. Such a service, with free rural mail delivery and telephone service, will give the farmer, who now receives his daily paper by the traction line before the ink is hardly dry, an independence equal to that of the broker in his office on Wall Street. He will be in close touch with the market prices of the day, and we will be able to transport his farm products to the cities to take advantage of that day's market quotations. It has already been demonstrated that fruits and vegetables which are carried by the electric roads are received in the market in such perfect condition as to demand higher prices than those shipped over the steam lines, where the rough handling causes considerable depreciation. There is still another plan that has been carried out by our company, and that is taking a merchant's order for his goods in the morning and placing it with the wholesale houses in the various cities in time for delivery that afternoon.

The advantage which the interurban lines have over the steam roads in catering to local freight traffic is shown in their ability to deliver goods frequently and promptly between the city and the suburban points. The frequency of freight service is bound to build up the small shipment business, and along these lines the merchants in the towns can order his goods and not be dependent on the steam road freight service. The merchant in being able to order his goods from day to day is not obliged to carry as heavy a stock. The depreciation of his stock is reduced to a minimum; his insurance rates are also reduced, and the income of the road is, of course, greater on account of frequent shipments. The small merchants in the various towns appreciate this service and have been quick to take advantage of it.

I would not for a moment recommend any cut below the steam road express or freight rates, particularly between competing points. The interurban roads from the start have made a very serious mistake in placing their passenger rates at too small a figure, and many roads, particularly in Ohio, have realized this, and have been forced to raise their rates for their own protection. The quicker and the more frequent and regular service of the interurban lines will be a sufficient inducement and will bring the major part of short-haul business to them. This, together with the central location of freight stations in the various towns, will give the interurban lines an advantage with which the steam roads cannot compete. The accessibility of the electric lines, both to the shipper and the merchant, will also always be an advantageous factor in favor of the interurban lines.

I have not attempted in this article to enter into the matter of express service, because I believe that a dividing line should be definitely drawn between the freight and the express business. Where the two are run in connection with each other, friction and misunderstanding always arises. Indeed, the policy has been seriously considered by many roads whether it is not always better to turn the express business over to some independent express company. The operation of an express service on a short road cannot, in my opinion, be maintained as profitably by the railway company itself as by a regular express company, operating over connecting lines. We have the example of the steam roads on this point.

I cannot but feel, in summing up this subject, that the interurban roads through the country should get together in the matter of standardizing their freight and express business, and I believe that the arguments in favor of this course apply just as forcibly to this department of their service as in that of standardizing equipment. And as the problems are adjusted we shall see the results in cheaper operation and increased revenue. The construction which has demanded our attention up to the present time is a thing of the past, and we must now give more thought and attention to the matter of successful and judicious operation.

"You have come here from all parts of the country for the purpose of forming a national street railway association. Some one may ask what interest in common, affecting the street railways of the country, corporations local in their character can have that would seem to call for an organization for their protection. I would say that, probably, our association is not to be formed so much to protect as to promote them. The street railways of this country have grown so rapidly during the past ten years, and are still growing with such rapidity, that an association of this character seems highly desirable. * * * If there is any benefit to be derived from this association, the young companies, just starting in growing places, will profit by it more than the large companies. They will receive the benefit that may arise from a knowledge of the various inventions that will be exhibited and discussed at our meetings, and from the experience of the older railroad men whom they may meet."—*From the Boston Meeting, 1882.*

ELECTRIFICATION OF THE NEW YORK CENTRAL & HUDSON RIVER RAILROAD IN THE NEW YORK ZONE

BY WILLIAM J. WILGUS

THE electrification of the passenger traffic of two of the most important steam railroads in the world, for distances of from 25 miles to 35 miles, radiating from a terminus in the greatest city on the Western Hemisphere, may well be termed the marking of the commencement of a new epoch in the history of transportation.

For over seventy years the steam locomotive has held undisputed and honorable possession of the field of long-haul traffic, and has steadily grown in weight and power from the 7½-ton "Rocket" of Stephenson, with its train of two ancient coaches weighing 9½ tons, to the 150-ton "Central Atlantic" type of to-day, hauling trains of nearly ¼ mile in length and weighing over 800 tons.

The time has arrived when changed conditions in great centers of population demand a different system of transportation on our trunk lines than has heretofore existed. Modern steam locomotives capable of hauling through passenger and freight trains will still dominate where units are comparatively infrequent and the haul long, but even for this class of service on roads with heavy traffic, electricity will gradually supplant steam as the cost of producing current decreases in central power stations and the cost of equipment is lowered, due to cheapened methods of manufacture, the use of water power, and the invention of labor-saving and more efficient devices.

The traveling public within what may be termed the suburban zones are no longer satisfied with trains of many cars hauled by heavy locomotives at lengthy intervals; neither do they longer tolerate with patience the smoke, gas, cinders and noise inseparable from the steam locomotive. In other words, the steam railroad, if it would successfully hold and multiply its suburban traffic, must offer the advantages to which the public has become educated by the marvelous development of electric railways within the past twenty years. Trains at short intervals, quick acceleration, frequent stops for local trains, independent tracks for express service, and the absence of products of combustion, all of which are possible only with the use of electricity, make the outlying districts attractive to the toiler in the city and thereby propagate traffic. The cultivation of suburban service, too often neglected and despised by steam railroads, in addition to its own pecuniary reward, has the even greater advantage that comes from the long-haul passenger and freight traffic of the growing communities thus fostered by a popular local service.

Furthermore, it would seem that the steam railroad, already owning its right of way and terminals, and in possession of the field, is better qualified to develop suburban traffic than newly constructed electric railways that invest their capital on chances of building up a remunerative traffic in opposition to existing lines.

Having these objects in view, the New York Central & Hudson River Railroad Company in 1899 commenced a careful study of the problem of changing motive power within what has been termed the "New York Zone," south of Croton, on the Hudson division main line, and on the Harlem division south of White Plains. This study also necessarily included the handling, in a similar manner, of the through and suburban service of the New York, New Haven & Hartford Railroad south of the point of junction at Woodlawn.

The natural conservatism of a large corporation like the New York Central & Hudson River Railroad Company, and the unprecedented magnitude and importance of the change, led to a more than ordinarily careful and deliberate consideration of the abandonment of the long and well-tried steam locomotive for a comparatively new method which had not yet been employed for the peculiar character of service existing on two of the principal trunk lines of the country.

The hauling of 800-ton trains laden with passengers, mail and express, at speeds exceeding 60 miles per hour, with regularity and safety, had not been attempted by electricity. The Grand Central Station, with its complex system of tracks and switches and handling from 500 to 700 trains in twenty-four hours, presented a problem of unusual difficulty. Moreover, the change of power naturally involves the embarrassment incidental to the successful maintenance of an existing enormous traffic in conjunction with radical changes in roadbed and structures. As a result of this thorough investigation of the entire subject, the company finally decided in 1902 to proceed with the change of motive power, and in the following year the State and municipal authorities gave their sanction.

This decision carries with it the necessity for the improvement and enlargement of the Grand Central Station; the increasing of the size of the Grand Central yard, and the depression of the grades in such a manner as to permit the passage overhead of cross streets from Forty-Fifth Street to Fifty-Sixth Street, inclusive; a new underground suburban terminal beneath the station, with the possibility of a connection with the Rapid Transit Subway in Forty-Second Street; the four-tracking of both the Hudson and Harlem divisions within the electrical zone; the elimination of grade street and track crossings within the same zone; the straightening of alignment at various places, as for instance at the Marble Hill cut-off in the Borough of the Bronx; and important station improvements at many places.

The planning and executing of the portion of the problem involving electrification of traffic has been intrusted to a commission comprised of J. F. Deems, B. J. Arnold, F. J. Sprague, George Gibbs and the writer, with a secretary, E. B. Katte, who also acts as electrical engineer of the company. The commission holds weekly meetings and fixes principles and policies that are carried out by a technical corps under the jurisdiction of the electrical engineer. This organization has worked admirably.

After the commission had settled upon the scope of territory to be electrified and had decided that the peculiar conditions in the neighborhood of New York justified the adoption of direct current as preferable to alternating current, contracts were awarded for the larger portion of structures and equipment. It should be here noted that for obvious reasons, through cars originating from points all over the country could not be individually equipped with motors, and that therefore electric locomotives for through trains are a necessity. Suburban cars, however, the use of which is confined to the electric zone, are to be equipped with multiple-unit controlled motors. This arrangement, by confining the use of locomotives to the through trains, entirely eliminates the delays and expense of switching suburban cars, and thereby enormously increases the capacity of the terminals. The multiple-unit system also improves the elasticity of service by permitting the building up of short interval trains from single to many cars, as circumstances require, without a corresponding loss of acceleration and without an undue increase in the cost of train service.

The desirability of harmonizing all of the larger electrical installations in the vicinity of New York, such as elevated, surface railways and subways, led to the selection of 11,000-volt three-phase alternating current for the high-pressure transmission lines between the central power stations and the substations, and 600-volt direct current for the low-pressure conductors and third rail.

Two central power stations, cross-connected, with an ultimate capacity of 40,000 hp each, have been decided upon, either of which, in the event of the disablement of the other, is capable of handling the entire load by using the spare units. One station is under construction at Port Morris and the other at Yonkers, and both are located on navigable waters so as to be accessible for boat as well as rail coal. The most interesting departure from the usual practice in modern power stations is the adoption of 5000-kw steam turbines of the Curtis type instead of reciprocating engines. Attention may also be called to the adoption of water-tube type boilers in units of 625 hp, each equipped with internal superheaters generating steam at 200 lbs. pressure and superheated to 200 degs.

The handling of through trains by electricity presents many very interesting problems. The wide range of train weights and speeds now requires many types of steam locomotives, whereas the adoption of electricity makes possible the use of but one type and size of locomotive, capable of being governed and grouped so as to be suitable for both main line and switching service. From the several plans submitted in accordance with the general requirements laid down by the commission, a selection was made of the design offered by the General Electric Company, consisting of a double-ended 2200-hp electric locomotive, equipped with a new type of gearless bipolar motors. The total weight of this machine is to be 85 tons, of which 67 tons will be borne on four pairs of drivers. Compared with existing steam practice, it will be interesting to note that the heaviest "Atlantic" type locomotive of this company weighs 150 tons, including the tender, of which but 47 tons are on the two pairs of drivers. It will therefore be seen that for every pound of effective draw-bar pull, the steam locomotive has a weight of 12.2 lbs. as compared with the electric locomotive's economical weight of but 5.2 lbs. This gives in a single electric unit over 25 per cent greater weight available for traction than the largest steam locomotive now in use in this service, with 43 per cent less dead weight, and with 29 per cent less weight on each axle. Moreover, the electric locomotive will have an entire absence of counterbalancing of drivers and twist from reciprocal motion, both of which are so destructive to track and roadbed.

The question of size and exact character of the suburban cars has not yet been settled. Unfortunately, a car designed for the comfort of passengers riding comparatively long distances will be too large to enter the subways, and therefore an interchange of equipment may be found to be impossible. In any event, convenient facilities for the interchange of passengers between the trains of this company and those of the subways and elevated and surface railways will be afforded at the Grand Central Station, and also at several exterior points north of the Harlem River.

For the purpose of testing and making improvements upon locomotives and cars as fast as they are completed, the railroad company is arranging for an experimental track 6 miles in length, near Schenectady. It is expected that the trial of the first locomotive will be made during the present month.

From these proposed improvements thus briefly outlined, the railroad company anticipates a marked increase in the comfort and safety of its passengers, and consequently a decided increase in suburban business. Property abutting on the railroad will naturally increase in desirability as a result of the withdrawal of the annoyances unavoidable in the operation of the steam passenger locomotive. The beautiful territory along the Hudson and Bronx Rivers and Long Island Sound, under these favorable conditions, will grow rapidly in popularity for home-seekers, to the mutual advantage of the railroad company and of the public. What is also of great importance, the adoption of electricity makes possible the future reclamation of between 30 and 40 acres of overhead space in the territory occupied by the terminal yard in the heart of the city of New York, which, instead of being left open as required with steam operation, may be utilized by the company for superimposed structures in any manner best suited for its purpose.

THE VAN DEPOELE ROAD AT MONTGOMERY

BY E. M. BENTLEY

DURING the years 1886 and 1887, the Van Depoele Electric Manufacturing Company, of Chicago, equipped and put into commercial operation fourteen electric railways in different parts of the United States and Canada. It is interesting, at this time, to note the list of places wherein these early railways were installed: Appleton, Wis.; Binghamton, N. Y.; Detroit, Mich.; Fort Gratiot, Mich.; Jamaica, N. Y.; Lima, Ohio; Port Huron, Mich.; Scranton, Pa.; Windsor, Ont.; Ansonia, Conn.; Dayton, Ohio; Wheeling, W. Va.; St. Catherine, Ont.; Montgomery, Ala. Of these, the roads at Ansonia, Conn., and Wheeling, W. Va., were not completed until early in 1888.

The most interesting one was that at Montgomery, Ala., since it was here that there was used for the first time, on a large commercial scale, the now well-known underrunning trolley and the modern overhead construction, substantially as it exists at the present time. It was in the summer of 1886 that Mr. Van Depoele first equipped a trial line with two cars for the Capitol City Street Railway Company at Montgomery. These cars were operated for nearly 2 miles on Court Street, and, by reason of their success, the Van Depoele Company was in September, 1886, given a contract to equip the entire street railway system of the city. The work was immediately started, and in May of 1887 the road was opened for public business. The lines equipped included between 12 miles and 14 miles of track, with numerous curves and switches, and operated fourteen cars. The trolley pole was placed near the forward end and, as the road was operated with loops or turntables, the cars and trolleys were not reversible. The overhead trolley wire was supported as in modern systems by cross wires, which, in some places on Commerce Street and on Dexter Avenue, were anchored to the buildings on either side. Of the fourteen cars, ten were equipped with 10-hp motors and four with 15-hp motors. The motor was placed at the front end of the car and geared directly to a countershaft, which in turn was connected to the axle by a sprocket chain. It is particularly interesting to note that in this road the central station was equipped with two generators of 250-hp each, this being a time when such large units were rare, if not practically unknown, in central station equipments in the country.

ELECTRIC TRACTION UNDER STEAM-ROAD CONDITIONS

BY LEWIS B. STILLWELL

THERE exists a growing conviction that electricity is destined to supplant steam in traction work, not only within the limits of our cities, not only in light and frequent interurban service, but also upon trunk-line railways in both freight and passenger transportation. The electric motor has banished the horse and the steel wire cable from our tramway service, and in suburban and short-haul interurban service has realized possibilities of utility and convenience which the steam locomotive is barely capable of suggesting. The most conservative engineer will admit that the further possibilities of a method of applying power to traction purposes, which has accomplished these things, are worthy of careful consideration even when the supremacy of that marvelous servant of man, the steam locomotive, is challenged.

General substitution of the electric motor engine and motor car for the steam locomotive in handling freight and passenger equipment obviously is a very long step—it should not and cannot be taken in a day or a year. The variety of conditions to be met; the magnitude of the interests involved, alike demand that the new method if adopted at all shall be applied not rashly, but conservatively and wisely—not by assuming that because it has attained a remarkable operative and financial success upon the Manhattan Railway Company it should be adopted at once by the New York Central Railway for operation of its entire system between New York and Buffalo, but by competent study of the many factors that enter into the problem as defined by the peculiar conditions and requirements of each individual case. The limits of this communication preclude any attempt to discuss this interesting and important subject in detail, but it may be of interest to point out briefly certain facts which show that the time for most earnest and serious consideration of the possibilities of the electric motor in heavy railway service has arrived. Among these are the following:

First—For three years alternating-current motors have operated both freight and passenger service upon the Valtellina line in Italy, under conditions and upon a scale sufficient to permit direct comparison of relative operative and financial results attained as compared with those previously secured in steam operation. The comparison demonstrates the decided superiority of electricity in this case in which traffic approximating 200,000 ton-miles per day over a railway 66 miles in length, in mountainous country having a severe climate, is handled with entire success by tri-phase alternating-current motor equipment.

Second—There are now available on the market two variable-speed single-phase alternating-current motors of American design and at least two of European design, each of which is guaranteed by a responsible manufacturer. These motors are practically as efficient as the standard continuous-current series-wound motor, which they resemble closely in speed characteristics.

Third—Transmission of power by alternating current even in northern climates is now effective and thoroughly practicable at potentials as high as 50,000 volts (plants using this potential are in actual service), and at this voltage a line of railway 300 miles in length can be supplied satisfactorily from a single power house located approximately at its middle point.

Fourth—A pound of coal burned under the boiler in a modern power house, if utilized by electric transmission and motors, will haul a given load certainly not less than twice, and as compared with average existing conditions of steam railway service, probably not less than four times as far as it will if burned in the fire-box of a steam locomotive.

Fifth—Experience has demonstrated the economy resulting from the employment of long trains, and in the effort to increase length of train the weight of locomotives has been increased steadily from year to year, the additional weight in many cases implying the necessity of using heavier rails and strengthening the entire permanent way at great expense. Moreover, freight trains are now so long and heavy that the cost of maintaining the rolling stock equipment has become abnormal by reason of the great strains to which draw-heads, couplers, and, in fact, the entire car, are subject. By tried methods of electric traction, motor equipment may be distributed at intervals throughout the length of a train and all controlled with ease and safety by the operator at the head of the train. This method makes it easily possible to operate trains of greater length than can be handled by steam, while the maximum weights to which the permanent way is subjected are greatly reduced by the elimination of the locomotive.

Sixth—In the operation of steam railways, wages of engineers, firemen and round-house men constitute on the average about one-third the cost per locomotive-mile. Judging from the experience of our electrically operated elevated railways, the adoption of electricity in general railway service will greatly reduce the aggregate cost of this very important item of expense.

Seventh—The maintenance of the electric locomotive is materially less than that of the steam locomotive, notwithstanding the at present higher first cost of the former. This statement rests upon experience and is very conservative. In the operation of the Manhattan Railway the total cost of maintenance of rolling stock since electric traction has been adopted has been materially reduced, notwithstanding the fact that two-thirds of the cars are equipped with motors and control apparatus, and notwithstanding the fact that the rate of acceleration and of braking is now about three times what it was when steam locomotives were employed. In the opinion of the writer, the cost of maintenance of an electric locomotive performing the work of a steam locomotive under average conditions of trunk-line operation will be less than one-half the cost of maintaining the steam locomotive.

Eighth—Electric locomotives can be kept in operation almost continuously, consequently the number required for the operation of a railway is much less than the number of steam locomotives necessary to take care of the same service.

Ninth—Electric power supply being available at all points along the line of the railway, passenger stations, freight stations and yards can be lighted and transfer cables, cranes, derricks and tools operated at very low cost.

Tenth—The tri-phase alternating-current system as developed by the Ganz Company, of Buda-Pest, presents possibilities of economy in the operation of mountain divisions, (1) by reason of its distinctive feature of recuperation, and (2) by reduction in wear and tear of brake rigging and wheels, which results from the fact that in running down grade the motor equipment acts as a magnetic brake and absolutely prevents the speed of the train exceeding the synchronous speed of the motors.

Eleventh—Automatic devices which instantly shut off the power if the motorman for any reason removes his hand from the control handle constitute a valuable safeguard to the traveling public for which it is impracticable, apparently, to find an equivalent in steam operation.

As regards objections to the use of electricity, aside from the cost of necessary installation and equipment, there are but two of importance, viz.: Interruption of service by failure of the power supply, and danger to employees and the public from the trolley and feeder circuits. As regards the former, the fact that occasional interruptions of the power supply are liable to occur should be recognized. It is safe to say, however, that the total delays to traffic which are liable to result from this cause will be less than the total delays which now result from the breakdown of engines and in cold weather from their failure to make sufficient steam. In respect to the danger from trolley and feeder circuits, if strictly first-class mechanical and electrical construction is insisted upon and attained, it can be practically eliminated.

In the foregoing I have not referred to the special advantages of electricity which result from the elimination of smoke. These advantages, as is generally realized, make it an ideal motive power for railway operation within city limits. In tunnels and subway construction its use is recognized to be practically imperative, and the great work which several of the most important railways in the country have recently undertaken in the electrification of their city terminals has attracted universal attention.

The adoption of electricity as motive power at terminals of trunk lines creates in itself a reason for the general extension of the use of this new motive power outside the city limits in order to avoid the delay which necessarily results from changing engines at the city line.

In the case of railway companies which may be in position to raise the necessary capital, decision of the question of adoption or non-adoption of electricity upon any given railway system or part thereof will be based primarily upon determination of the aggregate value of the economies and other advantages above referred to, balanced against the annual cost of the new equipment required.

Accurate generalization is, of course, impracticable, but under average conditions electricity will show a profit in the operation of railways where the daily traffic exceeds 10,000 ton-miles per mile of double-track line.

There are many places to-day where the intelligent substitution of electricity for steam would not only pay the entire cost of the change of equipment, but would realize a very handsome reduction in cost of operation. This is particularly true, of course, on mountain divisions and on lines of dense traffic. There are also many branches of our trunk-line systems where great gain would result, not perhaps from reduction in cost of operation, but from increase in revenue which would assuredly follow more frequent and otherwise attractive service. It is precisely in this field that our great railway systems can best begin the use of electricity. Some of them have already done so. Far-sighted directors, managers and engineers of many others are seriously considering the new motive power. In closing, I would point out the great importance of adopting promptly uniform standards of practice in the electric equipment of railways in order that trouble and expense may be avoided in the future. The advantages of a standard-track gage are now universally recognized; scarcely less important will be uniformity of frequency, number of phases employed and relative position of the overhead electrical conductors and the track. Thanks to the transformer, uniformity of potential on the trolley line is less imperative, although highly desirable. It would seem that the American Society of Civil Engineers and the Institute of Electrical Engineers might co-operate with each other and with the manufacturers of electrical apparatus in a systematic attempt to fix these standards.

THE DEVELOPMENT OF DIRECT-CONNECTED GENERATORS

BY LOUIS BELL, PH. D.

THE evolution of the direct-connected generating unit is almost too recent to pass as history. During the early years of electric railway development such a thing was unheard of. The Corliss type of engine reigned supreme in every station that made any pretense to economy of operation, and the rotative speed of this type was, and for that matter still is, far too low for economical direct driving save in very large sizes. And such sizes were not in demand in the early days of the art.

As every one remembers, the early electric cars were, many of them, converted horse cars or cars built rigorously on the old horse car lines. The game began with not over 15 hp of motor capacity per car, and it took a good-sized road to demand a maximum output of 150 or 200 kw. There was absolutely no incentive for several years to stimulate the building of anything save small belted machines. When electric traction began as a commercial proposition, and for several years after, there was not a d. c. multipolar generator of any kind in the country, if one excepts a few small machines designed by Bradley, who was the American pioneer in modern multipolar construction.

The canonical power station of the beginnings of electric traction was a structure equipped with one or two simple low-speed Corliss engines with mighty fly-wheels belted to a line shaft with clutch pulleys. From these were driven two or more bipolar 500-volt generators of 50 to 75-kw capacity each. They were not bad generators, either, those old high-speed machines, and some of them are doing good service yet. The old Thomson-Houston D-62 machine and an Edison dynamo of similar capacity were well designed and robust machines, considering that the armatures were still surface wound, and that castings of first-class permeability were in those days practically impossible to obtain.

The small output of these bipolar machines proved to be a very serious inconvenience, and the amount of shafting, belting and space required had a serious effect on both first cost and efficiency. No ingenuity can avoid losses when a score of small machines has to be employed to give the output required. About 1890, therefore, or very soon afterwards, there began to be a vigorous call for larger generators and a very little consideration showed the manufacturers that increase of output required passing to multipolar construction. If the writer remembers correctly, the largest bipolar railway generators attempted were of 100-kw output and proved rather unsatisfactory owing, probably, to high rating in the attempt to keep down the expense.

The first of the multipolar railway generators, turned out almost simultaneously by several makers, were 4-pole machines of 75 to 100-kw capacity, at first with surface-wound armatures of Gramme type. The passage from this crude construction, due to fear of commutating difficulties, to multipolar drum winding was rapid, although the generators were still belt driven. Speeds were fairly high, say about 400 to 750 r. p. m., and the earlier generators gave some trouble from sparking. This was gradually eliminated, but it was usual to find among the various sizes turned out by any one maker certain which were conspicuously better than the others in their performance. The belted multipolar railway generators increased rapidly in size as the electric roads grew and demanded more and more power, and in 1892 a multipolar machine of about 500-kw capacity, then the largest railway generator in the world, was set up in Los Angeles by the Westinghouse Company. This was, if memory serves the writer, a six-pole machine, and was rope driven. It was certainly the first step toward the modern big generator, although of too high speed to be directly connected to any first-class engine then in current use in this country.

It is somewhat difficult to analyze the causes which hindered the earlier development of the direct-connected unit. Chief among them was the question of cost. In the early days of dynamo design the engineer was constantly hampered by the difficulty of getting material of first-class permeability. To get any considerable density of magnetization in the poles meant a very uneconomical field winding, and a weak field meant an uneconomical armature winding and difficulty from sparking. These considerations blocked the way on large bipolar machines and hampered all the earlier multipolar designs. Concurrently with these troubles ran a fear of slot-wound armatures from the standpoint of commutation. A rather weak field and a drum armature of the ironclad construction meant sparking.

With improvement in the permeability of castings, and particularly with the introduction of steel castings for the fields, at about the date last mentioned, came relief. It became possible to get a compact and powerful multipolar field and to push the armature teeth economically to a point of saturation that greatly facilitated the use of ironclad armatures. With this construction, which produced sharply localized thermal loss in the teeth, came extra need of armature ventilation, and this condition once established made possible an increase of current density in the copper. The result was the rather rapid change in design that has made the modern generator possible. The long armature and massive field construction gave way to light fields worked at high density and short armatures of rather large diameter. With such construction it was not a long step to sufficient increase in the number of poles to permit direct connection to engines of moderate speed. Of course, it is well known that direct connection of electric generators to steam engines had been long practiced here and there. The old Edison "Jumbo" machines with all their disadvantages of design had been in some measure successful, and had certainly done good service to the extent of preparing the way for the ready acceptance of improved apparatus. But the essential point was to secure direct connection to engines of high economy, which meant here compound or triple expansion machines of rather low rotative speed—say 80 to 120 r. p. m. Abroad direct coupling to engines had been accomplished in England by Willans and others, and the way had been cleared in Germany by the construction of slow-speed direct-coupled generators for electric lighting. So far as America is concerned, the equipment of the Intramural Railway at the Chicago Exposition in 1893 marks an epoch. The generators, while not enormously larger in output than some of their predecessors, were coupled directly to compound modern engines, and in them the design had been so successfully worked out that they were an instant and evident hit with every railway man who saw them. That railway in fact was the beginning of the modern period in electric traction, and the generators settled once for all the question of direct coupling.

Beyond this point the main question was merely one of size. It must not be supposed that this was a trivial matter because it proved to be not difficult of settlement. With lowered speed and augmented capacity the field frames of direct-coupled dynamos became engineering structures instead of machine parts. To support them against the mechanical and magnetic stresses required what practically amounted to a girder construction, in the earlier forms a modified plate girder, in the later ones an approximation to a lattice girder. The commutators and brush holder rings likewise grew to almost architectural dimensions, but all these details were quickly and effectively worked out, and within a couple of years after the Chicago exhibit the dynamo builder was ready to meet practically any demand that his customer might make. It is worthy of comment, too, that in this period of very rapid growth in the art there were remarkably few failures, and what of difficulty there was could generally be charged up to the engines rather than to the electrical part of the equipment.

It must not be supposed for a moment that the railway generator of to-day differs from its ancestor a decade since merely in magnitude. There has been steady progress in design, in the direction of improved performance and cheapened construction. Ten years ago comparatively little was known of the fine art of commutation. In early days, the criterion at the commutator was volts per bar, coupled with a general realization that as the current per coil rose the practicable volts per bar fell. The rise of alternating-current apparatus very soon began to put emphasis on the phenomena in armature coils and gave broad hints on the treatment of coils under commutation. A study of field distribution of magnetism let in additional light, and experimental data on commutator surface and the action of brushes did the rest. The net result is that with less costly and complicated commutators than of yore the actual performance has been very much improved, and serious sparking now generally means gross lack of care. Some new mechanical problems arose in the construction of large commutators, but these were soon solved. It must not be supposed, however, that the present-day engineer knows all about commutation. Not yet, by long odds, and although himself an earnest and sincere "rooter" for alternating currents, the writer is strongly of the opinion that the issue can not be laid aside, like free silver, as dead to the world. One can yet learn a thing or two about commutation of relatively high-tension currents, an art little encouraged here but practiced with considerable success abroad.

It is quite possible that the introduction of alternating current for railway motors may reach a point of development that will put direct current permanently out of business, but it is undeniable that with the methods now in vogue a rise of the working voltage, even to a moderate extent, would greatly facilitate the operation of long interurban lines, and for reaching this end a little further study of commutation is desirable.

Another very important direction in which great advance has been made is in the matter of heating. Each year sees ventilation carried successfully a step further, with the result that not only do modern machines run on the whole much cooler than the older types, but they are smaller and cheaper for the same output. This line of improvement has really been followed through every class of electrical apparatus with most admirable results. There is good reason to think that the limit is far from being reached yet. As the art of commutation has advanced it has been possible to push the output further and further without bad results, and in railway motors at least there is something to be said for the merits of forced ventilation.

The economics of this question as regards generators deserve to receive far more attention than has yet been given them. There has been altogether too little realization of the fact that so far as electrical efficiency is concerned there is a maximum beyond which it does not pay to go. Of course, in the extreme case, everyone understands that to raise the efficiency of a generator from 96 per cent to 97 per cent costs something, but that is not the whole story. Take, for example, a 1000-kw generator. The cost of its output the year round may amount to, say, $100 per day. If, from the same structure, without running at a materially higher temperature, one could obtain 50 per cent more output, the general charges of interest, depreciation, cost of power house structure to cover the machines and even of attendance, would be materially less per kilowatt-hour, and one could well afford to lose a part of this gain in lessened efficiency for the sake of securing the rest. The same considerations apply forcefully to transformers where one generally has to pay high for the last per cent of electrical efficiency, and even to station equipment, which may cause one to pay dear in fixed and maintenance charges for fancied immunity from hypothetical accidents. The long and short of the matter is that the total cost of energy per kw-hour, and not the mere operative cost, is the true criterion of station efficiency. Unhappily the costs of power are nearly always given with the fixed charges of every kind eliminated, so that comparisons of station efficiency from the dollar-and-cent standpoint are very difficult to make.

Right along this line the turbo-generator calls for consideration. One of the things greatly to be desired for the sake especially of the smaller stations is a d. c. turbo-generator for railway service. One strong point of such machinery is its good efficiency at low load factors, which generally exist in stations for roads of moderate size. In very large stations, where the load factor is generally high, and can be kept high by regulation of the number of machines in service, efficiency at half and quarter load is a matter of much less moment. When d. c. turbo-generators of moderate size can be had and prove thoroughly good, the station designer will have his task much simplified. Some steps have been taken in this direction, but much remains to be done. Of turbo-generators at large it can fairly be said that they must tend strongly to economy in the matter of fixed charges to an extent that offsets to a very considerable extent any possible losses in steam efficiency. But if direct current is to be the electrical product of the station, one must at present use rotaries or motor generators, which not only raise the general expense but lower the efficiency very materially. Hence this plea for d. c. turbo-generators. If the direct current has got to go, as it surely must if the alternating-current traction motor is perfected, this question will become a dead issue; but so long as trolley systems are fed by direct current, direct-coupled turbo-generators will fill a long-felt want. Future improvements in direct-connected units for direct current must be mainly along the line of intensified output. As they exist to-day they are wonderfully reliable machines, of high efficiency and excellent operative qualities. They have advanced greatly in the ten years passed, and although just now thrust into the background by the huge alternators used in the big power transmission stations, can not yet be forgotten, laid aside, or denied the attention that leads to further improvement.

Electric traction is just at present in a stage of rapid evolution. The alternating street car motor is here for better or worse, and heavy, high-speed railroading looms in the distance. It is a time for watching developments, but we are not ready to lay the d. c. generator on the shelf yet. Pushing its output and improving the properties of the prime mover are the tasks of the next few years. Turbines, high superheating in these and other engines, and, perhaps, the internal explosion engines, are the steps to be taken toward further improvement, whether the direct-current generator holds its own or is pushed to the wall by the final triumph of the hard-fighting alternating-current contingent.

A RELIC OF BY-GONE AGES—HORSE CAR USED BETWEEN BROOKLYN AND JAMAICA IN THE EARLY EIGHTIES

STREET RAILWAYS DURING THE LAST DECADE.

IN this sketch of the development of the street railway industry no attempt will be made to recount the history of the American street railway prior to 1894. A short account of street railway development from 1832 to 1894 appeared in the tenth anniversary number of the STREET RAILWAY JOURNAL, and this, with the testimony presented by the pioneers themselves elsewhere in this issue, covers the origin and early history of the electric street railway. There remains, therefore, only the pleasant task of sketching briefly the steps by which the industry with its invested capital, in 1894, of $1,300,000,000, has grown to man's estate, with a capital investment in 1904 of about three and a quarter billion dollars and occupying an important place in the social and economic welfare of the entire country.

It is somewhat of a peculiar coincidence that the evolution of the electric railway should be so clearly marked into well-defined stages by the opening and closing years of the two decades which terminate with 1894 and with the present year. The first commercial trolley railway was that installed by Van Depoele at the Toronto Exposition of 1884, and the ten years from 1884 to 1894 may properly be considered the era of the city railway. In 1894 this form of road had about reached its full development, and if it had not been for the introduction of the three-phase system of power distribution electric railway construction would undoubtedly have begun to wane. It was in 1894 that three-phase system of power transmission was first practically applied to railway work, rendering the economical distribution of electricity, and with it the interurban railway, possible.

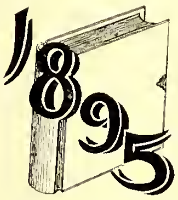
As 1894 constituted the beginning of the "interurban decade," is it not possible that 1904 will mark the beginning of another and equally as important an era in heavy traction service? Coming events cast their shadows before, and the improvements announced during the past twelve months in methods of power generation and its more economical utilization at the axle by means of single-phase motors portend, if we read the indications aright, a still greater development than has heretofore been experienced; one, indeed, which may mean the conversion of a considerable proportion of the present steam railroad system of the country with its 283,000 miles of track. This article must be devoted, however, to an account of what has been accomplished, not to a foretaste of what is to come. Laying aside then the pen of prophecy for the safer though more prosaic one of history, an attempt will be made to sketch briefly the street railway conditions in this country as they existed a decade ago, and to refer to the most important events of the succeeding ten years.

This year marked the date at which the promotion stage of the electric railway as a system was practically over and when operating questions, especially that of depreciation, began to be considered. The previous decade, which had opened with the electric railway in an experimental stage and with capitalists, city councils, and even street railway managers, suspicious of the new motive power, had closed under entirely different conditions. The initial mechanical and electrical difficulties had been overcome; the traffic which had been stimulated by the introduction of an improved motive power, had risen by leaps and bounds; the old period of distrust of the electric railway as a system had given place to an enthusiasm almost as unreasonable, and depreciation caused by natural causes and by advances in the art was forgotten for the time by city councils, as well as by many promoters, capitalists and street railway companies. Those who had been in the business for some time understood the conditions better than the general public, most of whom supposed that there was almost an unlimited amount of money to be made, and was being made, in electric railway work. The Railroad Commission of Massachusetts, whose foresight and judgment have always commanded the highest respect, was probably the first official body to call attention to the proper state of affairs. In their report for 1893, published early in 1894, the Commissioners said that, "while it is too early as yet to draw exact and final conclusions with regard to the financial economy of electric power, it is desirable that false or exaggerated ideas, if such have gained a footing, should be set aside." The Commissioners then pointed out that "the idea which seems to have obtained some currency that the electric railway system was a bonanza of rare and inexhaustible wealth is clearly a delusion, and has doubtless proved to some a snare." The Commissioners, in conclusion, urged the importance of setting aside year by year some substantial portion of the earnings as a fund for future contingencies.

In the meantime New York City had lagged behind the rest of the country in electric railway construction, owing to local conditions, which are described elsewhere in this issue in an interesting article by Mr. Starrett. The Metropolitan Traction Company, which then operated the lines in New York, had just completed its cable railway on Broadway, but financial considerations forbade the use of this motive power on any of the crosstown streets or on many of the other longitudinal thoroughfares of the city. The company, forbidden to use the trolley system, was in a very serious quandary, as it was forced to make some decision to provide an earning power for the numerous systems which it had leased. A prize of $50,000 had been offered by the company in December, 1893, for "a system of street railroad propulsion which should be superior to the cable and trolley." Over 3000 applications were received. Many of the schemes proposed were ludicrous; one inventor suggested the supply of motive power by means of wind-mills on top of the cars; another proposed to utilize the force exerted by the rise and fall of the tides at Sandy Hook, while a third made a proposition to run the street railways by harnessing the cars to balloons. In the meantime the company, discouraged with the failure of this plan, as well as by the delay of the Legislature in granting permission to the Railroad Commissioners to act as judges of the prize, withdrew its offer and decided to install a conduit system. Arrangements were made with the General Electric Company, and a short section on Lenox Avenue was selected for the important trial, which has since proved so successful.

One of the earliest three-phase transmission plants employed to transmit power at high potential for railway work, if not the first in the country, was put in operation in April. This was at Taftville, Conn., where the greater part of the power was used for mill service, but where a synchronous motor and railway generator of about 250 kw was installed to supply power to the Norwich street railways. This plant was constructed under the supervision of Dr. Louis Bell. Simultaneously with this installation, the important of which could not have been realized at that time, came the announcement that the Walker Manufacturing Company had decided to engage in electrical construction. This company, up to this time, had devoted its energies entirely to the manufacture of cable railway and power transmission apparatus, but soon became an active competitor in the business of supplying motors and generators.

Three important types of railway appliances were brought out during this year. One of these was the street railway air-brake, made available by the development of the Genett air-brake. In its original form the Genett compressor was driven by means of an eccentric mounted on the axle. The second important development of this kind during the year was the first application of electric welding to rail joints. Mr. Moxham, of the Lorain Steel Company, had discussed the possibility of connecting rails in this way, but during 1894 the Nassau Railway, of Brooklyn, which was then controlled by the Johnsons, applied the system practically. The third important appliance in the production of the year was the Sperry electric brake, which was used extensively on the People's Traction line in Philadelphia. A motor car using anhydrous ammonia gas as a motive power was also put in operation during the year on the Twenty-Eighth and Twenty-Ninth Street line in New York, and several new electric motors made their appearance, among them the Card, the Curtis and the Walker. In the latter a novel system of suspension was employed. The convention this year was held at Atlanta, and one of the papers was on "A Standard Form of Street Railway Accounting," in which a proposed form was recommended.



This year commenced with a disastrous strike on the Brooklyn system, the greater part of which had recently been equipped with the trolley. The police were found incapable of controlling the situation, and the National Guard had to be called upon to preserve order in the City of Churches. A particularly unfortunate feature of the situation was the position of Judge Gaynor, who had recently been elevated to the bench on account of distinguished services in bringing political rascals to justice. This justice ignored entirely the violence perpetrated by the mob, and at the request of the unions granted a writ calling upon the companies to run their cars on schedule time, saying: "If they cannot get their labor to perform such duties at what they offer to give, then they must pay more." The strike did not last long after the authorities showed that they were prepared to maintain the reputation of the city for law and order, and the cars were soon running merrily as before, the ex-strikers falling over themselves in the endeavor to regain their lost positions. Across the river in New York interest was concentrated chiefly upon the demonstrated success from an electrical standpoint of the conduit system which had been installed by the Metropolitan Street Railway Company during the previous year; in fact, so desirable did this form of motive power prove to be that in August the Third Avenue Railway Company decided to put in an experimental electric conduit line at the end of its Tenth Avenue Division, and the Metropolitan Railway Company, of Washington, commenced the reconstruction of its cable lines to electricity.

A survey of Chicago at this period discloses an equally interesting and important departure from previous practice. The Metropolitan West Side Elevated Railroad Company had recently completed the equipment of its line under the supervision of W. E. Baker, and commenced the operation of electric trains. This was the first continuous elevated railway put in operation by electricity in the United States. The electrical equipment consisted of 55 motor cars and 100 trail cars. The equipment of the company's station was equally characteristic of the foresight of the management, as it included two 1500-kw and two 800-kw generators, the former being the largest size of generator then manufactured. The West Side road was put in operation April 17, and the third rail was carried on one side of the track and mounted on wooden insulators which had been treated in paraffine.

In Boston the ceremony of removing the first spadeful of earth for the subway was conducted on March 28, and in Detroit Mr. Everett started on the construction of his Detroit Electric Railway. The track was laid on continuous concrete stringers, a somewhat novel form of construction at that time in the United States. Cast-welded joints, which had first been exhibited at the Atlanta convention, began to come into more general use, and double-truck cars became more popular. A rotary snow-plow had been introduced in Rochester during the previous winter, and was attracting considerable attention. The Union Traction Company, of Philadelphia, was organized to take over the People's Traction Company and the Electric Traction Company; the Buffalo & Niagara Falls Electric Railway was put in operation, and the Niagara Gorge Road was being constructed. The Pennsylvania Railroad Company put its Burlington & Mount Holly Branch in electrical operation on June 3, and the Baltimore & Ohio Railroad had the first of its 35-ton locomotives for drawing freight and passenger trains in service on June 29.

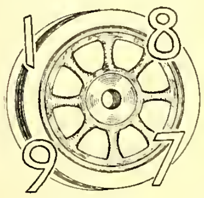
The description of the work in this country cannot be concluded without reference to two important events which occurred in New England. One of these was the installation of a three-phase transmission with double-current generators by the Lowell & Suburban Street Railway Company. This is said to have been the first three-phase transmission plant with direct-current conversion installed exclusively for railway work. The other was the commencement of the reconstruction of the Nantasket Branch of the New York, New Haven & Hartford Railroad Company. This was the first road to use a figure 8 trolley wire.

Several important events occurred in London during the year. The Central London Railway was put in operation in July, and the Mersey Railway secured a bill through Parliament permitting it to substitute electricity for steam power on its line between Liverpool and Birkenhead.

In 1896 the energies of the railway companies were devoted largely to the development of plans which had been inaugurated the previous year. In May the Nantasket Beach Branch of the New York, New Haven & Hartford Railroad Company was put in operation, and the increase in traffic was so large that electrical extensions were immediately commenced. Heavy electric railroading became popular and carried the day with even the conservative managers of the Brooklyn Bridge. The Bridge transportation system had for a long time been operated exclusively by the cable, and was often referred to as an example of conditions under which the cable was much more satisfactory and economical than electric power ever could be; nevertheless, the advantages of electricity could no longer be overlooked, and arrangements were made under the specifications of the late C. C. Martin for an electric service on the Bridge. Twenty motor cars, each equipped with four $62\frac{1}{2}$-hp motors and hand control, re-

TEN MILE-STONES IN THE HISTORY OF THE PAST DECADE placed the steam shifting engines, and were put in operation on Nov. 29. Two weeks previously, or on Nov. 16, Niagara power was received in Buffalo over a long-distance transmission line 26 miles in length. The Buffalo Street Railway Company had made arrangements to purchase this power as soon as it could be delivered, and was one of the company's first customers in Buffalo. Cast-welded joints, which had been introduced upon a small scale during the previous year, were largely adopted, and the Everett system of interurban roads around Cleveland began to attract the attention of capitalists. The Lugano three-phase railway was put in operation by Brown, Boveri & Company.

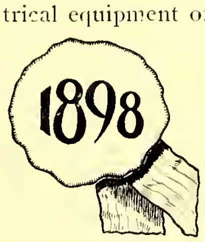
The annual convention of the American Street Railway Association was held in St. Louis, where at that time there was a large number of different railway companies. St. Louis was one of the first cities to adopt long double-truck cars, and the inspection of these large cars by the railway men who attended the convention stimulated their wide adoption in other parts of the country.



By 1897 the underground conduit system had won a recognized place as a means of city transportation in New York City. It was formally adopted as the standard equipment for the longitudinal lines of the Metropolitan Street Railway Company, and the conversion of the Fourth, Sixth and Eighth Avenue lines from horses to electricity was decided upon. In Chicago, the principal feature of interest was the adoption of the multiple-unit system by the South Side Elevated Railway. This line had been constructed about the time of the Chicago World's Fair, and had been using steam as a motive power. The management had naturally given a great deal of attention to the electrical conversion of the line, and during the previous year had received estimates from practically all of the manufacturing companies. Plans for a locomotive system similar to that in use on the West Side were tentatively prepared, but were abandoned in favor of the multiple-unit system, which had recently been devised by F. J. Sprague, and which was put in operation under his supervision on the South Side Road on April 20 of the following year.

A meeting of the street railway accountants of the country was called in Cleveland on March 23 to organize an association, which was satisfactorily concluded. One of the first subjects taken up was that of a standard system of accounts. The General Electric Company abandoned its former method of motor nomenclature derived from the draw-bar pull, and brought out a new motor, which was called the No. 52, and which had a capacity of about midway between the GE 800 and GE 1000.

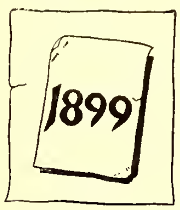
The commission sent out by the Glasgow municipality for a trip in the United States during 1895 reported in favor of the overhead system, and arrangements were begun for the electrical equipment of the tramways in that city.



The commencement during the previous year of electrical service on the Brooklyn Bridge was but the stepping-stone to a more important change, so far as convenient transportation for the residents of Brooklyn were concerned. The conviction forced itself on the minds of the city authorities that isolated systems of this kind 1½ miles or so in length belonged to the past, so that it was not a great surprise when the Brooklyn Rapid Transit Company offered to lease the Brooklyn Bridge Railway, an offer which was accepted by the city authorities. The formal use of the Brooklyn Bridge by the Brooklyn Rapid Transit Company took place on Jan. 22, 1898. During this year also the historical West End Railway was leased by the Boston Elevated Railway Company, and the united system entered upon an era of improvement and development which has done more for the citizens of Boston than any event since the initial contract for electrical equipment on the West End Railway was awarded.

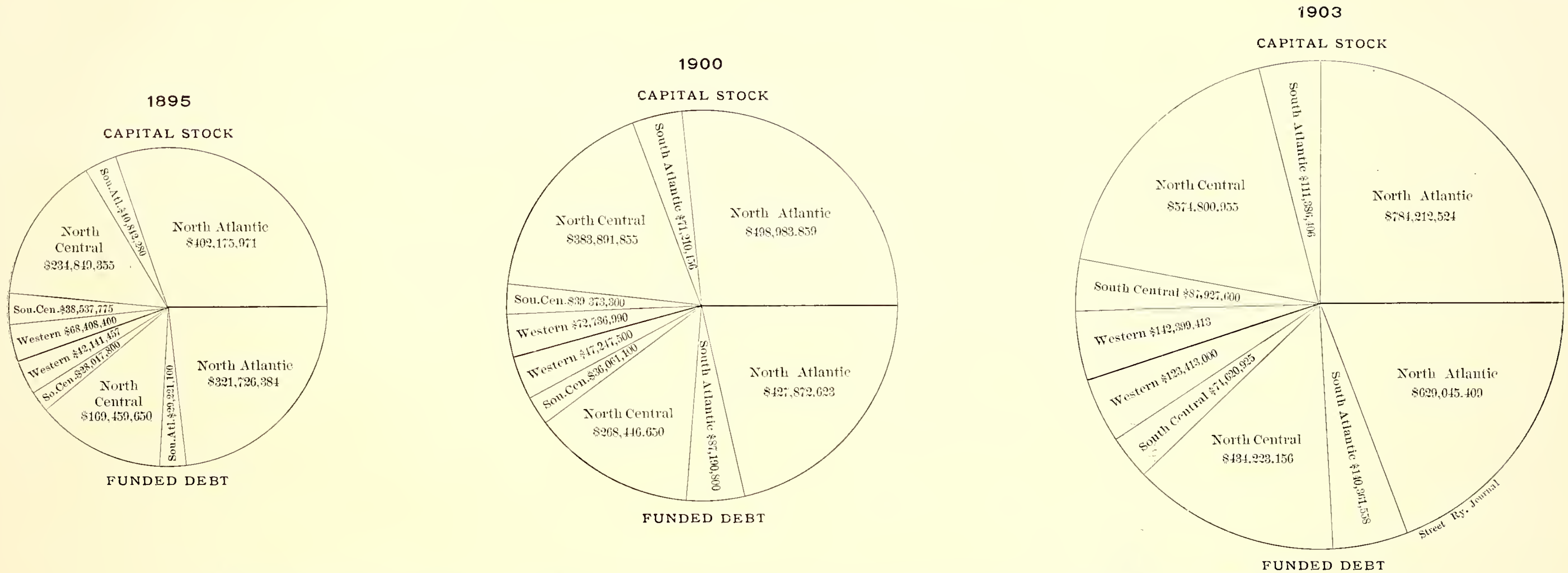
Work on the transformation of the Broadway Road in New York was commenced early in the year, the first step being the installation of feeder conduits the entire length of the line. The hydraulic power plant at Mechanicsville was also completed during the year. The use of storage batteries as station auxiliaries became more general, and the Capitol Traction Company, of Washington, whose power station had been destroyed by fire late in 1897, decided to introduce electricity in place of the cable.

During the year the war between the United States and Spain broke out, and a number of electrical engineers went to the front. Many of them joined the Volunteer Corps of Engineers, under the command of General Griffin, while others took an active part in the naval or military operations. In Great Britain the electrification of the systems in Glasgow and Liverpool, both of which were owned by the municipality, was concluded.

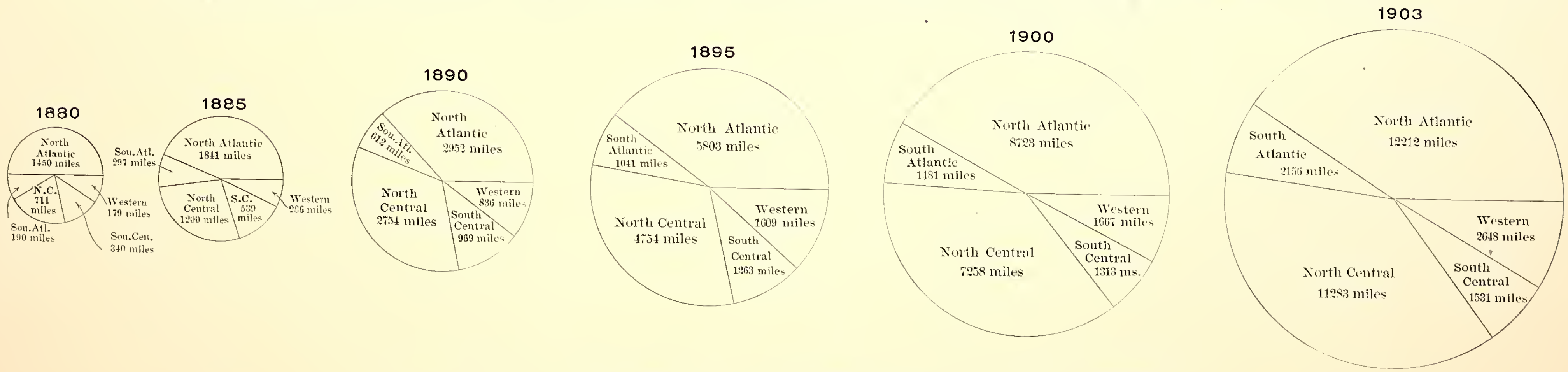


This was the year of the passage of the hastily executed and crudely revised Ford franchise bill, which taxed all the corporations in New York State operating under public franchises. The history of this bill is so well known as not to require repetition, and its constitutionality is still being contested by several of the largest companies affected. Hurried through as it was during the closing days of a busy session, it was found to be so poorly drawn as to be practically invalid; doctored up at an emergency call of the Legislature at which practically no opportunity was given for those companies whose interests were vitally affected to present evidence as to its results, the bill passed into history as one of the most extraordinary acts of tax legislation in modern times.

Outside of this bill there were many noteworthy events in electrical history. Early in the year President Gould, of the Manhattan Railway Company, made the important announcement to the stockholders that the company had decided to introduce electric traction. According to the president's circular, "the most conservative estimates made by experts show a saving of 2½ cents per car-mile on the entire car-mileage of the elevated roads. As we are now running 4,000,000 car-miles annually, the saving in operating expenses alone will be over $1,000,000 a year, which, with other expenses possible, is sufficient to pay 5 per cent on the $18,000,000 capital, which it is proposed to put into the elevated roads, and 1 per cent additional on present capital." The circular also refers to the probable increase in traffic, the ease with which cars can be handled at terminal points, the running of open cars in summer, etc. This circular marked the culmination of a series of efforts made by electrical inventors and manufacturers as far back as 1883 to convert the directors of the Manhattan Railway Company to change their system to electric traction. While the company had permitted the operation of the "Ben Franklin" and a Sprague equipment in the early days and had received estimates galore for the electrical equipment of its line from practically every electrical manufacturing company in the



DIAGRAMS SHOWING DISTRIBUTION OF CAPITAL STOCK AND FUNDED DEBT OF STREET RAILWAY ENTERPRISES IN THE UNITED STATES



The Classification of States Comprising Different Sections of the United States, Used in the Above Compilations, was:

States Comprising Different Sections of the United States

North Atlantic:
Maine.
New Hampshire.
Vermont.
Massachusetts.
Rhode Island.
Connecticut.
New York.
New Jersey.
Pennsylvania.

South Atlantic:
Delaware.
Maryland.
District of Columbia.
Virginia.
West Virginia.
North Carolina.
South Carolina.
Georgia.
Florida.

North Central:
Ohio.
Indiana.
Illinois.
Michigan.
Wisconsin.
Minnesota.
Iowa.
Missouri.
South Dakota.
North Dakota.
Idaho.
Nebraska.
Kansas.

South Central:
Kentucky.
Tennessee.
Alabama.
Mississippi.
Louisiana.
Texas.
Arkansas.

Western:
Montana.
Wyoming.
Colorado.
New Mexico.
Arizona.
Utah.
Washington.
Oregon.
California.

country, it had steadfastly refused to withdraw the puffing steam dummy. Although the company undoubtedly lost considerable traffic which would have been secured through an earlier decision to adopt electricity, it undoubtedly benefited by securing much more modern and efficient machinery by postponing the inevitable moment until electrical apparatus had been so standardized that radical changes in design were comparatively unlikely.

In addition to the elevated decision, New York City was the center of electrical interest, owing to the rapid transit situation. After many years of laborious work, the Rapid Transit Commissioners had finally succeeded in inducing a responsible financial syndicate, in the person of the Metropolitan Street Railway Company, to bid upon an underground subway. The offer of the Metropolitan Company, which was sent to the Rapid Transit Commissioners on March 27, proposed the construction of a subway on which the local fare was to be 5 cents, but for which an express fare of 10 cents was asked. Transfers were offered to passengers to and from the surface cars without additional charge, but local passengers were to pay 3 cents additional fare. The Metropolitan Company also required a perpetual franchise. The latter clause aroused some public opposition, and on April 17 the Metropolitan Street Railway Company withdrew its offer. This paved the way for the McDonald contract, which was awarded during the following year.

While these events were occurring in New York, attention became directed to Michigan through the irrepressible Governor Pingree. This gentleman, who had distinguished himself while Mayor of Detroit by a series of noisy, though futile, attacks upon the local street railway system as a step toward securing public favor, had been elected Governor of the State, from which vantage point he carried on a campaign against the railway interests, although in a somewhat different manner. During the winter of 1898-99 he succeeded in getting through the Legislature of Michigan a bill by which the city of Detroit was authorized to purchase the street railways of the city at an appraised valuation, and under this act three commissioners were appointed to determine the purchase price. This committee considered the subject in a more elaborate and complete manner than has ever been applied before or since to a street railway system in any American city. The price finally fixed upon as a fair valuation was $16,500,000, a sum which was undoubtedly very much in excess of that which the filibusters in the city and State councils expected to pay. On July 5, however, the Michigan Supreme Court decided that the bill authorizing the appointment of the street railway commission was unconstitutional, and the whole scheme fell through.

Stimulated by the example of the Metropolitan Street Railway Company, the Third Avenue Railroad Company, which was then a separate corporation, had completed contracts for the electrical equipment of its cable lines. The 125th Street Crosstown line was put in operation Sept. 28, the section from 130th Street to Sixty-Fifth Street on Oct. 22, and the first through car on the Third Avenue line was run from the Harlem River to the Post Office on November 24.

Other important events during the year were the organization of the International Traction Company to consolidate the street railways in Buffalo and Niagara Falls, the announcement of the discovery of thermit in Germany by Dr. Goldschmidt and of the perfection of an electro-pneumatic system of train control by the Westinghouse Electric & Manufacturing Company.

During 1899 the Street Railway Journal published a weekly supplement devoted to notices of current interest, and entitled the "Weekly News Bulletin."

1900

The extent of the street railway field had now become so great that it became evident that a monthly paper could no longer satisfactorily serve the field. The publishers of this paper, therefore, decided to place it on a weekly basis, and the first issue appeared Jan. 6, 1901. The events of the succeeding four years have amply demonstrated the wisdom of this decision.

On Jan. 15 John B. McDonald was awarded a contract for the construction of a rapid transit subway system in New York. This contract was transferred by Mr. McDonald, with the approval of the Rapid Transit Commission, to a corporation which had been organized by him to carry out the work, and in which August Belmont was largely interested. On March 24 the first ground was broken for the subway. The event was made the occasion of elaborate ceremonies in front of the City Hall, in which the Mayor of New York, Mr. McDonald, Mr. Belmont and several of the Rapid Transit Commissioners took an active part.

The work has been vigorously prosecuted ever since, and at the time of going to press the opening of the subway seems a matter of only a few days.

During this preliminary work on the subway important events were occurring rapidly in New York, which were destined to affect vitally the surface transportation system. The extensions and improvements which the Third Avenue Railroad Company had introduced during the previous two or three years had been carried out with borrowed money, and an attempt of the company to issue a mortgage on its property had culminated during the first two or three months of the year in a serious fall in the market value of its securities. While the stock was selling at about 50, and while the speculators in Wall Street were wondering whether it would drop to 25, the announcement was made on March 20 that the control of the property had been secured by the Metropolitan Street Railway Company, and on March 21 Mr. Vreeland was elected president of the company. The results so far as the completion of a harmonious plan of surface transportation in New York was concerned were far-reaching, and with this step all the surface railways in Manhattan and Bronx boroughs, New York, were brought under one management.

This was essentially a year for consolidations, among others that of the St. Louis railways, the plan for which was announced by Brown Brothers on March 26, while the Connecticut Railway & Lighting Company secured control of the Bridgeport Railway and a number of other properties during the year. The St. Louis consolidation was followed in that city by an extended strike, which went into effect on May 8. A number of persons were killed, and efforts were made to induce the Governor to call out troops to suppress the riots, but for a long time without avail. The strike lasted about fifty days, and was finally settled by the employees, or as many of them as the railway companies would take back, going back to work.

A large part of the month of April was given up in Boston to conducting a series of tests on different motor train control systems to be used on the elevated railway then nearing completion.

The Paris Exposition was held during 1900 and was visited by a great many Americans. The most interesting features of

SOME ADVERTISERS IN VOLUME 1 OF THE STREET RAILWAY JOURNAL WHO ARE STILL DOING BUSINESS WITH STREET RAILWAY COMPANIES the Exposition from an electric railway standpoint were the moving sidewalk and the electric locomotives and multiple-unit systems. Preparatory to the Paris Exposition, a section of the Paris Metropolitan Railway was put in operation. This was the first complete subway railroad to be equipped with electricity, as all of the electric underground roads in London were tube lines. The first section of the Metropolitan system was put in operation July 16. An International Tramway Congress was held in connection with the Paris Exposition on Sept. 10-13, in the Hall of Congresses, and was attended by representatives from all parts of Europe. During the latter part of the year the London Metropolitan District Underground Railway, the Yerkes system, called for bids for the equipment of 50 miles of underground line.

1901

The success of the third rail as used by the New York, New Haven & Hartford Railroad and on the elevated railways in Chicago, and its demonstrated capacity for heavy currents, lead to its adoption by the Albany & Hudson Railway, which was put in commercial operation during the spring of this year. The third rail was not laid in the center of the track, as on the Nantasket and New Berlin divisions of the New York, New Haven & Hartford Railroad, but at the side, according to the Chicago practice, and also that which has been followed ever since. This Albany & Hudson was probably the first independent interurban third-rail railway to be put in service. The following May an extensive strike occurred in Albany, and during the first few months of the year the Broadway, Columbus and Lexington Avenue cable lines, in New York City, were converted to electricity. The last cable to be taken out, that between Houston Street and Thirty-Sixth Street, was removed May 25, and complete electrical operation was commenced. The Union Railroad Company, of Providence, announced the establishment of a pension system for superannuated employees. A disastrous strike occurred in Scranton during the latter part of the year.

On Dec. 12 the Pennsylvania Railroad Company announced its intention of running its trains into New York through a tunnel under the Hudson River, making an all-rail connection by means of a series of tunnels under the East River with the Long Island Railroad.

Several important events occurred in Europe during the year; the Metropolitan and District Railways, of London, being unable to settle between themselves whether they would use direct current or the polyphase system for the operation of their underground lines, decided to leave the subject to an arbitrator. The polyphase side was advocated by Ganz & Company, and a number of American manufacturers testified in favor of the direct-current system. The arbitration hearings extended for the greater part of the year, and some of the most noted spellbinders in the United Kingdom argued in favor of one system or the other. The arbitrator finally decided in favor of the direct-current system, and arrangements were immediately made for carrying out the proposed equipment. In the meantime the Studien Gesellschaft, which had been organized to carry on a series of high-speed electric motor tests in Germany, secured the use of the line between Berlin and Zossen, 20 miles in length, and the tests were carried on during the late summer and fall, although no results were made public until the following summer.

On Dec. 30 the first train on the Manhattan Elevated Railway, in New York, to be operated by the new electrical equipment, with the company's own power and over any considerable section of the road, was run on the Second Avenue division.

1902

This year opened with several important events. One of these was the first official trip with the new electric equipment on the Manhattan Elevated Railway, in New York, which occurred Jan. 9.

Early in January announcement was made of the financial embarrassment of the Everett-Moore syndicate, which up to this time had been one of the most important syndicates in the country engaged in the construction of electric railways. Its operations had been confined principally to Ohio and South Michigan, and had been quite successful, but ventures in independent telephone companies were reported to have been the cause for the financial trouble.

On Jan. 8 a serious accident occurred in the Park Avenue Tunnel of the New York Central Railroad, by which one of the trains had an end-on collision with another. At a special meeting of the directors of the company, held on Jan. 15, to consider means for avoiding future accidents of this character, it was voted that the stockholders at the April meeting be requested to pass upon the plan of increasing the capital $35,000,000 to introduce electric motive power in the tunnel. The tunnel disaster elicited many suggestions for improvements in tunnel operation, including a letter by George Westinghouse calling attention to the value of using non-combustible cars. The wisdom of this suggestion has been shown after four years by the general adoption of fireproofing methods by the underground and elevated railway lines, both in this country and abroad.

On Feb. 4 announcement was made of the organization of a holding company in New York to take over the Metropolitan Street Railway Company of that city, at a guarantee of 7 per cent on its outstanding capital stock. The official plan of this lease was made public Feb. 14. When the organization of the Interurban Street Railway Company, the leasing company, was announced, it was found that the directors included a number of the most prominent capitalists and representatives of business interests in the city. On March 6 the Metropolitan Street Railway Company established a pension fund for its superannuated employees. This pension system went into force July 1.

The first of the year witnessed the inauguration of Tom. L. Johnson as Mayor of Cleveland. Soon after his induction into office the Mayor started a campaign against the street railways in Cleveland, and attempted to secure important franchises in that city for a new company, which was to charge a fare of 3 cents.

Mr. Yerkes, who had sold out his Chicago line, organized the Underground Electric Railways Company, London, to take over a number of the existing and proposed underground railways in London. In opposition to the Yerkes system of underground railways in London, another consolidation of proposed underground electric railways was formed in that city, known as the "Morgan group," and an active fight developed in Parliament. On Oct. 21 it was announced that Mr. Yerkes had secured control of the London United Tramways Company, which interfered considerably with the plans of the Morgan group of underground railway builders.

The London meeting of the International Tramways and Light Railways Association, the first meeting ever conducted in an English-speaking country, was held during the first four days of July. There was a large attendance.

During the summer and fall there was an extensive strike on the Hudson Valley Railway, during which the militia had to be called out. This strike was declared on the morning of Aug. 30, and extended until late in the following October.

At the Sept. 26 meeting of the American Institute of Electrical Engineers, Mr. Lamme read a paper on the single-phase motor, marking a new phase in the struggle against the limitations imposed by a direct-current distribution. During the close of the year the Philadelphia Rapid Transit Company made public plans for the construction of a subway on Market Street, and on Dec. 9 a bill authorizing the construction of a subway on Washington Street, in Boston, was passed by a referendum vote of the citizens. On Dec. 10 it was announced that the directors of the Interborough Rapid Transit Company and of the Manhattan Railway Company had provided a form of lease which is to be signed by the two companies. The ratification of this lease by the Manhattan stockholders took place Jan. 16 of the following year.

We are now treating such recent events that they need be discussed only briefly:—1903 opened with the Chicago situation in a new stage. B. J. Arnold, who had been engaged as an expert by the local transportation committee of the Chicago City Railway Company, rendered an elaborate report on the situation in that city, making various recommendations to relieve the transportation situation. In New York City, where the street congestion was even worse, public attention became directed to the transportation problem through a series of hearings held by the Railroad Commissioners on the street railway facilities in the city. The Merchants' Association offered a set of regulations, some of which were absurd, but others of which had been vainly sought by the railway company to relieve the congestion, particularly in the downtown district. The managers of the surface system agreed to co-operate with the Commissioners in any steps which they might suggest for relieving a condition which had grown extremely onerous, and by the adoption of rules governing the movement of vehicles in the streets considerable progress has been made.

The personnel of the New York Central engineering commission was announced the second week in January. It was found to consist of two representatives of the New York Central Railroad and three independent consulting engineers. The Boston Elevated Railway Company on Jan. 19 announced the establishment of a pension fund for aged employees who had been in the service of the company for twenty-five years or more. On March 14 Mayor Low drove the first spike in the track of the New York subway. The most serious strike of the year was that in Waterbury, and resulted in considerable disorder and bloodshed.

The consolidation of the larger part of the street railway companies in Newark, Jersey City and the Orange district was completed early in the year under the title of the Public Service Corporation of New Jersey. The official notice of the consolidation was contained in a report issued by the boards of directors of interested companies, on April 13. The Mersey Railroad was put in operation. The first public announcement of the details of construction of the Curtis turbine was made April 2, 1903. The census report of street railways, which was taken in 1902, became available in June. The Boston & Worcester Street Railway, the longest interurban electric railway operating through cars in New England, was put in operation July 1 between Boston and Worcester. On Aug. 29 announcement was made that Thomas F. Ryan and

TABLE SHOWING ELECTRIC, MISCELLANEOUS, CABLE AND HORSE MILEAGE OF STREET RAILWAYS IN THE UNITED STATES

	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903
Electric	.....	.....	8	29	289	805	1,262	4,061	5,939	7,476	10,363	12,133	.....	13,765	15,942	17,665	19,314	22,217	25,592	29,212
Miscellaneous	.....	.....	.....	.....	.....	.....	711	642	589	543	679	519	.....	467	508	454	428	400	407	358
Cable	129	266	291	357	467	564	488	594	646	658	632	599	.....	539	448	403	330	241		
Horse	.....	.....	.....	.....	.....	.....	5,662	5,302	4,460	3,497	1,914	1,219	.....	947	651	420	370	326	293	260
Total	3,752	4,113	4,577	5,446	7,100	7,399	8,123	10,599	11,634	12,174	13,588	14,470	.....	15,718	17,549	18,942	20,542	23,184	26,292	29,830

Statistics from 1884 to 1890 inclusive, from United States Census Report for 1890, and are, presumably, for the year ending July 1.
Statistics from 1891 to 1903 inclusive, compiled by the Street Railway Journal, and are for the year ending December 31. No compilation was made in 1896.

TABLE SHOWING MILES OF TRACK AND NUMBER OF CARS OF THE STREET RAILWAYS OF THE UNITED STATES

	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903
Miles of track	3,752	4,113	4,577	5,446	7,100	7,399	8,123	10,599	11,634	12,187	13,588	14,470	.....	15,718	17,549	18,942	20,442	23,184	26,292	29,830
Number of cars	.....	.....	.....	.....	.....	.....	32,505	37,405	38,802	41,027	44,745	48,182	.....	51,532	56,772	58,569	62,918	65,900	70,006	76,186

Statistics from 1884 to 1890 inclusive, from United States Census Report.
Statistics from 1891 to 1903 inclusive, compiled by the Street Railway Journal.

his associates had purchased the holdings of Kuhn, Loeb & Company in the Metropolitan Securities Company.

At the Saratoga convention the Westinghouse Electric & Manufacturing Company made its first exhibit of the turret system of electro-pneumatic control, and later in the year announced that it was ready to take contracts for single-phase railway motor equipments. Almost simultaneously news came from abroad of the development of the Eichberg-Winter motor by the Union Electricitäts Gesellschaft and the Finzi motor by Dr. Finzi, of Italy. On Oct. 15 the Brooklyn Rapid Transit Company announced the establishment of a merit system for all of its employees.

During the latter part of November the New York Central & Hudson River Railroad Company awarded contracts for the electrical equipment of its New York terminal, making the largest electrical contract given in the history of electric traction.

No article on the development of the street railway industry during the last ten years would be complete without some statistics as to its material growth. Figures of this kind have been compiled and are presented herewith. For convenience in making comparisons, they have been carried back as far as any reliable statistics are available. The diagrams on page 594 show respectively the distribution of the capital liabilities of the street railway enterprises in different sections of the country for 1895, 1900 and 1903. A table showing the total capital stock, funded debt and capital liabilities for these and for a number of intervening years, is published on this page. The lower series of diagrams on page 594 shows graphically the relative amount of street railway track in different sections of the country, and the corresponding table appears on page 598. In both of these compilations the figures for 1890 and previous years are from the Census Bulletin of 1890, which, in addition to the statistics of the year, contained considerable tabulated information in regard to previous years. The figures for the following years—that is, from 1891 to 1903—are from American Street Railway Investments. No compilation was

TABLE SHOWING CAPITAL STOCK, FUNDED DEBT AND TOTAL CAPITAL LIABILITIES OF STREET RAILWAYS OF THE UNITED STATES

	1890	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903
	$	$	$	$	$	$	$	$	$	$	$
Capital stock	289,058,133	748,014,206	784,813,781	....	846,131,691	904,169,236	991,012,762	1,066,196,460	1,360,712,238	1,522,068,760	1,700,726,898
Funded debt	189,177,824	522,125,505	590,596,391	....	633,079,178	698,830,423	782,963,471	866,868,673	1,055,451,817	1,272,269,491	1,401,664,048
Total capital liabilities	478,235,957	1,300,139,711	1,375,410,172	....	1,479,210,869	1,602,999,659	1,773,976,233	1,933,065,133	2,416,164,055	2,794,338,251	3,102,390,946

Statistics for 1890, from United States Census Report, and are for year ending July 1.
Statistics from 1894 to 1903 inclusive, compiled by the Street Railway Journal, and are for year ending December 31.

TABLE SHOWING INCREASE IN MILEAGE, CARS, ETC., BETWEEN 1890 AND 1902, FOR THE STREET RAILWAYS OF THE UNITED STATES

	1890	1902	Per Cent Increase
Length of line (miles)	8,123	22,577	177 9
No. of cars	32,505	60,290	85.5
No. of employees	70,764	133,641	88.9
No. of companies	706	987	39.8
Passengers carried	2,023,010,202	4,809,554,438	137.7
Capital stock	$289,058,133	1,315,572,960	355.1
Funded debt	189,177,824	992,709,139	424.7
Capital liabilities	478,235,957	2,308,282,099	382.6
Earnings from operations	90,617,211	247,553,999	173.2

Compiled from United States Census Report.

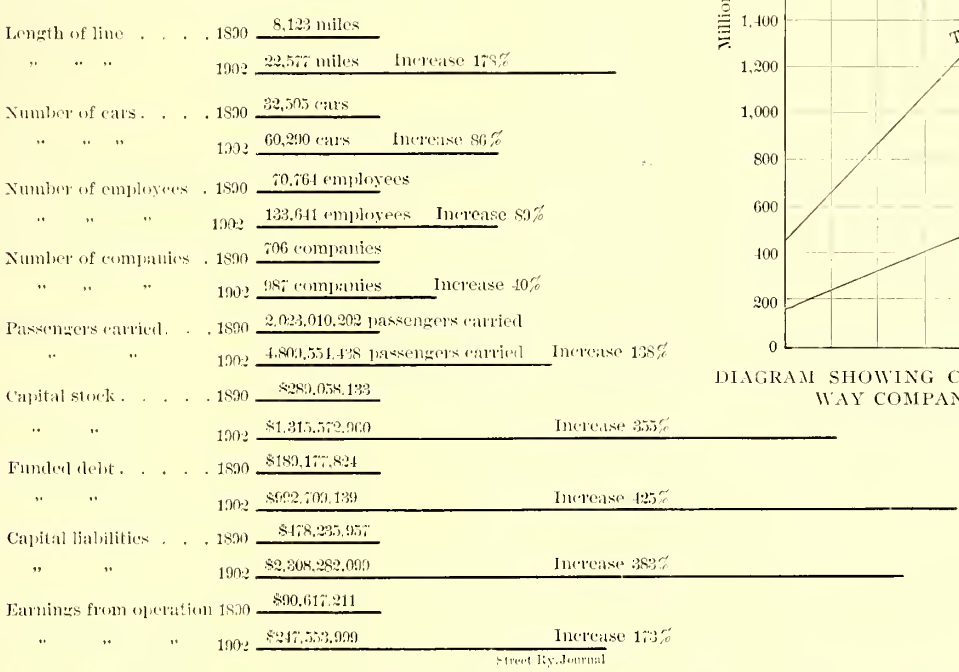


DIAGRAM SHOWING INCREASE IN MILEAGE, CARS, ETC., BETWEEN 1890 AND 1902, FOR THE STREET RAILWAYS IN THE UNITED STATES.

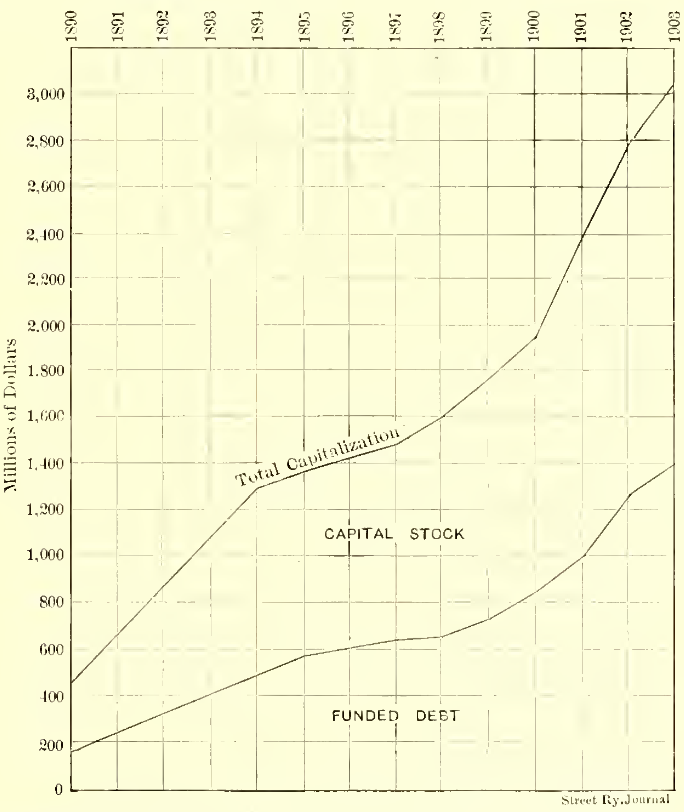


DIAGRAM SHOWING CAPITAL LIABILITIES OF STREET RAILWAY COMPANIES IN THE UNITED STATES made of the figures for 1896, so this year appears blank in the several tables.

The two diagrams published on this page showing miles of track and number of cars, divided into the different motive powers, illustrate in a most striking way the rapid adoption of

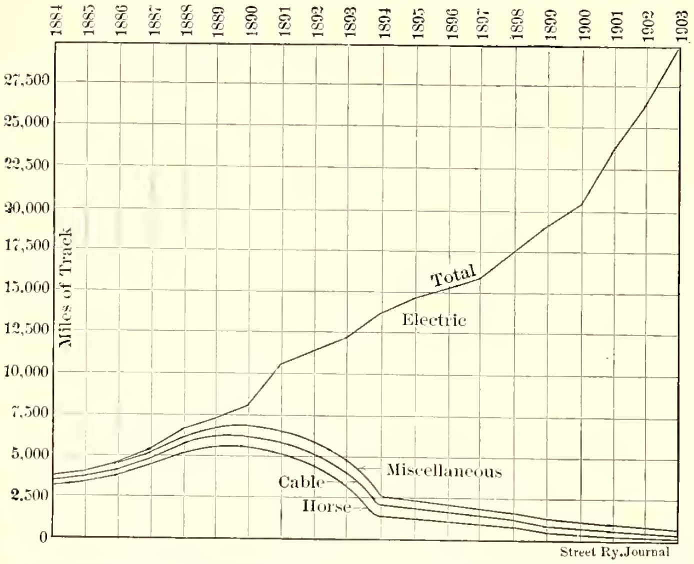


DIAGRAM SHOWING MILES OF TRACK AND DIFFERENT MOTIVE POWERS OF STREET RAILWAYS IN THE UNITED STATES

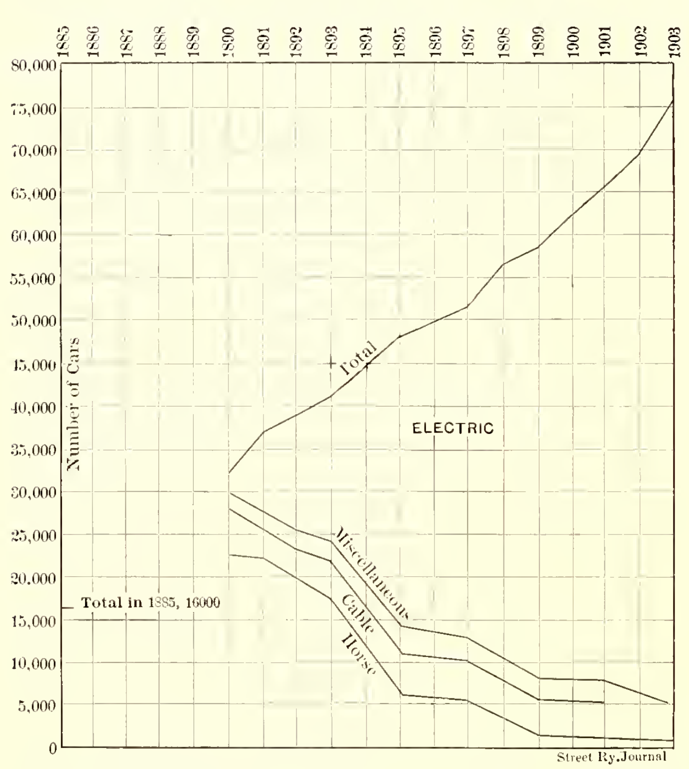


DIAGRAM SHOWING NUMBER OF CARS, WITH DIFFERENT MOTIVE POWERS, IN USE ON STREET RAILWAYS IN THE UNITED STATES

electricity. The upper line shows the total number of cars or length of line for each year, and the increments into which the height is divided give respectively, counting from the base line, the cars or mileage under horse, cable, miscellaneous and electric traction. A table giving the miles of track in operation under the different systems appears on page 598. A comparison of the status of the industry in 1890 and in 1902 appears on the opposite page.

The United States Census Bulletin for 1890, which was issued at the time that electricity was coming to be recognized as the motive power of the future, contained a tabulation of the dates at which the electric lines which were then running were put in operation. This is reproduced below.

DATE OF OPENING OF EARLY ELECTRIC RAILWAYS IN THE UNITED STATES IN OPERATION IN 1890

(UNITED STATES CENSUS BULLETIN OF 1890)

Aug. 1, 1886—Appleton Electric Street Railway Company, Appleton, Wis.
Oct. " —Highland Park Railway Company, Detroit, Mich.
April 7, 1887—Gratiot Electric Railway Company, Port Huron, Mich.
May " —East Detroit & Grossepoint Railway Company, Detroit, Mich.
July 1, " —Lima Street Railway Motor & Power Company, Lima, Ohio.
Aug. 8, " —Mansfield Electric Street Railway Company, Mansfield, Ohio.
" —Sea Shore Electric Railway Company, Asbury Park, N. J.
Jan. 1, 1888—Jamaica & Brooklyn Road Company, Brooklyn, N. Y.
Jan. 3, " —Ithaca Street Railway Company, Ithaca, N. Y.
Jan. 14, " —Pennsylvania Motor Company, Easton, Pa.
Feb. 2, " —Richmond Union Passenger Railway Co., Richmond, Va.
Mar. 1, " —Asheville Street Railway Company, Asheville, N. C.
Mar. 5, " —Wilmington City Railway Company, Wilmington, Del.
Mar. 27, " —Wheeling Railway Company, Wheeling, W. Va.
April " —Suburban Rapid Transit Street Railway Company, Pittsburg, Pa
April 1, " —Wilkesbarre & Suburban Street Railway Company, Wilkesbarre, Pa.
May 1, " —Derby Street Railway Company, Birmingham, Conn.
July 4, " —Lynn & Boston Railway Company, Boston, Mass.
Aug. " —Lafayette Street Railway Company, Lafayette, Ind.
Aug. 12, " —Davenport Central Railway Company, Davenport, Ia.
Aug. 15, " —East Harrisburg Passenger Railway Company, Harrisburg, Pa.
Aug. " —Pittsburg, Knoxville & St. Clair Street Railway Company, Pittsburg, Pa.
Sept. " —Binghamton Street Railway Company, Binghamton, N. Y.
Sept. " —Hartford & Wethersfield Horse Railway Company, Hartford, Conn.
Sept. 2, " —Sault Ste. Marie Street Railway Company, Sault Ste. Marie, Mich.
Oct. 16, " —Danville Street Car Company, Danville, Va.
Oct. 17, " —Eckington & Soldiers' Home Railway Co., Washington, D. C.
Nov. 1, " —East Side Street Railway Company, Brockton, Mass.
Nov. 3, " —Akron Street Railway Company, Akron, Ohio.
Nov. 7, " —Omaha & Council Bluffs Railway & Bridge Company, Council Bluffs, Ia.
Nov. 27, " —East Reading Railway Company, Reading, Pa.
Nov. 29, " —Third Ward Railway Company, Syracuse, N. Y.
Dec. " —Peoples' Street Railway Company, Scranton, Pa.
Dec. 12, " —Steubenville Street Railway Company, Steubenville, Ohio.
Dec. 15, " —Huntington Electric Light & Street Railway Company, Huntington, W. Va.
Dec. 19, " —East Cleveland Railway Company, Cleveland, Ohio.

THE NEW YORK RAPID TRANSIT SUBWAY

THE STEAM GENERATING AND ENGINE EQUIPMENT OF THE POWER PLANT

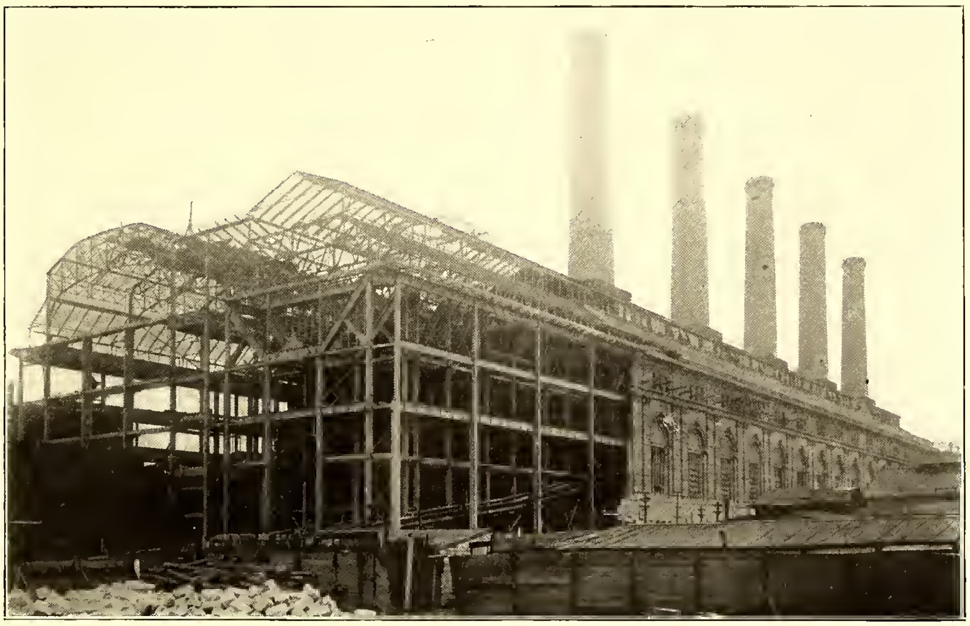
BY JOHN VAN VLECK

EARLY in the year 1901, when the engineers of the Rapid Transit Subway Construction Company first gave consideration to the matter of selecting a site for the power house that was to be needed for the operation of the subway trains, it became apparent that the extent of land required would largely depend on the general design of the power house. Consideration was given to all the various plans and arrangements employed by other engineers for power house construction, and studies were made of the designs of all the large power houses already constructed and in process of construction in this and foreign countries. In the case of certain designs the saving of space had apparently been an essential feature, while in others a more extensive employment of area had been adopted. A careful review of the advantages and disadvantages of the various plans was made, with special attention to the matter of constructing a plant in which interruption of service would be reduced to a minimum.

As a result, the engineers recommended to the company a somewhat extended arrangement of plant, similar, for instance, to that of the Seventy-Fourth Street power plant of the Manhattan Elevated Railroad in New York City. This type of power plant was therefore adopted—in which a single row of large engines and generators was placed in an operating room located alongside a boiler house. It was then considered that provision should be made for generating at least 60,000 kw electrical energy, representing approximately 100,000 hp at the engines, and with this determined, it was possible to select a suitable building site for the power plant, to be located as nearly as possible to the electrical center of the distributing system, and yet near the water front for condensing purposes. The work of locating such a site of the area needed included a most extensive and arduous search on the part of those deputed to effect the purchase. The questions of titles, foundation conditions, water facilities and many other matters had to be taken into account, and it was not until the present site was inspected that any purchasable land was found which satisfied all the requirements.

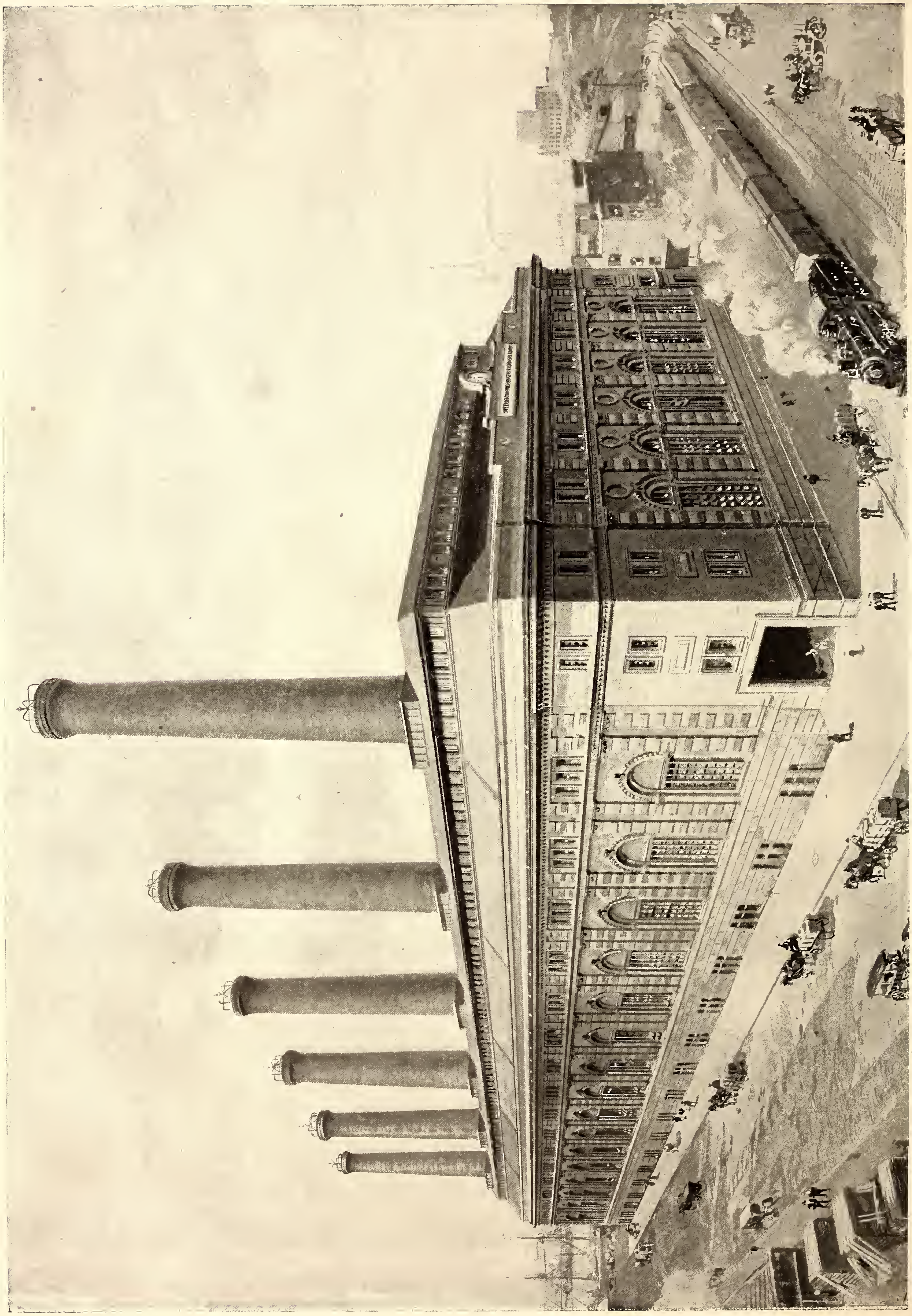
This property was bounded by West Fifty-Eighth Street, Eleventh Avenue, West Fifty-Ninth Street and the bulkhead line of the North River, with a certain area excepted in favor of the city for the bed of Twelfth Avenue. East of Twelfth Avenue the property included the entire city block, 800 ft. x 200 ft. On the purchase of this property steps were taken to prepare plans for the power house structure, and in addition to this, the matter of constructing a new pier at the foot of West Fifty-Eighth Street was taken up along with the construction of underground condensing water conduits with an underground coal-conveying passage, which resulted in consummating a lease with the Department of Docks and Ferries for the construction of a pier 700 ft. long and 60 ft. wide, at the foot of West Fifty-Eighth Street.

The work of preparing the detail plans of the power house structure was, in the main, completed early in 1902, which resulted in the present plan, which may be briefly described as follows: The structure is divided into two main parts, an operating room and a boiler house, with a partition wall between the two sections. The face of the structure on Eleventh Avenue is 200 ft. wide, of which width the boiler house occupies 83 ft. and the operating room 117 ft. The operating room occupies the Fifty-Ninth Street, or northerly side of the structure, while the boiler house is located on the Fifty-Eighth Street, or southerly side. The designers were enabled to employ a contour of roof and wall section for the northerly side that was identical with the roof and wall contour of the southerly side, so that the building, when viewed from either end, presents a symmetrical appearance, with both sides of the building alike in form and design. The operating room section is practically symmetrical with respect to its center; it consists of a central area, with a truss roof over same, and galleries along both sides. The galleries along the northerly side are primarily for the electrical apparatus, while those along the southerly side are given up chiefly to the steam pipe equipment. The boiler room section is also practically symmetrical with respect to its center.



EXTERIOR VIEW OF THE POWER PLANT DURING CONSTRUCTION, SHOWING STEEL WORK

A sectional scheme of the power house arrangement was de-



EXTERIOR VIEW OF THE COMPLETED POWER HOUSE AT FIFTY-EIGHTH STREET AND ELEVENTH AVENUE, NEW YORK CITY termined upon, by which the structure was originally to consist of five generating sections, each similar to the others in all its mechanical details, but at a later date a sixth section was added, with a space remaining on the westerly end of the block for a seventh section. Each section embraces one chimney, along with the following generating equipment: twelve boilers, having each 6000 sq. ft. of heating surface; two engines, each direct connected to a 5000-kw alternator; two condensing equipments; two boiler feed pumps; two smoke flue systems; along with this is included the detail apparatus necessary to make each section complete in itself, the only variation being the turbine plant afterward referred to. In addition to the space occupied by the before-mentioned sections, an area was set aside, at the Eleventh Avenue end of the structure, for the passage of the railway spur from the New York Central tracks. The total length of the original five-section power house was 515 ft. 9½ ins., but the additional section, afterward added, makes the over-all length of the structure 693 ft. 9¾ ins. In the fourth section it was decided to omit a regular engine with its 5000-kw generator, and in its place substitute a 5000-kw lighting and exciter outfit, this comprising in part the turbine plant. Arrangements were made, however, so that this outfit can afterward, if desired, be replaced by a regular 5000-kw traction generator.

The plan of the power house included a method of supporting the chimneys on steel columns instead of erecting them through the building, which modification allowed for the disposal of boilers in spaces which would otherwise be occupied by the chimney bases. By this arrangement it was possible to place all the boilers on one floor level. The economizers were placed above the boilers instead of behind them, which made a material saving in the width of the boiler room. This saving resulted in the before-mentioned gallery construction at the side of the operating room, which is closed off from both boiler and engine rooms, for the reception of the main pipe system and for a pumping equipment below it.

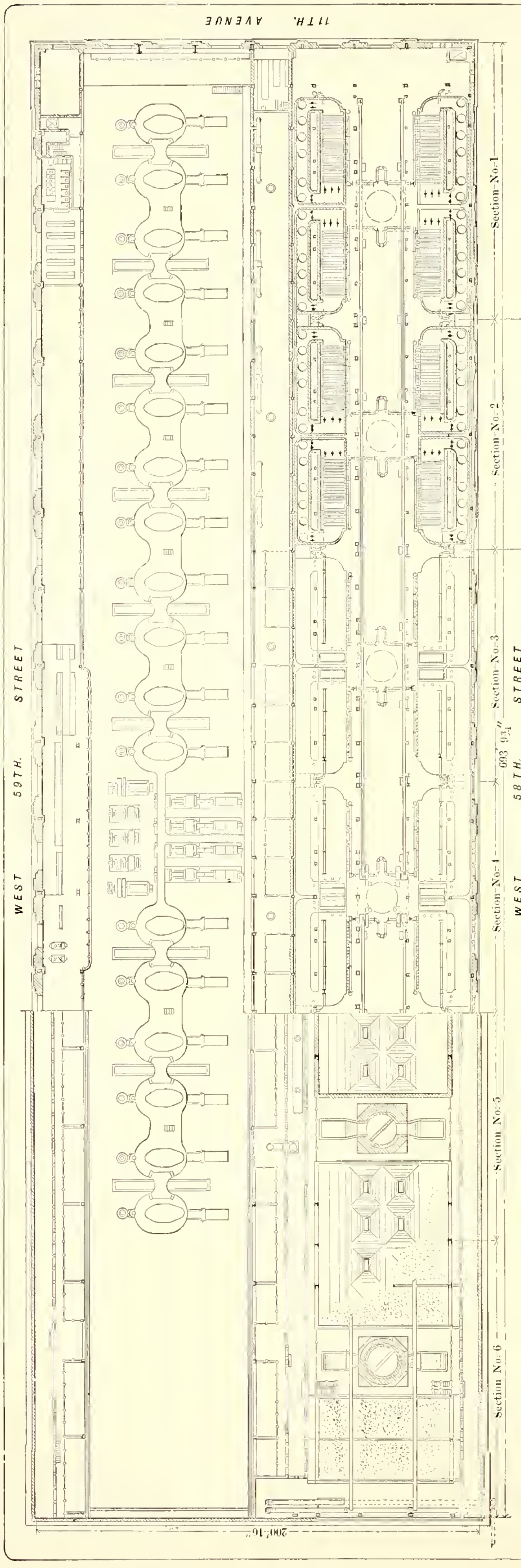
The advantages of the plan can be enumerated briefly as follows: The main engines, combined with their alternators, lie in a single row along the center line of the operating room, with the steam or operating end of each engine facing toward the boiler house, and the opposite end toward the electrical switching and controlling apparatus arranged along the outside wall. Within the area, between the boiler house and operating room, there is placed, for each engine, its respective complement of pumping apparatus, all controlled by and under the operating jurisdiction of the engineer of that engine. Each engineer has thus full control of the pumping machinery required for his unit. Symmetrically arranged with respect to the center line of each engine, are the six boilers in the boiler room, and the piping from these six boilers forms a short connection between the nozzles on the boilers and the throttles on the engines. The arrangement of piping is alike for each engine, which results in a piping system of maximum simplicity, which can be controlled, in the event of difficulty, with a degree of certainty not possible with a more complicated system. As described later, the main parts of the steam pipe system, located inside the area between the boiler house and operating room, can be controlled from outside this area. The main valves so placed are assembled at a point, for each main engine, immediately back of it, greatly facilitating surety and speed of action. The placing of the main features of the steam pipe system within the area in question prevents the leakage of steam into the boiler house or into the operating room, in case of difficulty in this locality, and in addition, the heat radiated from the piping contained within the area cannot escape, to elevate the temperature of either the boiler or operating room.

The single tier of boilers makes it possible to secure a high and well ventilated boiler room with ventilation into a story constructed above it, aside from the ventilation afforded by the windows themselves. The boiler room will therefore be well lighted and cool in warm weather and all difficulties from escaping steam will be minimized. In this respect the boiler room will be superior to corresponding rooms in plants of older construction, where they are often low, dark and sometimes extremely hot during the summer season. The placing of the economizers, with their auxiliary smoke flue connections, in the economizer room, all symmetrically arranged with respect to each chimney, removes from the boiler room an element of disturbance and make it possible to pass directly from the boiler house to the operating room at convenient points along the length of the power house structure. The location of each chimney, in the center of the boiler house between sets of six boilers, divides the coal bunker construction into separate pockets by which trouble from spontaneous combustion can be localized, and, as described later, the divided coal bunkers can provide for the storage of different grades of coal. The unit basis on which the economizer and flue system is constructed will allow making repairs to any one section without shutting other portions not connected directly to the section needing repair.

THE FOUNDATION WORK

The rock on which the power house is built is of the micaceous schist and bastard granite formation universal on Manhattan Island. Its surface was found to be very irregular, varying from a level of 12 ft. above to 40 ft. below mean high tide. The general inclination of the rock surface was downward from east to west, and it was covered with some sand and earth, but mainly by a fill of city refuse up to a level of about 4 ft. above mean high tide. The excavation to the rock surface, where the depth of the latter did not exceed about 45 ft. below the surface of the street, was made in the usual way with shovels, teams, scrapers and wagons, the excavated material being loaded on barges and dumped at sea.

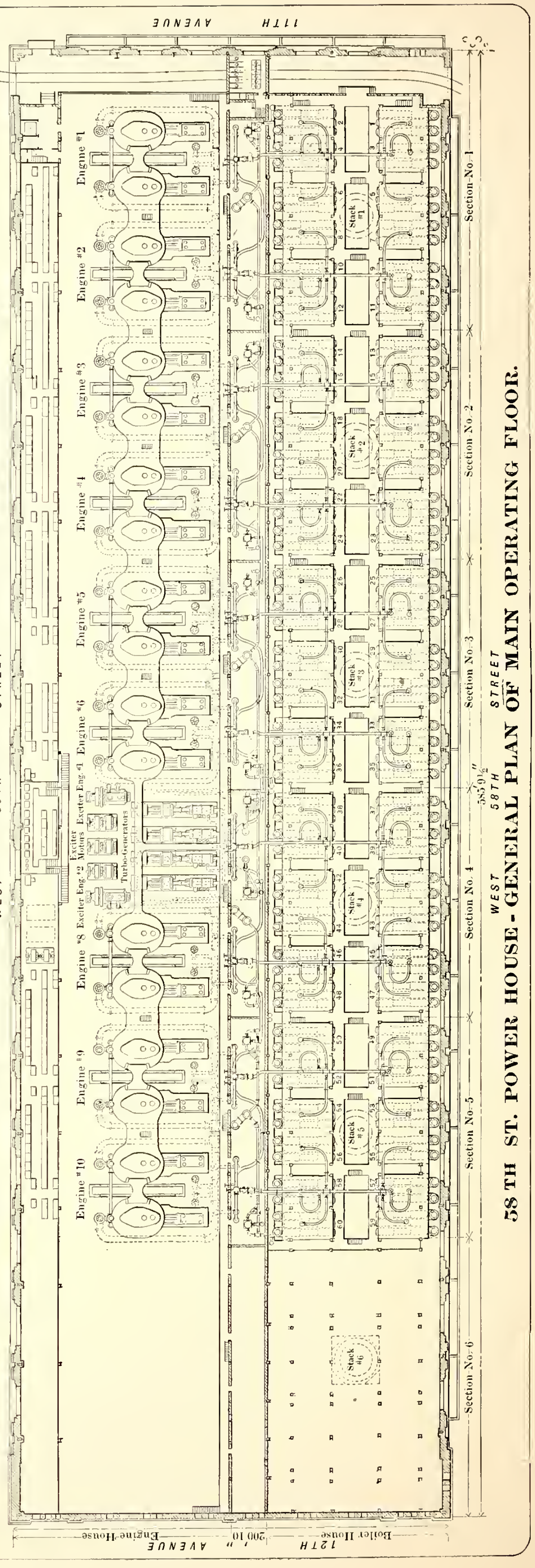
At the east, or shore end of the lot, the rock was excavated to a uniform depth required for the column and wall footing courses, and at the river end, where its surface dipped rapidly, the general excavation was carried down through the earth to a maximum depth in some cases of 40 ft. below mean high tide. Here the excavation was made in sections, enclosed by 6-in. sheet piles driven closely by steam hammers. The pits were drained without serious difficulty by centrifugal pumps. The surface of the rock was everywhere cleaned and dressed off to sound material, but not always leveled. A concrete mixing plant was established near the river end of the lot, and economy of transportation was effected by sending the concrete up to the east end of the lot on the cars which were used to bring the excavated material down to the river front. The concrete used in the work was composed, by measure, of one part Portland cement, two parts sand and five parts of broken stone. In some cases rubble concrete was employed for filling, this including proper size stones suitably embedded. The cement was American Portland cement, and had to pass the rigid inspection and examination required of the cement used in the subway. The floor of the power house, between the column bases, is a continuous mass of concrete, nowhere less than 2 ft. thick. The massive concrete foundations for the main engines and generators contain each 1400 yards of concrete above mean high water level, and in some cases twice as much concrete is used



58 TH ST. POWER HOUSE - GENERAL PLAN OF COAL BUNKERS AND ECONOMIZERS.

WEST 58TH STREET

WEST 59TH STREET



58 TH ST. POWER HOUSE - GENERAL PLAN OF MAIN OPERATING FLOOR.

below that level. The total amount of concrete in the foundations of the finished power house is roughly 80,000 yards.

Water for condensing purposes is drawn from the river, and discharged into it, through two monolithic concrete tunnels, through West Fifty-Eighth Street, parallel to the axis of the building. The intake conduit has an oval interior, 10 ft. x 8½ ft. in size, and a rectangular exterior cross-section; the outflow tunnel has a horseshoe shape cross-section and is built on top of the intake tunnel. These tunnels are built throughout in open trench, which, at the shore end, was excavated in solid rock. At the river end the excavation was almost entirely through the mud, and was made in a coffer-dam composed of sheet piles. At the extreme river end the rock was so deep that the concrete could not be carried down to its surface, and the tunnel section was built on a foundation of piles driven to the rock and cut off 19½ ft. below mean high tide. This section of the tunnel was built in a 65-ft. x 48-ft. floating caisson 24 ft. deep. The concrete was rammed in it around the mold, and the sides were braced as it sunk. After the tunnel sections were completed the caisson was sunk, by water ballast, to a bearing on the pile foundation. Adjacent to the condensing water conduits is the rectangular concrete tunnel for the underground coal conveyor between the shore end of the pier and the power house.

POWER-HOUSE SUPERSTRUCTURE

The design of the face work of the power house received the personal attention of the directors of the company, and its character and the class of materials to be employed were carefully considered. The influence of the design on the future value of the property and the condition of the environment in general were studied, together with the factors relating to future ownership of the plant by the city. Several plans were considered looking to the construction of a power house of massive and simple design, but it was finally decided to adopt an ornate style of treatment, by which the structure would be rendered architecturally attractive and in harmony with the recent tendencies of municpal and city improvements from an architectural standpoint. At the initial stage of the power house design, Stanford White, of the firm of McKim, Mead & White, of New York, volunteed his services to the company as an adviser on the matter of the design of the face work, and as his offer was accepted, his connection with the work has resulted in the development of the present exterior design and the selection of the materials used.

The structure faces properly on Eleventh Avenue, and the Eleventh Avenue facade is the most elaborately treated, but the scheme of the main facade is carried along both the Fifty-Eighth Street and Fifty-Ninth Street fronts. The westerly end of the structure, facing the river, may ultimately be removed, in case the power house is extended to the Twelfth Avenue building line, for the reception of two additional generator equipments, and for this reason this wall is designed plainly of less costly material. The general style of the face work is what may be called French renaissance, and the color scheme has therefore been made rather light in character. The base of the exterior walls has been finished with cut granite up to the water table, above which the walls are faced with a light colored buff, pressed brick. This brick has been enriched by the use of similarly colored terra-cotta, which appears in the pilasters, about the windows and in the several entablatures, and in the cornice and parapet work. The Eleventh Avenue facade is further enriched by marble medallions, framed with terra-cotta, and by a title panel directly over the front of the structure.

All window frame and sash for the walls is constructed of cast iron, and all the windows are glazed with wire glass for protection against fire. The window frame and sash in the upper monitor construction is covered with copper, and all the exposed gutters, bulkhead coverings, flashings and trims for the roof are of sheet copper. The flat portions of the roof are constructed of concrete, reinforced with expanded metal, with suitable water-proofing laid over it. The sloping sides of the roof are constructed with terra-cotta blocks laid on T-bar purlins. The terra-cotta blocks are protected by water-proofing, and over the water-proofing there are laid Spanish roll tiles which are enameled green on the exposed surface. The sloping sides of the roof, directly over the operating room, are constructed of heavy glass, suitably supported on steel bars with copper trim work. Copper condensation gutters are provided, and under each section of glass is erected a wire screen. Permanent ladders are constructed on the roof to render every portion of it readily accessible.

The main doorways leading into the structure are trimmed with cut granite, and the entrance lobby at the northeast corner is finished with a marble wainscoting. The exposed wall face of the operating room is faced with a light cream-colored, pressed brick, with an enameled brick wainscoting 8 ft. high, extending around the entire operating area; the wainscoting is white, except for a brown border and base. The offices, the toilets and locker rooms are finished and fitted with marble and other materials in harmony with the general character of the building. The masonry floor construction consists of concrete, reinforced with expanded metal, and except where iron or other floor plates are used, or where tile or special flooring is laid, the floor is covered with a cement granolithic finish.

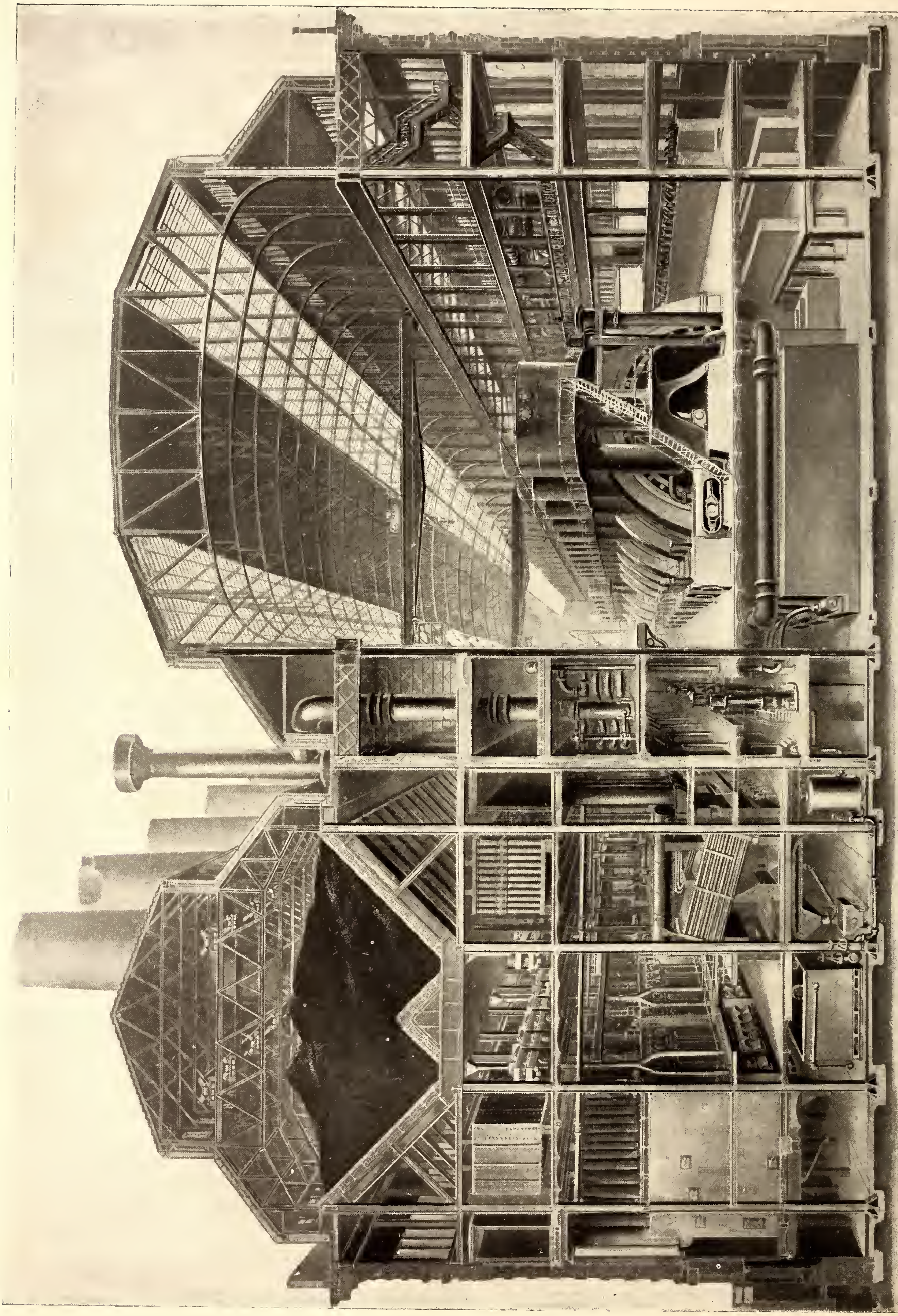
The value of a generous supply of stairways was appreciated and all parts of the structure are made readily accessible, especially the boiler house section; the extent to which stairways have been provided throughout can be seen by reference to the general floor plans. The main stairways are of ornate design, with marble and other trim work, and the railings of the main gallery construction are likewise ornate, to correspond with the stairways. All the exterior windows, doors and trim are of cast or wrought iron, and all interior carpenter work is covered with Kalomein iron protection, so that the building, in its strictest sense, will contain nothing in the way of combustible material.

CHIMNEYS

The twelve-unit power house as now extended will have six chimneys, spaced 108 ft. apart on the center line of the boiler room. Each chimney is 15 ft. inside diameter at the top, and the top of each chimney is located 225 ft. above the grate bars. Each chimney will serve the twelve boilers which form the section of which it is the center. To provide for overload capacity which may be demanded by future conditions, a forced draft system is provided for, as will be described later.

As stated elsewhere, the chimneys are all supported on the steel structure of the building on a platform which is placed at an elevation of 76 ft. above the basement floor and 63 ft. above the grates. The supporting platforms are, in each case, carried on six of the building columns, and each platform is composed of single-web plate girders, well braced and surmounted by a grillage of 20-in. beams. The grillage is filled solidly with concrete and flushed smooth on top to receive the brick work of the chimney.

The top of each chimney is 162 ft. above the top of the supporting platform, and each weighs 1200 tons. The octagonal base is of red brick, this being carried to a height of 32 ft. 6 ins.,



TYPICAL CROSS SECTION OF THE POWER HOUSE, SHOWING PRINCIPAL DETAILS OF THE BUILDING AND ARRANGEMENT OF APPARATUS at which point the circular section of radial brick begins. The outside diameter of the round shaft at its bottom starting point is 21 ft. 11⅜ ins., and it tapers to an outside diameter, at the top, of 16 ft. 5¼ ins., the sides thus having a batter of about 2½ ins. in 10 ft. This large batter was preferred in order to obtain as much stability as possible in connection with the method of supporting the chimney. The thickness of the radial brick work at the bottom is 24 ins., decreasing in eight vertical sections, to a thickness of 8⅝ ins. at the top. Above the roof of the boiler house the exposed face brick on the chimney is of a light gray color, corresponding in color to the facades of the building.

The octagonal base of the chimney is of hard-burned red brick 3 ft. in thickness between the side of the octagon and the interior circular section. The brick work is started from the top of the grillage platform within a steel channel curb, 3 ft. in depth, through which two lines of steel rods are run in each direction, thus binding together the first 3 ft. of brick work. At a level, 3 ft. above the bottom of the brick work, a layer of water-proofing is placed over the interior area, and same is covered with two courses of brick, upon which are built diagonal brick walls, 4 ins. thick, 12 ins. apart and about 18 ins. in height. These walls are themselves perforated at intervals, and the whole is covered with hard-burned terra-cotta blocks, thus forming a cellular air space, which communicates with the interior air and serves as an insulation against heat for the steel work beneath. A single layer of fire brick completes this flooring of the interior area, which is flush with the bottom of the flue openings at the sides of the chimney.

There are two flue openings in the base of the chimney, placed diametrically opposite; each opening is 6 ft. wide x 17 ft. high. The openings are lined with fire brick, which joins the fire-brick lining of the interior of the shaft, this latter being bonded to the red brick walls. The usual baffle wall is provided of fire brick, 13 ins. thick, extending diagonally across the chimney to a point 4 ft. above the tops of the flue openings.

Where the chimney passes through the roof of the boiler house, a steel plate and angle curb, which clears the chimney by 6 ins. at all points, is provided in connection with the roof framing. This is covered by a hood flashed into the brick work, so that the roof has no connection with or bearing upon the chimney.

At a point about 4 ft. 6 ins. below the cap of the chimney, the brick work is corbeled out for several courses, forming a ledge; around the outside of this ledge is placed a wrought-iron railing, thus forming a walkway around the circumference of the chimney top. The cap is of cast iron, surmounted by eight 3-in. x 1-in. wrought-iron ribs, forming an ornamental cage over the outlet, with pointed ends gathered together at the center. Galvanized iron ladder rungs are built in the brick work for ladders both inside and outside the shaft. The ornamental cage, constructed over the top of each chimney, supports, in turn, a system of vertical lightning rods, all tipped with platinum points about 18 ins. long. The vertical lightning rods are connected to two lightning cables of stranded copper running down the chimney, each having a section of 300,000 circ. mils.

THE TRAVELING HOISTING TOWER UPON THE COAL UNLOADING PIER, FOR HANDLING COAL TO THE CONVEYOR SYSTEM

The chimneys were built by the Alphons Custodis Chimney Construction Company, and, except for the octagonal red brick base, are constructed of the radial perforated bricks manufactured by that company.

COAL UNLOADING PIER

Exceptional facilities have been provided for the unloading of coal from vessels or barges which can be brought to the northerly side of the pier at the foot of West Fifty-Eighth Street. The pier was specially built by the Department of Docks and Ferries, and is 700 ft. long and 60 ft. wide. The outer end, for a distance of 220 ft., is utilized by the Union Stock & Market Company, and the balance is reserved for use by the power house, except for a driveway along the southerly side. The section used by the power house has been built with special piling, and is provided with a deck designed to receive two or more coal unloading towers.

The pier construction included a special river wall across Fifty-Eighth Street, at the bulkhead line, through which the condensing water will be taken from, and returned to, the river.

Immediately outside of the river wall and beneath the deck of the pier, there is a system of screens through which all the intake water is passed; on each side where the water enters the screen chamber, a heavy steel grillage is arranged, and inside this there is a system of fine screens arranged so that the several screens can be raised, by a special machine, for the purpose of cleaning. The advantages of a well designed screening outfit has been appreciated, and considerable care has been exercised to make it as reliable and effective as possible.

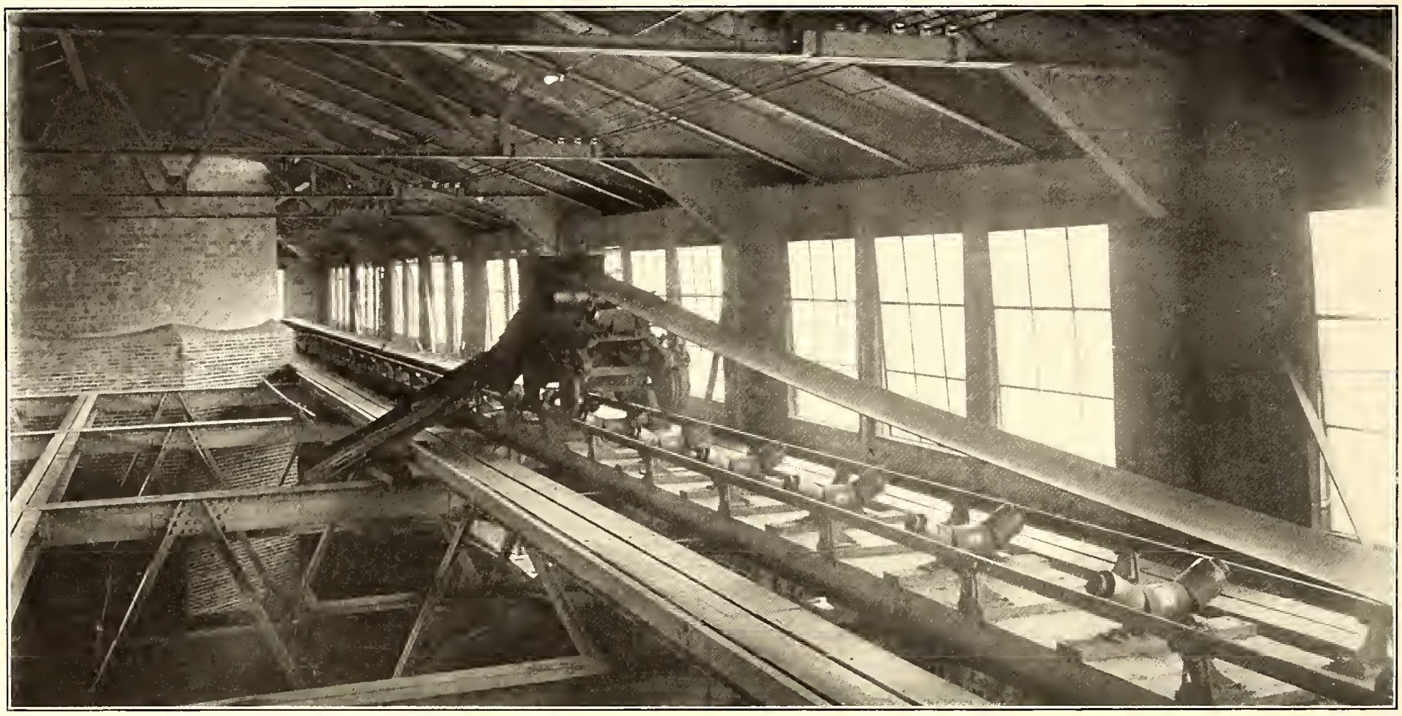
At each side of the center of the pier, just below the deck, there are two discharge water conduits constructed of heavy timber to conduct the warm water from the condensers away from the cold water intakes at the screens. Two water conduits are employed within the pier construction in order that one may be repaired or renewed while using the other; in fact, the entire pier is constructed with the view of renewal without interference in the operation for which it was provided.

COAL AND ASH-HANDLING EQUIPMENT

The coal-handling equipment includes a movable electric hoisting tower with crushing and weighing apparatus; a system of horizontal belt conveyors, with 30-in. belts, to carry the crushed and weighed coal along the pier, thence by an underground tunnel to the southwest corner of the power house to a system of 30 in. Robins elevating belt conveyors, to elevate the coal to the top of the boiler house, and a system of 20-in. belt conveyors to distribute the coal horizontally over the coal bunkers. These conveyors have automatic self-reversing trippers which distribute the coal evenly in the bunkers. For handling different grades of coal a system of chain and plate conveyors is arranged underneath the coal bunkers for delivering the coal from the particular bunker to the downtake hoppers in front of the boilers.

The equipment for removing the ashes from the boiler room basement and for storing and delivering the ashes to barges, includes a system of tracks of 24-in. gage, extending under the ash hopper gates in the boiler house cellar and extending to an elevated storage bunker at the water front, and with this track system are provided twenty-four steel cars of 2 tons capacity, having gable bottoms and side dumping doors. Each car has two four-wheel pivoted trucks with springs. Motive power is supplied by an electric storage battery locomotive. The cars deliver the ashes at the pier to a Robins elevating belt conveyor which fills the ash bunker. This will contain 1000 tons, and is built of steel, with a Berquist suspension bottom lined with concrete. For delivering stored ashes to barges, a collecting belt extends longitudinally under the ash pocket, being fed by eight gates. It delivers ashes to a loading belt conveyor, the outboard end of which is hinged so as to vary the height of delivery and to fold up inside the wharf line when not in use.

The coal-handling system in question was considered desirable because any serious interruption of service would be of short duration, as any belt, or part of the belt mechanism, could quickly be repaired or replaced. The system also possessed advantages with respect to the automatic even distribution of coal in the bunkers, by means of the self-reversing trippers; these derive their power from the conveying belts. Each conveyor has a rotary cleaning brush to cleanse the belt before it reaches the driving pulley, and they are all driven by induction motors.



VIEW OF THE AUTOMATIC UNLOADING MECHANISM IN THE DISTRIBUTING BELT CONVEYOR ABOVE THE COAL POCKETS, NEAR BASE OF CHIMNEY

COAL-HOISTING TOWER

The tower frame and boom are of steel. The tower rolls on two rails along the pier and is self-propelling. The lift is unusually short, for the reason that the weighing apparatus is removed horizontally to one side in a separate house instead of lying vertically below the crusher. This arrangement reduces, by 40 per cent, the lift of the bucket, which is of the clam-shell type of 44 cu. ft. capacity. The motive power for operating the bucket is perhaps the most massive and powerful ever installed for such service. The main hoist is directly connected to a 200-hp motor, with the Ward-Leonard system of control. The trolley for hauling the bucket along the boom is also direct coupled to a multipolar motor.

The receiving hopper has a large throat, with a device in it which sorts out coal small enough for the stokers and by-passes it around the crusher. The crusher is of the two-roll type, with relieving springs, and is operated by the motor, which is also used for propelling the tower. The coal is weighed in duplex 2-ton hoppers, hung in beam and level scales. The boom can be housed by an electric winch to permit the tower to operate over vessels with masts and rigging, if it should ever become necessary to bring coal in deep-water carriers instead of by the usual mastless harbor barges.

Special attention has been given to providing for the comfort and safety of the coal-tower operators. The cabs have bay window fronts, to enable the men to have an unobstructed view of the bucket at all times without peering through slots in the floor. Walks and hand lines are provided on both sides of the boom for easy and safe inspection.

STORAGE BATTERY LOCOMOTIVE

This type of motive power was selected in preference to a trolley locomotive for moving the ash cars, owing to the rapid destruction of overhead lines and rail bonds, caused by the action of ashes and water. The locomotive consists of two units, each of which has four driving wheels, and carries its own motor and battery. The use of two units allows the locomotive to round curves with very small overhangs as compared with a single-body locomotive; curves of 12-ft. radius, of the 24-in. gage, can be turned with ease. The gross weight of the locomotive is about 5 tons, all of which is available for traction.

The motors are of the highest grade vehicle type, operated by a controller on one unit in such a manner that at no time is it necessary to introduce external resistance in the circuit, which gives maximum economy to the consumption of battery energy. They are set well up over the frames, entirely spring-supported, at a point well up out of wind and dust, and where they may be readily inspected by opening the side doors which protect them.

The batteries have Manchester positive plates and chloride negatives made by the Electric Storage Battery Company. They are set up in a new form to prevent electrical leakage between adjacent cells. The cells are supported and separated by point contact insulators which give large ventilating and drainage areas. The controller cannot be reversed when the circuit is closed, and when the controller is "off," the batteries are correctly poled for charging. The locomotive is so designed that when coupled to a load which will cause overdrafts on the battery, the drivers will slip.

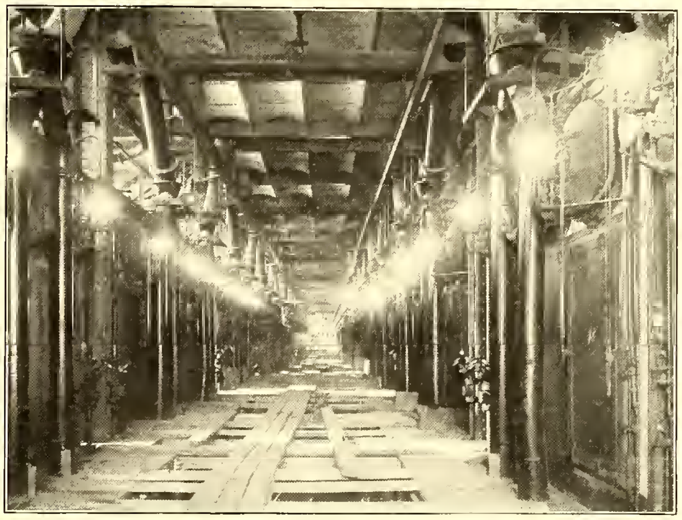
COAL DOWNTAKES

The coal from the coal bunkers is allowed to flow down into the boiler room through two rows of downtakes, one on each side of the central gangway or firing space. Each bunker has eight cast-iron outlets, four on each side, and to these outlets are bolted gate valves for shutting off the coal from the corresponding downtakes. From these gates the downtakes lead to hoppers which are on the economizer floor, and from these hoppers the lower sets of downtakes are carried to the boilers.

Just above the hoppers, on the economizer floor, the coal downtakes are provided with two valves to feed the coal, either into the coal downtakes to the boilers or into a distributing flight conveyor alongside of it. These conveyors, one corresponding with each row of downtakes, permits the feeding of coal from any bunker or bunkers to all the boilers when desired. They are the ordinary type of flight conveyor, capable of running in either direction, and provided with gates in the bottom of the trough for feeding into the several above-mentioned coal downtakes. In order to eliminate the stresses that would develop in a conveyor of the full length of the building, the conveyors are of half the entire length of the building, with electric-driving engines in the center of each continuous line. The installation of this conveyor system, in connection with the coal downtakes, makes it possible to carry a high-grade coal in some of the bunkers for use during periods of heavy load, and a cheaper grade in other bunkers for periods of light load.

To provide means of shutting off the coal supply to each boiler, a small hopper is placed just over each boiler, and the downtake feeding into it, is provided with a gate at its lower end. Two vertical downtakes drop from the boiler hopper to the boiler room floor or to the stokers, as the case may be, and they are hinged just below the boiler hopper to allow of their being drawn up out of the way when necessary to inspect the boiler tubes.

Wherever the direction of the flow of the coal is changed, poke holes are provided in the downtakes to enable the firemen to break any arching tendency of the coal in the downtakes. All parts of the downtakes are of cast iron except the vertical parts in front of the boilers, which are of wrought-iron pipe, the frequency of their being swung up to expose the tubes making lightness desirable. These vertical downtakes are 10 ins. in inside diameter, while all others are 14 ins. in inside diameter. The coal downtakes were furnished and erected by the Thomas Reese, Jr., Company.



VIEW ON WATER-TENDERS' GALLERY IN THE BOILER ROOM, SHOWING DOUBLE ROW OF BOILERS

BOILERS

The main boiler room is designed to receive seventy-two safety water-tube three-drum boilers, each having 6008 sq. ft. of effective heating surface, by which the aggregate heating surface of the boiler room will be 432,576 sq. ft. Sixty boilers have been ordered and are now being erected by the Babcock & Wilcox Company, of New York.

The boilers are designed for a working steam pressure of 225 lbs. per square inch, and for a hydraulic test pressure of 300 lbs. per square inch. Each boiler is provided with twenty-one vertical water-tube sections, and each section is fourteen tubes high. The tubes are of lap-welded charcoal iron, 4 ins. in diameter and 18 ft. long. The drums are 42 ins. in diameter and 23 ft. 10 ins. long. All drum parts are of open-hearth steel; the shell plates are 9-16 in. thick, and the drum-head plates 11-16 in., and in this respect the thickness of material employed is slightly in excess of standard practice. Another advance on standard practice is in the riveting of the circular seams, these being lap-jointed and double-riveted. All longitudinal seams are double butt-strapped and secured by six rows of rivets. Manholes are only provided for the front heads, and each front head is provided with a special heavy bronze pad for making connection to the stop and feed-water check valve.

The settings of the boilers embody several special features which are new in boiler erection. The boilers are erected in pairs, or batteries, and between each battery is a walkway 5 ft. wide. They are set higher up from the floor than in standard practice. This feature provides a higher combustion chamber, for either hand-fired grates or automatic stokers; and for inclined grate stokers the fire is carried well up above the supporting girders under the side walls, so that these girders will not be heated by proximity to the fire.

For the coping needed for the top edge of the boiler side walls, there is provided a pair of 12-in. channels, which form a part of the structural steel of the building, and each outside wall is carried up to the under side of these channels. This prevents the loosening up of the upper row of bricks which usually occurs in ordinary brick settings. The buckstays for the outside walls are upright 6-in. channels, which also form a part of the frame work of the building, and in this respect the buckstays differ from the independent buckstays usually provided.

A beam construction is carried over the top of the boilers, certain beams being used to support the upright steam main and others to support a steel flooring. This flooring, of removable steel plates, embodies a new and desirable feature for the reason that an unobstructed floor is provided. The workmen can thus pass over it without risk when obliged to move about over the drum coverings, which are usually obstructed by piping and other fixtures. For further protection a hand rail is provided around the top of each boiler; then again, stairways, ladders and cross-over walks render the tops of the boilers especially accessible. Beneath the steel flooring it is proposed to fill in the space over the brick boiler-drum covering with insulating material, which will be an extra measure against the waste of heat from the boiler plant.

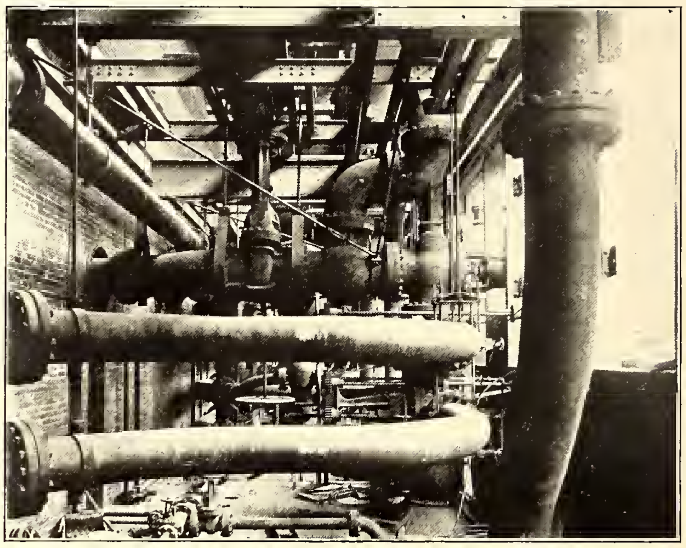
As regards the masonry setting, practically the entire inside surface of the setting that is exposed to hot gases is lined with a high-grade of fire brick. The back of the setting, where the rear cleaning is done, is provided with a sliding floor plate which is used when the upper tubes are being cleaned. This space is provided with a door at the floor line and an additional door at a higher level for light and ventilation when cleaning. Over the tubes arrangements have been made for the reception of superheating apparatus without changing the brick work.

Where the brick walls are carried out, at each side of the building columns at the front, cast-iron plates are erected to a height of 8 ft. on each side of the column. An air space is provided between each cast-iron plate and the column, which is accessible for cleaning from the boiler front, the object of the plates and air spaces being to prevent the transmission of heat to the steel columns.

An additional feature of the boiler setting consists in the employment of a soot hopper back of each bridge wall, by which the deposit back of the wall can be discharged into ash cars in the basement. The main ash hoppers are constructed of ½-in. steel plate, the design being a double inverted pyramid with an ash gate at each inverted apex. The hoppers are well provided with stiffening angles and tees, and the capacity of each is about 80 cu. ft.

The cross-over pipe which connects the three drums is specially constructed to receive four 4-in. safety valves in addition to the main 9-in. angle valve. This cross-over pipe is of the extra heavy proportions employed in the high-pressure steam work of the plant, and where the bottom flanges bolt fast to the pads on the boiler drums, there are bronze ball and socket rings, which are ground steam-tight to take up any lack of alignment of the top surfaces of the boiler pads.

In front of all the boilers is a continuous platform of openwork cast-iron plates, laid on steel beams, the level of the platform being 8 ft. above the main floor; these platforms are connected across the firing area, opposite the walk between the batteries, and at these points this platform is carried between the boiler settings. At the rear of the northerly row of boilers the platform runs along the partition wall between the boiler house and operating room; at intervals, doorways are provided which open into the pump area. The level of the platform is even with that of the main operating room floor, so that it may be freely used by the water tenders and by the operating engineers without being obstructed by the firemen or their tools. The platform in front of the boilers will also be used for cleaning purposes and, in this respect, it will do away with the unsightly and objectionable scaffolds usually employed for this work. The water tenders will also be brought nearer to the



VIEW IN THE PIPE AREA OF THE STEAM PIPING CONNECTION TO A MAIN ENGINE

water columns than when operating on the main floor. The feed-water valves will be regulated from the platform, as well as the speed of the boiler-feed pumps.

Following European practice, each boiler is provided with two water columns, one on each outside drum, and each boiler will have one steam gage above the platform for the water tenders and one below the platform for the firemen. The stop and check valves on each boiler drum have been made specially heavy for the requirements of this power house, and this special increase of weight has been applied to all the several minor boiler fittings.

Hand-fired grates of the shaking pattern have been ordered from the Gibson Iron Works, for thirty-six boilers, and for each of these grates a special lower front has been constructed. These fronts are of sheet steel, and the coal passes down to the floor through two steel buckstays which have been enlarged for the purpose. There are three firing doors, and the sill of each door is 36 ins. above the floor. The grate area of the hand-fired grates is 100 sq. ft., being 8 ft. deep x 12 ft. 6 ins. wide.

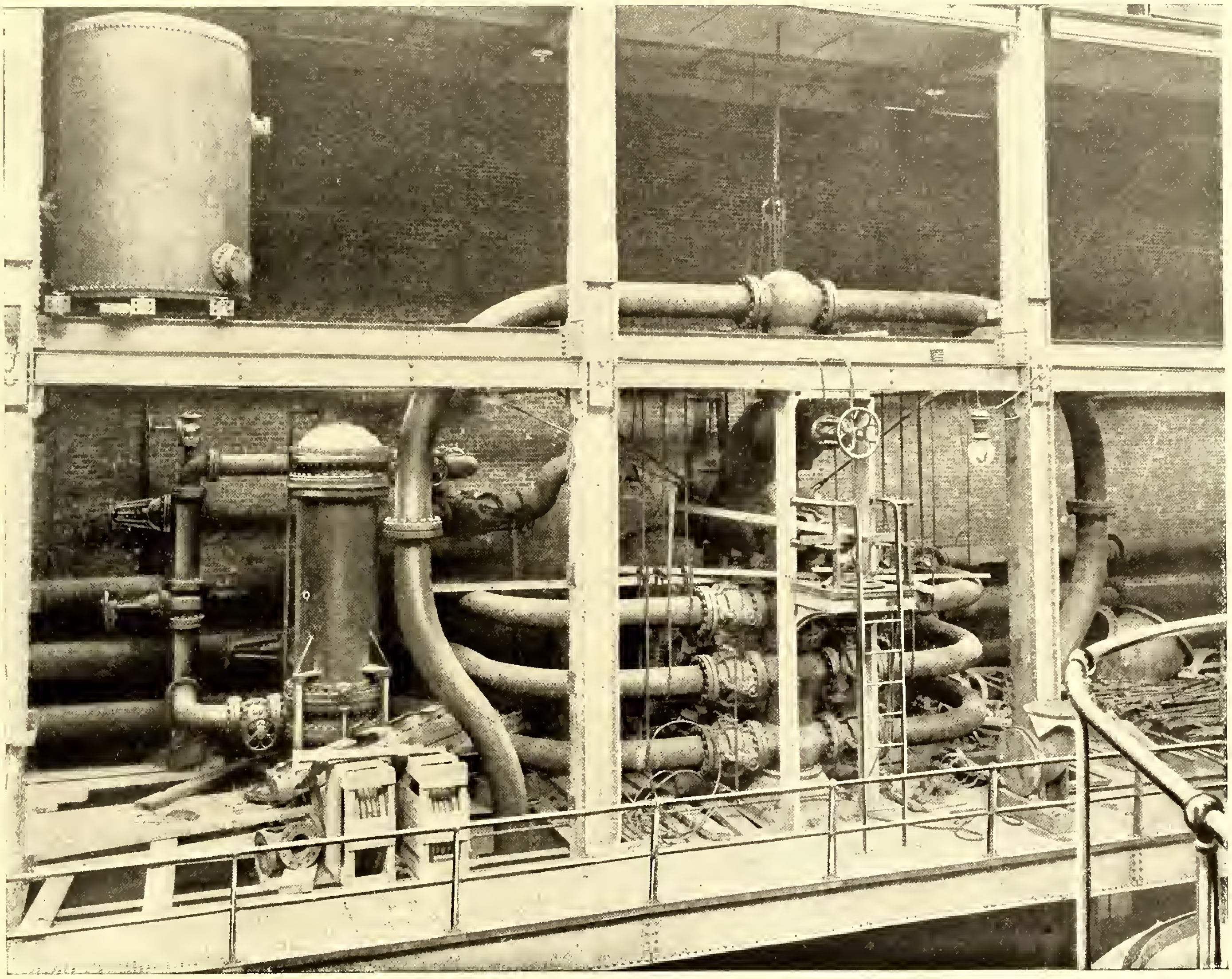
For the balance of the boiler plant which will receive coal from the soft coal bunkers located between the third and fifth chimneys, there has been ordered Roney automatic stokers, as it is proposed to employ bituminous coal for this section of the power house. These stokers embody several recent improvements.

It is proposed to apply superheaters to the entire boiler plant, but it was considered prudent first to make a trial of the two well-known makes of superheaters in this country. An order was placed with the Babcock & Wilcox Company for eight Rosenthal superheaters, each having 767 sq. ft. of heating surface, for eight boilers, and another was placed with the Foster Engineering Company for four special superheaters, on the Schwoerer system, each having 900 sq. ft. of heating surface. It is proposed to make an extended trial of both makes of superheater before equipping the entire plant. The pipe connections at the top of each boiler are arranged so that either make of superheater can be employed.

As before stated, the boiler room ceiling has been made especially high and, in this respect, the room differs from most power houses of similar size. The distance from the floor to the ceiling is 35 ft., and from the floor plates over the boilers to the ceiling is 13 ft. Over each boiler is an opening to the economizer floor above, covered with an iron grating. The height of the room, as well as the feature of these openings and the stairway wells, and with the large extent of window opening in the south wall, will make the room light and especially well ventilated. Under these conditions the intense heat usually encountered over boilers will largely be obviated.

In addition to making provisions for the air to escape from the upper part of the boiler room, arrangements have been provided for allowing the air to enter it at the bottom. This inflow of air will take place through the southerly row of basement windows, which extend above the boiler room floor, and through the wrought-iron open-work floor construction extending along in the rear of the northerly row of boilers.

A noteworthy feature of the boiler room is the 10-ton hand-power crane, which travels along in the central aisle through the entire length of the structure. This crane is used for erection and for heavy repair, and its use has greatly assisted the speedy assembling of the boiler plant.

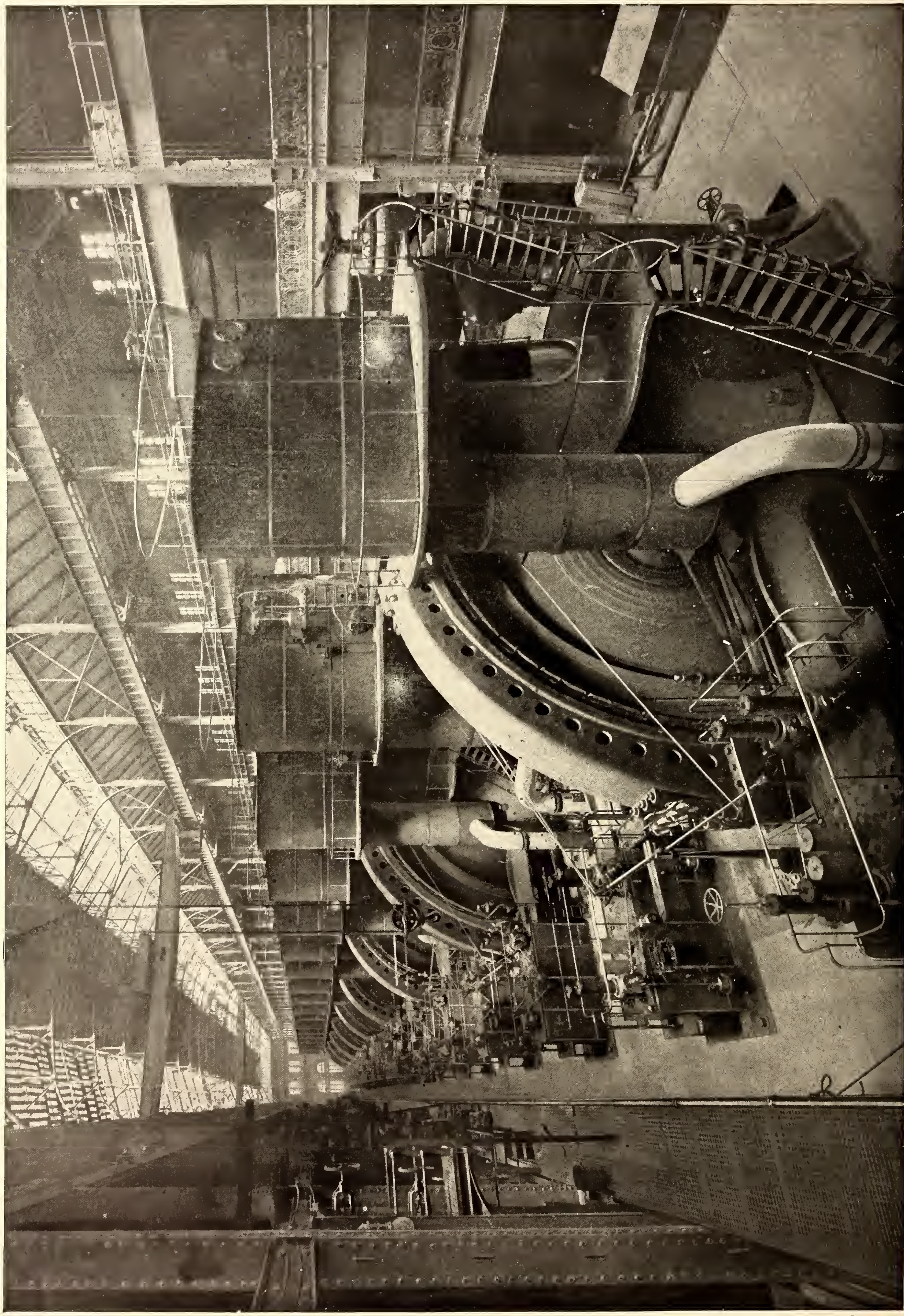


VIEW SHOWING ARRANGEMENT OF PIPING CONNECTIONS FROM ONE BOILER GROUP TO A MAIN ENGINE, AND ALSO INTERCONNECTING COMPENSATING TIE LINE HEADERS IN THE PIPE AREA (SECOND LEVEL)

BLOWERS AND AIR DUCTS

In order to burn the finer grades of anthracite coal in sufficient quantities to obtain boiler rating with the hand-fired grates, and in order to secure a large excess over boiler rating with both the larger grades of anthracite and bituminous coals, on the hand-fired grates and the automatic stokers, respectively, a system of blowers and air ducts has been provided in the basement under the boilers. The air-duct system is designed so that one blower is provided for every three boilers, with arrangements for supplying all six boilers from one blower.

A partial equipment of twelve blowers is being supplied by the B. F. Sturtevant Company. The blowers are 11 ft. high above the floor and 5 ft. 6 ins. wide at the floor line. Each blower is direct connected to a two-crank 7½-in. x 13-in. x



GENERAL VIEW IN THE MAIN OPERATING ROOM OF THE POWER PLANT, SHOWING ARRANGEMENT OF GENERATING UNITS

6½-in. upright, compound, steam engine of the self-enclosed type. Each blower is to provide a sufficient amount of air to burn 10,000 lbs. of combustible per hour with 2-in. water pressure in the ash pits.

SMOKE FLUES AND ECONOMIZERS

The smoke-flue and economizer construction throughout the building is of uniform design, or in other words, the smoke-flue and economizer system for one chimney is identical with that for every other chimney. In each case the system is symmetrically arranged about its respective chimney, as can be seen by reference to the accompanying plans.

The twelve boilers for each chimney are each provided with two round smoke uptakes, which carry the products of combustion upward to the main smoke-flue system on the economizer floor. A main smoke flue is provided for each group of three boilers, and each pair of main smoke flues join together on the center line of the chimney, where in each case one common flue carries the gases into the side of the chimney. The two common flues last mentioned enter at opposite sides of the chimney. The main flues are arranged and fitted with dampers, so that the gases can pass directly to the chimney, or they may be diverted through the economizers and thence reach the chimney.

The uptakes from each boiler are constructed of ⅛-in. plate, and each is lined with radial hollow brick 4 ins. thick. The dampers which are provided operate on shafts turning in roller bearings. The uptakes rest on iron beams at the bottom, and at the top where they join the main flue, means are provided to take up expansion and contraction.

The main flue, which rests on the economizer floor, is what might be called a steel box; the bottom is lined with brick laid flat, and the sides with brick walls 8 ins. thick, and the top is formed of brick arches sprung between.

The accompanying plan shows the main smoke-flue system in combination with an economizer system, which will be installed on the basis of one economizer for each set of three boilers. The installation of economizers is to be made upon an experimental basis, in order to determine if the economy effected warrants the investment. All the economizers are symmetrically arranged, and they will all be similar as to their design and proportions.

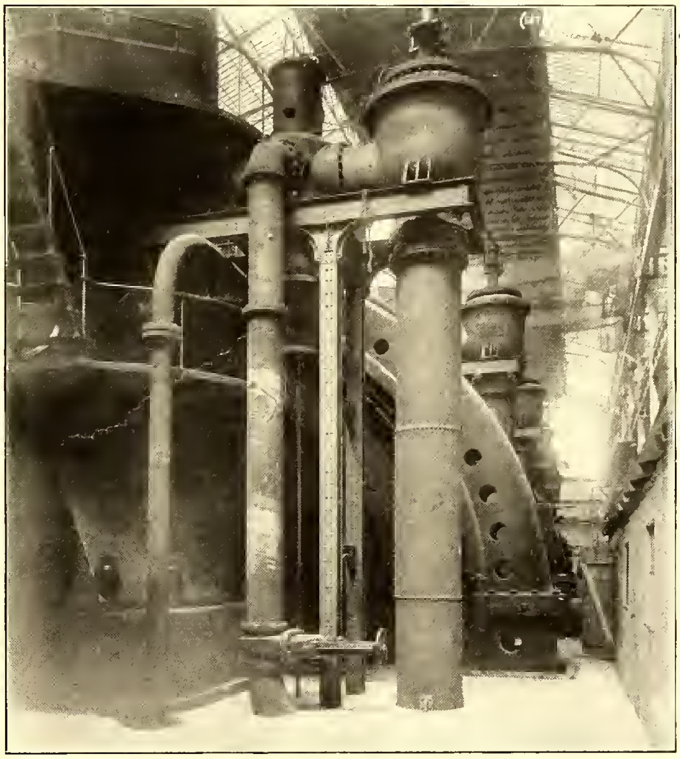
STEAM PIPING

The sectional plan on which the power house is designed has made a uniform and simple arrangement of steam piping possible with the piping for each section, except that of the turbine bay, identical with that for every other section. Starting with the group of six boilers for one main engine, the steam piping is interestingly arranged as follows:

A cross-over pipe is erected on each boiler, this to be provided with four 4-in. safety valves and with a 9-in. outlet in the center; in the delivery from each boiler a quick closing 9-in. valve of Allis-Chalmers design is provided, which can be closed from the boiler room floor by hand or from a distant point, individually or in groups of six. By a combination of valves and fitting the steam may be passed through the superheater. Risers with 9-in. wrought-iron goose necks thence connect each boiler to the steam main, where 9-in. angle valves are inserted in each boiler connection. These valves can be closed from the floor over the boilers, and, as shown in the plans, are grouped three over one set of three boilers and three over the opposite set.

The main from the six boilers is carried directly across the boiler house in a straight line to a point in the pipe area, where it rises to the two 14-in. steam downtakes to the engine throttles. At this point the steam can also be led downward to a manifold to which the compensating tie lines are connected. These compensating lines are run lengthwise through the power house for the purpose of joining the systems together, as desired. The two downtakes to the engine throttles drop to the basement, where each, through a goose neck, delivers into a receiver and separating tank, and from the tank through a second goose neck into the corresponding throttle.

A quick-closing valve appears at the point where the 17-in. pipe divides into the two 14-in. downtakes, and a similar valve is provided at the point where the main connects to the manifold. The first valve will close the steam to the engine and the second will command the flow of steam to and from the manifold. These valves can be operated by hand from a platform located on the wall inside the engine room, or they can be closed from a distant point by hydraulic apparatus. In the event of accident the piping to any engine can be quickly cut out or that system of piping can quickly be disconnected from the compensating system.



THE ARRANGEMENT OF BAROMETRIC CONDENSERS USED UPON THE ENGINES, SHOWING PIPING CONNECTIONS

The pipe area containing, as mentioned, the various valves described, together with the manifolds and compensating pipes, is divided by means of cross walls into sections corresponding to each pair of main engines. Each section is thus separated from those adjoining, so that any escape of steam in one section can be localized, and by means of the quick-closing valves the piping for the corresponding pair of main engines can be disconnected from the rest of the power house, in the event of accident.

The important details of the main steam-pipe system are probably apparent from the drawings. In the first place the important elements of the system, like, for instance, the heavier valves, the manifolds, the compensating pipes, are all contained within the pipe area and do not appear, therefore, in either the boiler or engine room. All the radiated heat passes upward through this area, so that the temperature of both the boiler and engine rooms should be much lower than otherwise.

The uniform arrangement of piping makes it much more easily understood, and in the event of difficulty much less confusion or loss of time will result in handling the connections than if a complicated system were employed.

All cast iron used in the fittings is called air-furnace iron, which is a semi-steel and tougher than ordinary iron. All fittings are heavier in their proportions than ordinary practice, and all are of special design. All line and bent pipe is of wrought iron, and the flanges are loose and made of wrought steel, which was rolled by Krupp, of Essen, Germany. The shell of the pipe is bent over the face of the flange, according to the special Walworth practice. All the joints in the main steam line above 2½ ins. in size are ground joints, metal to metal, no gaskets being used.

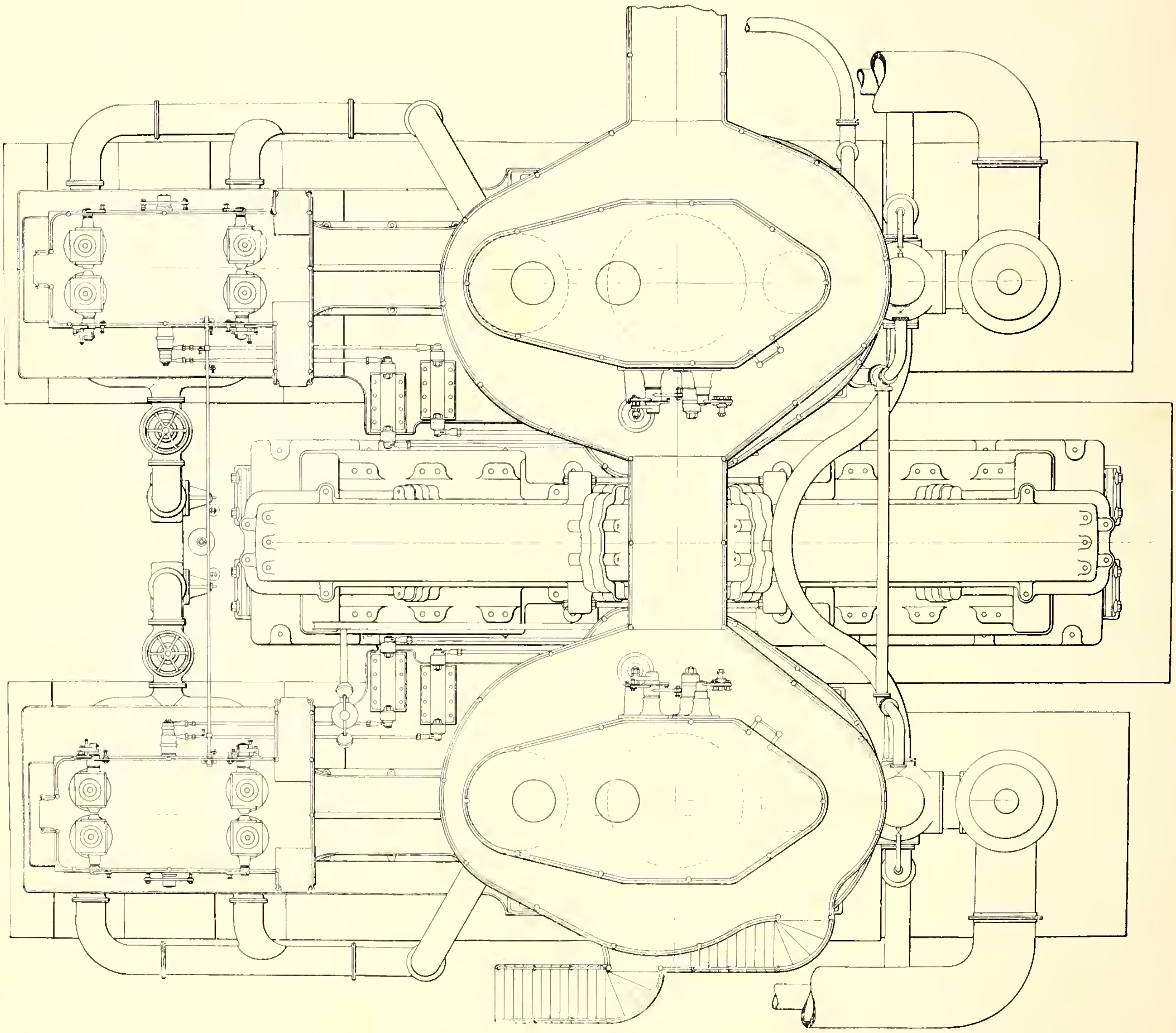
Unlike the flanges ordinarily used in this country, special extra strong proportions have been adopted, and it may be said that all flanges and bolts used in same are 50 per cent heavier than the so-called extra heavy proportions used in this country.

Before the design of the valves was attempted, information was obtained from abroad with respect to the qualifications needed in valve construction for superheated steam, and certain departures were made in the design and materials used for the valves in question. Special attention was also given to the matter for expansion and contraction required for superheated steam.

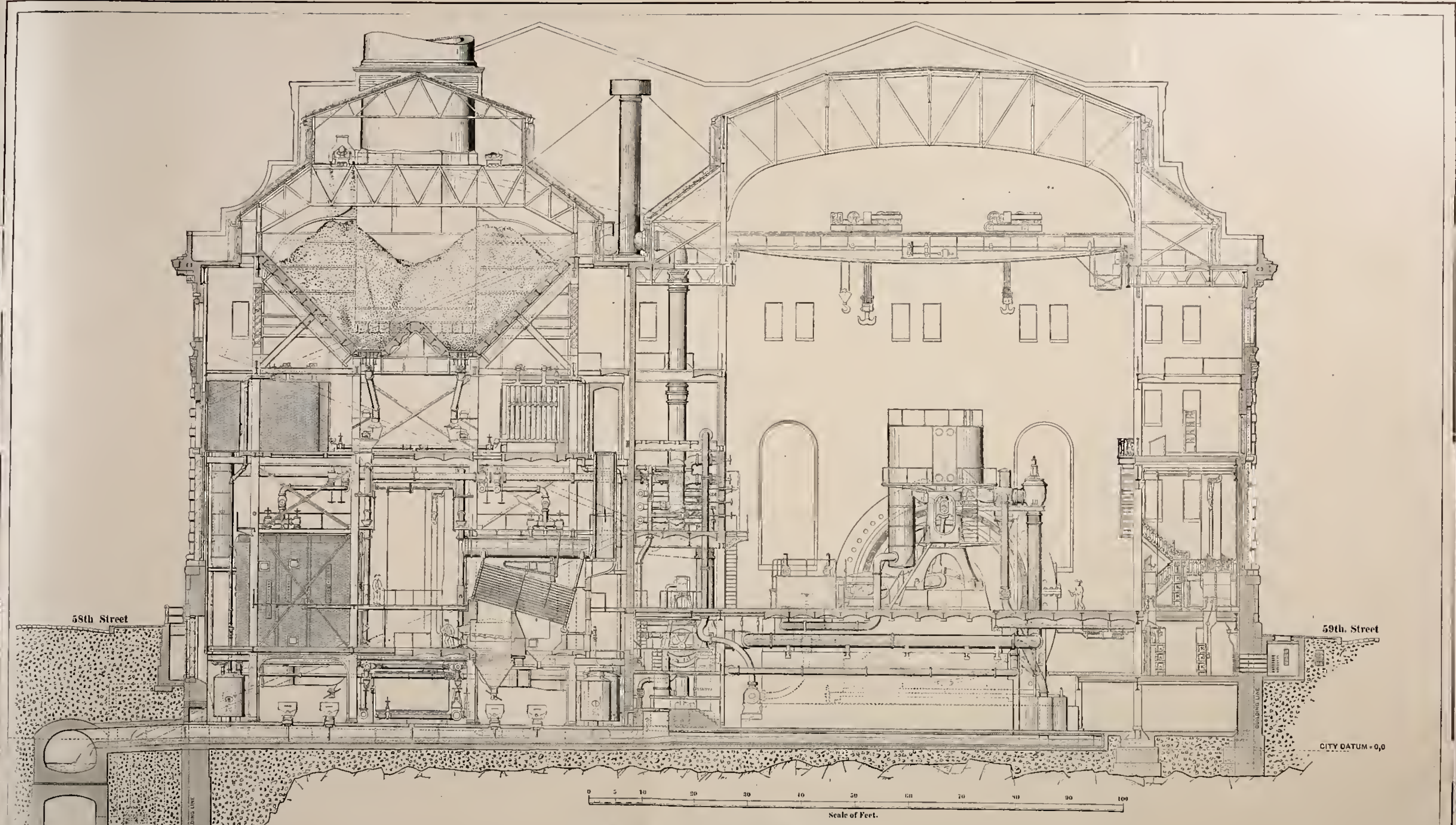
FEED-WATER PIPING

The feed-water will enter the building at three points, the largest water service being 12 ins. in diameter, which enters the structure at its southeast corner. The water first passes through fish traps and thence through meters, and from them to the main reservoir tanks, arranged along the center of the boiler house basement, flowing into each tank by means of an automatic float valve. The water will be partly heated in these reservoir tanks by means of hot water discharged from the high-pressure steam traps—in this way heat represented in the drainage from the high-pressure steam is, for the most part, returned to the boilers. From the reservoir tanks the water is conducted to the feed-water pumps, by which it is discharged through the auxiliary exhaust steam feed-water heaters directly to the boilers, or through the economizer system to be further heated by the waste gasses from the boilers.

Like the steam-pipe system, the feed-water piping is laid out on the sectional plan, the piping for the several sections being identical, except for the connections from the street service to the reservoir tank. The feed-water piping is constructed wholly of cast iron, except the piping above the floor line to



PLAN OF ONE OF THE MAIN 11,000-HP GENERATING UNITS, SHOWING ARRANGEMENT OF THE STEAM PIPING THROUGHOUT



CROSS-SECTION OF POWER-HOUSE

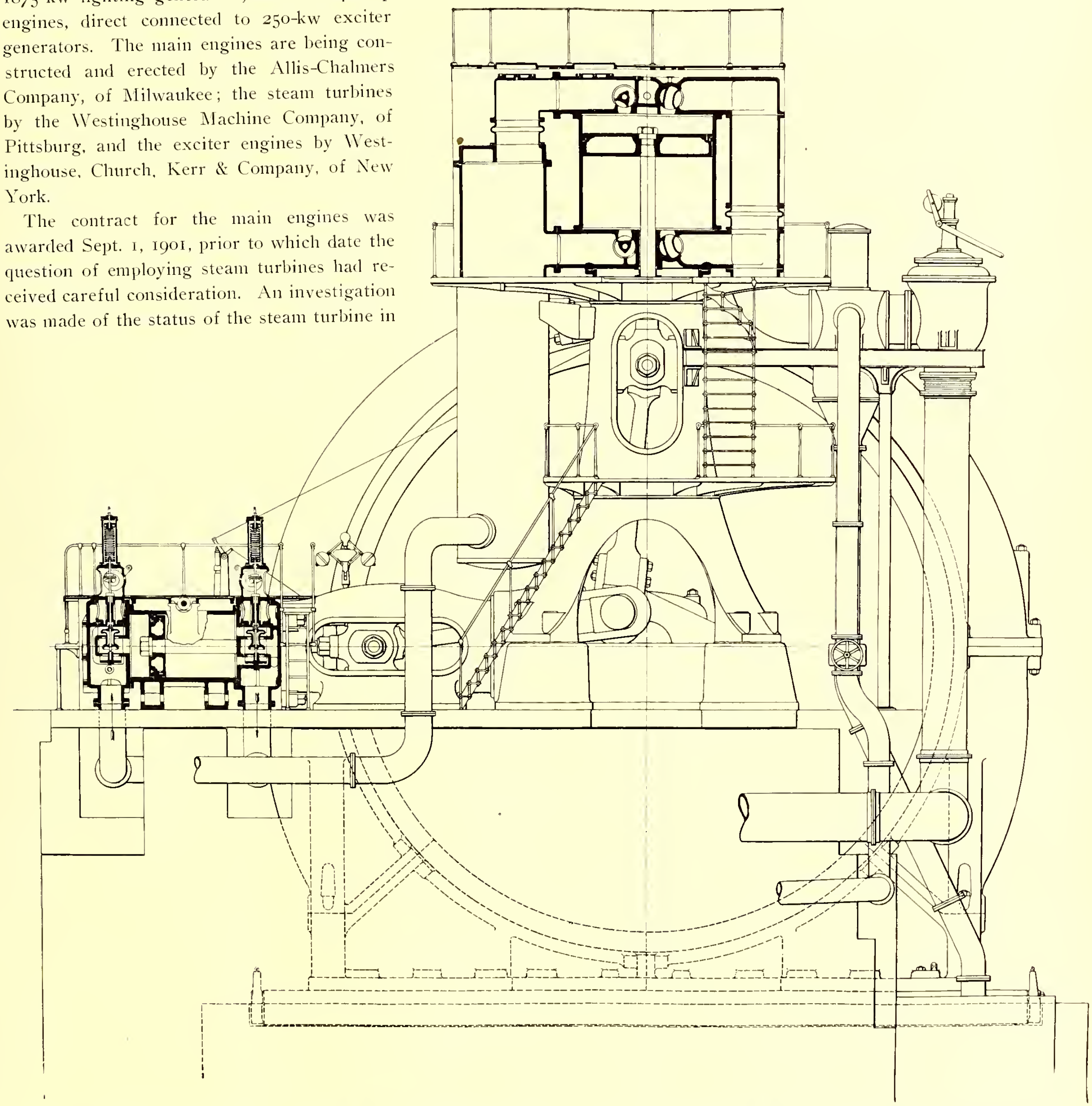
the boilers, which is of extra heavy semi-annealed brass with extra heavy cast-iron fittings. The installation of the piping systems, both steam and water, were made by the Walworth Manufacturing Company, Boston.

ENGINE AND TURBINE EQUIPMENT

The engine and turbine equipment under contract embraces nine 8000-hp to 11,000-hp main engines, directed connected to 5000-kw generators; three steam turbines, direct connected to 1875-kw lighting generators, and two 400-hp engines, direct connected to 250-kw exciter generators. The main engines are being constructed and erected by the Allis-Chalmers Company, of Milwaukee; the steam turbines by the Westinghouse Machine Company, of Pittsburg, and the exciter engines by Westinghouse, Church, Kerr & Company, of New York.

The contract for the main engines was awarded Sept. 1, 1901, prior to which date the question of employing steam turbines had received careful consideration. An investigation was made of the status of the steam turbine in this and foreign countries, and it was found that aside from the construction of certain 3500-kw Parsons turbine-generators pending at the works of Brown, Boveri & Company, at Baden, Switzerland, nothing was then being done in the way of an actual construction of a turbo-generator of the capacity needed for the Rapid Transit Subway power house, nor were the results obtained from the use of smaller turbines considered to be of a character which would justify the purchase of a turbine equipment for the plant in question requiring successful operation on the opening of the road beyond all question of doubt.

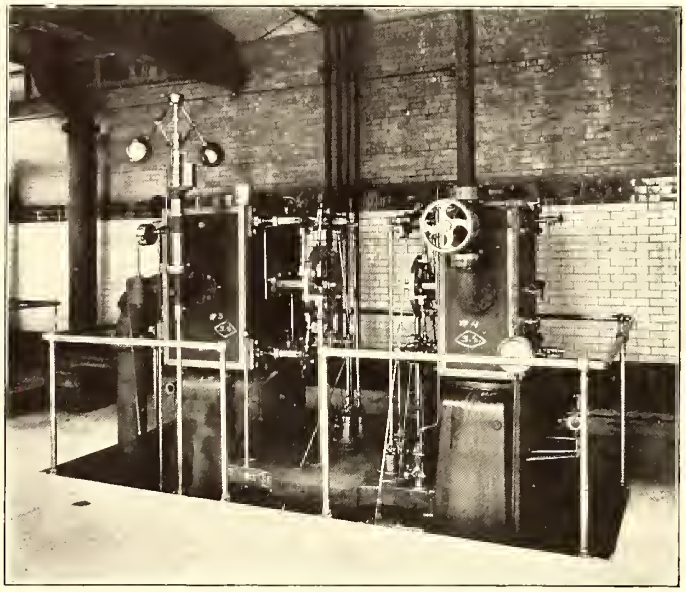
The recent improvements, however, which have taken place in steam turbine design have indicated the possible desirability of turbines for the future increase to the generating equipment, and arrangements have accordingly been made in the westerly 108-ft. extension of the structure to provide for the installation of steam turbines, if desired, of 8000-kw or 9000-kw generating capacity.



SIDE ELEVATION OF ONE OF THE MAIN GENERATING UNITS, TO SHOW ARRANGEMENT AND DETAILS OF CYLINDERS

MAIN ENGINES

The main engines are similar in type to those installed by the Allis-Chalmers Company in Seventy-Fourth Street power house of the Manhattan division of the Interborough Rapid Transit Company, in that each consists of two component compound engines, both connected to a common shaft, with the generators placed between the two component engines. The principal details of the engine are shown in an accompanying drawing. This type of engine is now well known and will not be described in detail, but as a comparison of various dimensions and features of the Manhattan and Rapid Transit Sub-



THE STEAM CYLINDERS OF THE CONDENSER CIRCULATING PUMPS, EXTENDING ABOVE THE MAIN OPERATING FLOOR

way engines may be of interest, the accompanying tabulation is submitted:

	Manhattan	Rapid Transit Subway
Diameter of high pressure cylinders, inches	44 inches	42 inches
" " low pressure " "	88 "	86 "
Stroke, inches	60 "	60 "
Speed, revolutions per minute	75 R. P. M.	75 R. P. M.
Steam pressure at throttle, pounds	150 lbs.	175 lbs.
Indicated horse power at best efficiency	7,500	7,500
Diameter of L. P. piston rods, inches	8 inches	10 inches
" " H. P. " "	8 "	10 "
" " crank pin, inches	18 "	20 "
Length of crank pin, inches	18 "	18 "
Type of L. P. valves	Double Ported, Corliss	Single Ported, Corliss
" H. P. "	"	Poppet type
Diameter of shaft in journals, inches	34 inches	34 inches
Length of journals, inches	60 "	60 "
Diameter of shaft in hub of revolving element	37 1-16 "	37 1-16 inches

The guarantees under which the main engines are being furnished and which will govern their acceptance by the purchaser are in substance as follows:

First—The engine will be capable of operating continuously when indicating 11,000 hp without producing abnormal wear, jar, noise or other objectionable results.

Second—It will be suitably proportioned to withstand in a serviceable manner all sudden fluctuations of load as are usual and incidental to the generation of electrical energy for railway purposes.

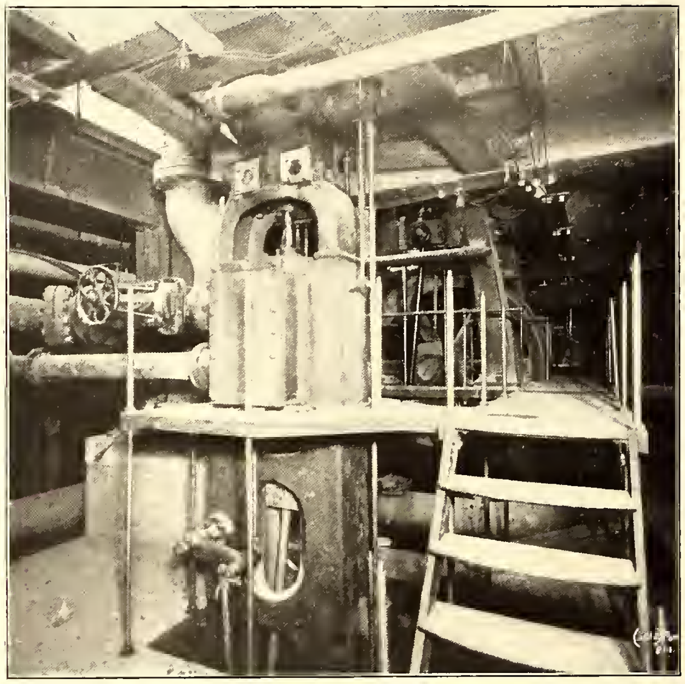
Third—It will be capable of operating with an atmospheric exhaust producing 2 lbs. back pressure at the low-pressure cylinders, and when so operating the engines will fulfil all the operating requirements, except as to economy and capacity.

Fourth—It will be proportioned so that when occasion shall require it, it can be operated with a steam pressure at the throttles of 200 lbs. above atmospheric pressure, and when so operating the engine will fulfil all the guaranteed operating requirements.

Fifth—The engine will operate successfully with a steam pressure at the throttle of 175 lbs. above atmosphere, should the temperature of the steam be maintained at the throttle at from 450 to 500 degs. F., in lieu of its normal temperature at saturation, and should the engine be so operated, then no undue strains, wear or excessive use of oil will be occasioned thereby.

Sixth—The engine will not require more than 12¼ lbs. of dry steam per indicated horse-power per hour when indicating 7500 hp at 75 revolutions per minute, with a vacuum of 26 ins. at the low-pressure cylinders, with a steam pressure at the throttle of 175 lbs. and with saturated steam at the normal temperature due to its pressure. The guarantee includes all of the steam used by the engine, and by the jackets or reheater.

The new features contained within the engine construction are principally: First, the novel construction of the high-pressure cylinders, by which only a small strain is transmitted through the valve chamber between the cylinder and the slide surface casting. This is accomplished by employing heavy bolts which clamp the shell of the cylinder casting to the slide surface casting, said bolts being carried past and outside the valve chamber. Second, the use of poppet valves, which are operated in a very simple manner from the wrist plate on the side of the cylinder, the connections from the valves to the



VIEW BENEATH FLOOR, SHOWING LOWER PORTION OF CIRCULATING PUMPS, AND ALSO A BOILER—FEED PUMP IN FOREGROUND

wrist plate and the connections from the wrist plate to the eccentric being similar to the parts usually employed for the operation of Corliss valves.

Unlike the Manhattan engines, the main steam pipes are carried to the high-pressure cylinders under the floor and not above it. Another modification consists in the use of the adjustable strap for the crank-pin boxes instead of the marine style of construction at the crank-pin end of the connecting rod.

The weight of the revolving field is about 335,000 lbs., which gives a fly-wheel effect of about 350,000 lbs. at a radius of gyration of 11 ft., and with this fly-wheel inertia the engine is designed so that any point on the revolving element shall not, in operation, lag behind or forge ahead of the position that it would have if the speed were absolutely uniform, by an amount greater than one-eighth of a natural degree.

TURBO-GENERATORS

Arrangements have been made for the erection of four Westinghouse-Parsons turbo-generators, although only three have been ordered. They are of the multiple-expansion parallel-flow type, consisting of two turbines arranged in tandem-eompound. When operating at full load, eaeh of the two turbines, eomprising one unit, will develop approximately equal power in eaeh for direct connection to an alternator giving 7200 alternations per minutes at 11,000 volts and at a speed of 1200 revolutions per minute. Each unit will have a normal output of 1700 ehp, with a steam pressure of 175 lbs. at the throttle and a vacuum in the exhaust pipe of 27 ins. measured by a mercury column and referred to a barometric pressure of 30 ins. The turbine is guaranteed to operate satisfactorily with steam superheated to 450 degs. F. The economy guaranteed under the foregoing conditions as to initial and terminal pressure and speed, but with saturated steam, is as follows: Full load of 1250 kw—15.7 lbs. of steam per electrical horse-power-hour. Three-quarters load, 937½ kw—16.6 lbs. per electrieal horse-power-hour. One-half load, 625 kw—18.3 lbs. One-quarter load, 312½ kw—23.2 lbs. When operating under the conditions of speed and steam pressure mentioned, but with pressure in the exhaust pipe of 27 ins. vacuum by mereury eolumn (referred to 30 ins. barometer), with steam at the throttle superheated 75 degs. F. above the temperature of saturated steam at that pressure, the guaranteed steam consumption is as follows: Full load, 1250 kw—13.8 lbs. per electrical horse-power-hour. Three-quarter load, 937½ kw—14.6 lbs. One-half load, 625 kw—16.2 lbs. One-quarter load, 312½ kw—20.8 lbs.

EXCITER ENGINES

The two exciter engines are eaeh direct conneeted to a 250-kw direct-current Westinghouse generator. Each engine is a vertical quarter-crank compound engine with a 17-in. high-pressure cylinder and a 27-in. low-pressure cylinder with a common 24-in. stroke. The engines will be non-eondensing, for the reason that extreme reliability is desired at the expense of some eeonomy. They will operate at best efficieney when indicating 400 hp at a speed of 150 revolutions per minute with a steam pressure of 175 lbs. at the throttle. Eaeh engine will have a maximum capaeity of 600 ihp.

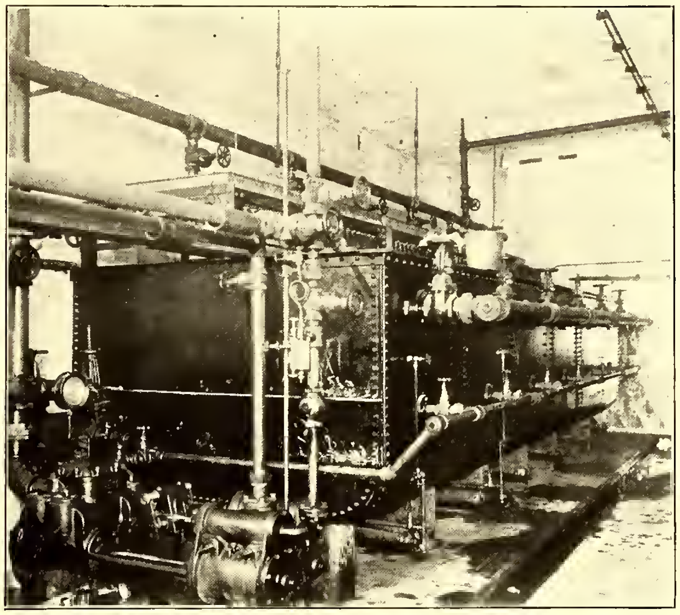
CONDENSING EQUIPMENT

In selecting condensing apparatus for a power house of the magnitude of the one in question, a most careful consideration of the design and efficiency seemed warranted. It was appreciated that the value of the vacuum to the engines is equal to at least one-third of their total power, and it is evident that the condensers and their appurtenances should be economical as well as reliable from an operative point of view.

Each engine unit is supplied with its own condenser equipment, consisting of two Alberger barometric condensing ehambers, each of which is attached as closely as possible to its respective low-pressure cylinder. For every engine also is provided an Alberger vertical Corliss circulating pump along with a vacuum pump, and for the sake of flexibility the pumps are cross-eonnected with those of other engines and can be used interchangeably. The equipment will be seen from the following description to combine many features that have proved by long experience to be of great value to a power house of this kind.

The barometric condenser is characterized by a condensing chamber having a tail pipe that contains a barometric column of water, the function of the column being to allow the water whieh has produced eondensation in the condenser to flow by gravity into the hot well against the pressure of the atmosphere without allowing air to enter. The condensing water passes an opening at the upper right hand side and, passing downward, is finally divided by the spray eone and brought into intimate contact with the exhaust steam to be condensed, which latter enters the condensing chamber at the opposite side and fills the entire interior.

The circulation pumps are vertical, cross-compound, Corliss pumping engines with outside packed plungers. Their foundations are upon the basement floor level, and the steam cylinders extend above the engine room floor, so that the starting valves and control of speed is therefore entirely under the supervision of the enginer. Each pump has a normal capacity of 10,000,000 gallons of water per day, so that the total pumping capacity of all the pumps in the station is 120,000,000 gallons per day. While the head against which these pumps will be required to work, when assisted by the vacuum in the condenser, is mueh less than the total lift from low tide water to the entrance into the eondensing chambers, still they are so designed as to be ready to deliver the full quantity to the full height, if for any



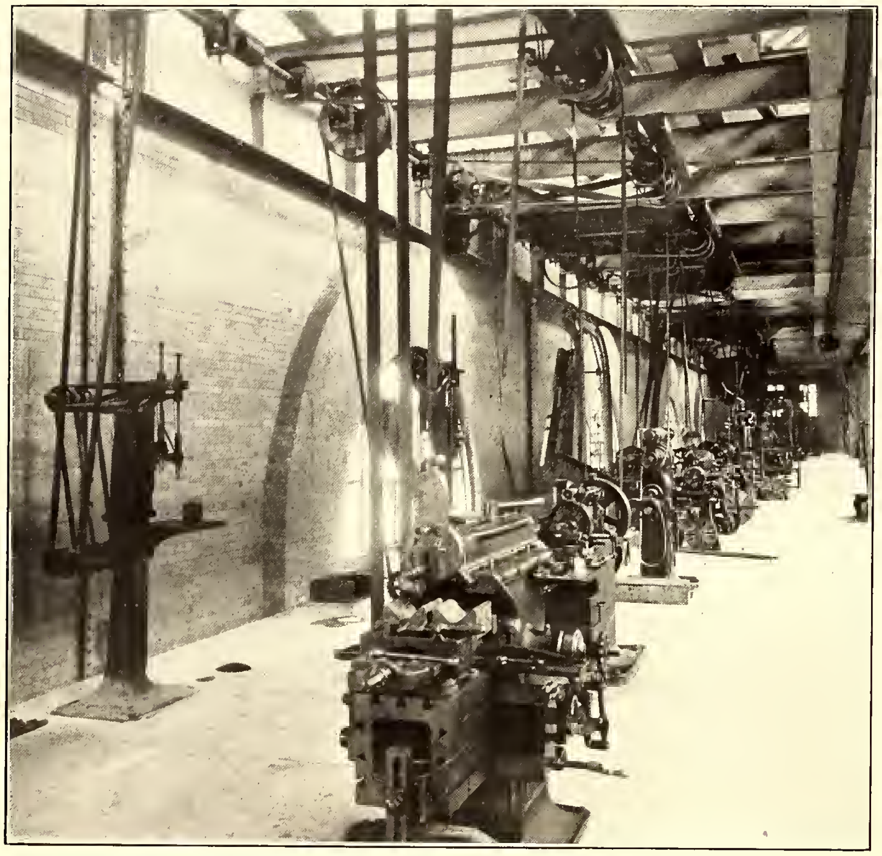
THE OIL-FILTERING TANKS OF THE AUTOMATIC LUBRICATING OIL-HANDLING SYSTEM, FROM WHICH THE FILTERED OIL IS DELIVERED TO THE ELEVATED STORAGE TANKS

reason the assistance of the vacuum should be lost or not available at times of starting up.

The high-pressure steam cylinder is 10 ins. in diameter and the low-pressure is 20 ins. The two double-acting water plungers are each 20 ins. in diameter, and the stroke is 30 ins. for all. The water ends are composition fitted for salt water, and have valve decks and plungers entirely of that material.

The dry vacuum pumps are of the vertical form, and each is located alongside of the corresponding circulating pump. The steam cylinders also project above the engine room floor. The vacuum cylinder is located immediately below the steam cylinder and has a valve that is mechanically operated by an eccentric on the shaft. These pumps are of the close-clearance type and, while controlled by a Corliss governor, can be changed in speed while running, to any determined rate.

The three turbines which will be used for lighting equipment of the subway will each exhaust into an Alberger counter-current surface condenser. The characteristic feature of these condensers is that the exhaust steam enters the shell at the bottom, while the circulating water enters at the top, the water passing through the upper nest of the tubes, then through the lower ones. In this way the water of condensation is brought into contaet with the ineoming exhaust steam before leaving the condenser, and is heated up to practically the temperature of the steam, thus rendering primary heaters superfluous. The air remaining after condensation of the steam passes upward and is cooled by the upper tubes before passing to the vacuum pump. The water of condensation is removed by a simple duplex pump which runs according to the amount of water formed, and discharges directly to the feed tanks. As the highest possible degree of vacuum is of great importance to the economy of the turbines, a dry vacuum pump with compounded vacuum cylinders is used. These cylinders are driven by a Corliss engine and placed in a horizontal position upon a substantial bed plate. They are of a capacity to produce 29 ins. of vacuum when load and temperatures of cooling water allow it, and under contract requirement are to maintain 28 ins.



THE MACHINE SHOP, SHOWING EQUIPMENT OF MACHINE TOOLS FOR MAKING REPAIRS TO MACHINERY

EXHAUST PIPING

From each atmospheric exhaust valve, which is direct connected to the condensing chamber at each low-pressure cylinder, is run downward a 30-in. riveted-steel exhaust pipe. At a point just under the engine room floor the exhaust pipe is carried horizontally around the engine foundations, the two from each pair of engines uniting in a 40-in. riser to the roof. This riser is between the pair of engines and back of the high-pressure cylinder, thus passing through the so-called pipe area, where it also receives exhaust steam from the pump auxiliaries. At the roof the 40-in. riser is run into a 48-in. standpipe, which is capped with an exhaust head, with the top 35 ft. above the roof.

All the exhaust piping 30 ins. in diameter and over is longitudinally riveted steel, with cast-iron flanges riveted on to it. Expansion joints are provided where necessary to relieve the piping from the strains due to expansion and contraction, and where the joints are located near the engine and generator they are of the corrugated copper Wainwright pattern. The expansion joints in the 40-in. risers above the pipe area are ordinarily packed slip joints.

The exhaust piping from the auxiliaries is carried directly up into the pipe area, where it is connected with a feed-water heater, with connections for by-passing the latter. Beyond the heater it joins the 40-in. riser to the roof. The feed-water heaters are three-pass vertical, water-tube heaters, designed for a working water pressure of 225 lbs. per square inch, and are made by the Wheeler Condenser & Engineering Company.

OIL SYSTEM

For the lubrication of the engines an extensive oil-distributing and filtering system is provided. Filtered oil will be supplied under pressure from elevated storage tanks, with a piping system leading by branches to all the various journals. The piping to the engines is constructed on a duplicate, or crib, system, by which the supply of oil cannot be interrupted by a break in any one pipe. The oil on leaving the engines is conducted to the filtering tanks, and a pumping equipment then redelivers the oil to the elevated storage tanks.

All piping carrying filtered oil is of brass, and fittings are inserted at proper pipes to facilitate cleaning. The immediate installation includes two oil filtering tanks at the easterly end of the power house, but the completed plant contemplates the addition of two extra filtering tanks at the westerly end of the structure. Each filtering tank is 24 ft. long, 8 ft. wide and 5 ft. high. The oil first passes through a system of six-bag trays, arranged in multiple, each tray having sixty filtering bags placed on cartridges, making 360 cartridges in all. The oil then passes to an end compartment and finally through five separating compartments, in which the oil is heated or cooled by steam or water coils.

CRANES AND SHOP EQUIPMENT

The power house is provided with the following traveling cranes: For the operating room—one 60-ton electric traveling crane and one 30-ton electric traveling crane. For the area over the oil switches—one 10-ton hand-operated crane. For the center aisle of the boiler room—one 10-ton hand-operated crane. The electric cranes have been supplied by the Shaw Electric Crane Company, and the hand-operated cranes by the Cleveland Crane & Car Company. The span of both of the electric cranes is 74 ft. 4 ins., and both cranes operate over the entire length of the structure. The 60-ton crane has two trolleys, each with a lifting capacity, for regular load, of 50 tons. Each trolley is also provided with an auxiliary hoist of 10 tons capacity. The 30-ton crane is provided with one trolley, having a lifting capacity, for regular load, of 25 tons, together with auxiliary hoist of 5 tons.

The power house is provided with an extensive tool equipment for a repair and machine shop, which is located on the main gallery at the northerly side of the operating room. The equipment includes the following machine tools: One 30-in. planer, one 20-in. shaper, one two-spindle sensitive drill, one 1½-in. bolt cutter, one 26-in. drill press, one Universal milling machine, three engine lathes, 16-in., 20-in. and 32-in., one 60-in. radial drill, and one 61-in. vertical boring mill.

THE ELECTRIC GENERATING EQUIPMENT AND POWER DISTRIBUTION SYSTEM OF THE NEW YORK RAPID TRANSIT SUBWAY

BY L. B. STILLWELL

THE system of electrical supply chosen for the Rapid Transit subway comprises alternating-current generation and distribution and direct-current operation of motor cars. Four years ago, when the engineering plans were under consideration, the single-phase alternating-current railway motor was not even in an embryonic state, and notwithstanding the marked progress recently made in its development, it can scarcely yet be considered to have reached a stage that would warrant any modifications in the plans adopted, even were such modifications easily possible at the present time. The comparatively limited headroom available in the subway prohibited the use of an overhead system of conductors, and this limitation, in conjunction with the obvious desirability of providing a system permitting interchangeable operation with the lines of the Manhattan Railway system, practically excluded tri-phase traction systems and led directly to the adoption of the third-rail direct-current system.

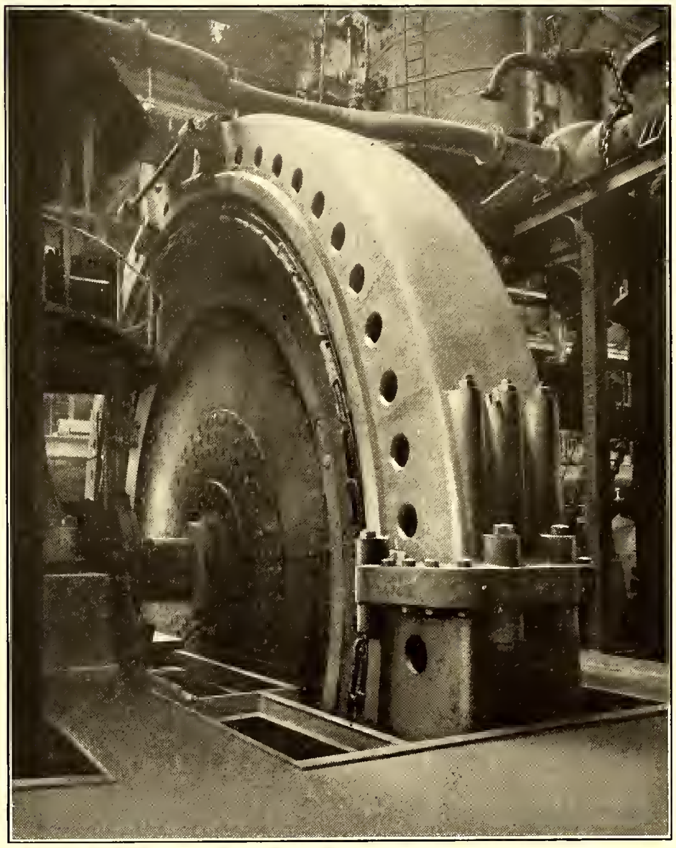
It being considered impracticable to predict with entire certainty the ultimate traffic conditions to be met, the generator plant has been designed to take care of all probable traffic demands expected to arise within a year or two of the beginning of operation of the system, while the plans permit convenient and symmetrical increase to meet the requirements of additional demand which may develop. Express trains in rush hours will comprise five motor cars and three trail cars; the first, third, fifth, sixth and eighth will be motor cars. An eight-car multiple-unit train can be reduced therefore to a six-car train by uncoupling three cars from the rear end, or to a three-car train by uncoupling five cars from either end. In each case a motor car will remain at the head and at the end of the reduced train. The normal local train will consist of five cars, the first, third and fifth cars being motor cars. The weight of each motor car with maximum live load is 88,000 lbs. and the weight of each trail car 66,000 lbs.

The plans adopted provide electric equipment at the outstart capable of an acceleration with maximum load at a rate of 1.25 miles per hour per second and of operating express trains at an average speed approximating 25 miles per hour, while the control system and motor units have been so chosen that higher speeds up to a limit of about 30 miles per hour can be attained by increasing the number of motor cars, providing experience in operation demonstrates that such higher speeds can be obtained with safety.

The speed of local trains between City Hall and Ninety-Sixth Street will average about 15 miles an hour, while north of City Hall, on both the west side and east side branches, their speed will average about 18 miles an hour, owing to the greater average distance between local stations.

As a result of careful consideration of various plans, the company's engineers recommended that all the power required for the operation of the system be generated in a single power house in the form of three-phase alternating current at 11,000 volts, this current to be generated at a frequency of 25 cycles per second, and to be delivered through three-conductor cables to transformers and converters in sub-stations suitably located with reference to the track system, the current there to be transformed and converted to direct current for delivery to the third-rail conductor at a potential of 625 volts.

Calculations based upon contemplated schedules require for traction purposes and for heating and lighting cars a maximum delivery of about 45,000 kw at the third rail. Allowing for losses in the distributing cables, in transformers and converters, this implies a total generating capacity of approximately 50,000 kw, and having in view the possibility of future extensions of the system it was decided to design and construct the power house building for the ultimate reception of eleven 5000-kw units for traction current in addition to the lighting sets. Each 5000-kw unit is capable of delivering during rush



ONE OF THE 5000-KW MAIN ALTERNATORS IN THE POWER PLANT

hours an output of 7500 kw, or approximately 10,000 ehp, and, setting aside one unit as a reserve, the contemplated ultimate maximum output of the power plant therefore is 75,000 kw, or approximately 100,000 ehp.

The power house is fully described in another article in this issue, but it is not inappropriate to refer briefly in this place to certain considerations governing the selection of the generating unit, and the use of engines rather than steam turbines.

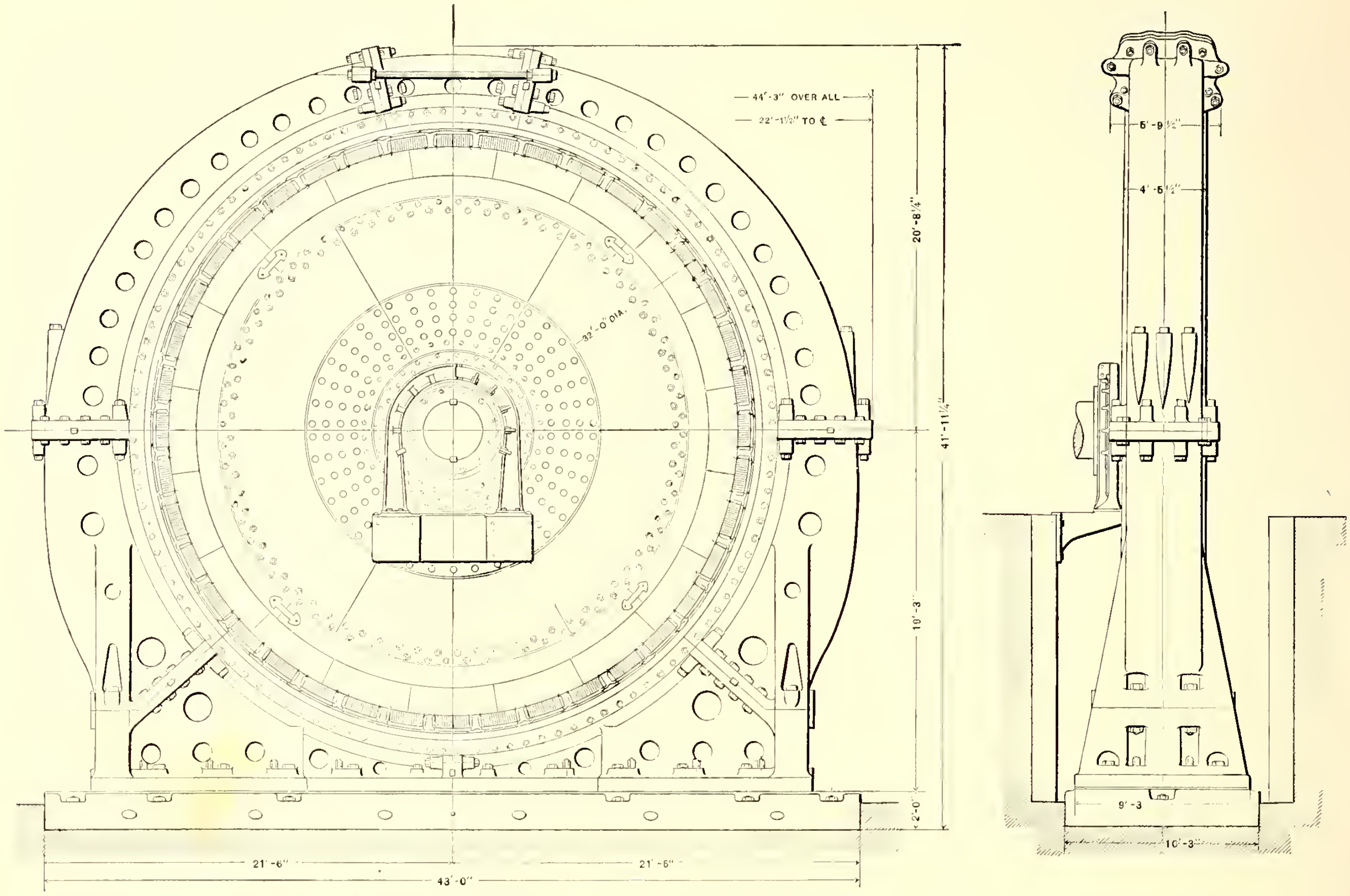
The 5000-kw generating unit was chosen because it is practically as large a unit of the direct-connected type as can be constructed by the engine builders unless more than two bearings be used—an alternative deemed inadvisable by the engineers of the company. The adoption of a smaller unit would be less economical of floor space and would tend to produce extreme complication in so large an installation and, in view of the rapid changes in load, which in urban railway service of this character occur in the morning and again late in the afternoon, would be extremely difficult to operate. The experience of the Manhattan plant has shown, as was anticipated in the installation of less output than this, the alternators must be put in service at intervals of twenty minutes to meet the load upon the station while it is rising to the maximum attained during rush hours.

After careful consideration of the possible use of steam turbines as prime movers to drive the alternators, the company's engineers decided in favor of reciprocating engines. This decision was made three years ago and, while the steam turbine since that time has made material progress, those responsible for the decision are confirmed in their opinion that it was wise.

THE ALTERNATORS

The alternators closely resemble those installed by the Manhattan Railway Company (now the Manhattan division of the Interborough Rapid Transit Company) in its plant on the East River, between Seventy-Fourth and Seventy-Fifth Streets. They differ, however, in having the stationary armature divided into seven castings instead of six, and in respect to details of the armature winding. They are three-phase machines, delivering 25-cycle alternating current at an effective potential of 11,0000 volts. They are 42 ft. in height, the diameter of the revolving part is 32 ft., its weight 332,000 lbs., and the aggregate weight of the machine 889,000 lbs. The design of the engine-dynamo unit eliminates the auxiliary fly-wheel generally used in the construction of large direct-connected units prior to the erection of the Manhattan plant, the weight and dimensions of the revolving alternator field being such with reference to the turning moment of the engine as to secure close uniformity of rotation, while at the same time this construction results in narrowing the engine and reducing the engine shafts between bearings.

Construction of the revolving parts of the alternators is such as to secure very great strength and consequent ability to resist the tendency to burst and fly apart in case of temporary abnormal speed through accident of any kind. The hub of the revolving field is of cast steel, and the rim is carried, not by the usual spokes, but by two wedges of rolled steel. The construction of the revolving field is illustrated in the cuts on this and the opposite page. The angular velocity of the revolving field is remarkably uniform. This result is due primarily to the fact that the turning moment of the four-cylinder engine is far more uniform than is the case, for example, with an ordinary two-cylinder engine. The large fly-wheel capacity of the rotating element of the machine also contributes materially to secure uniformity of rotation.

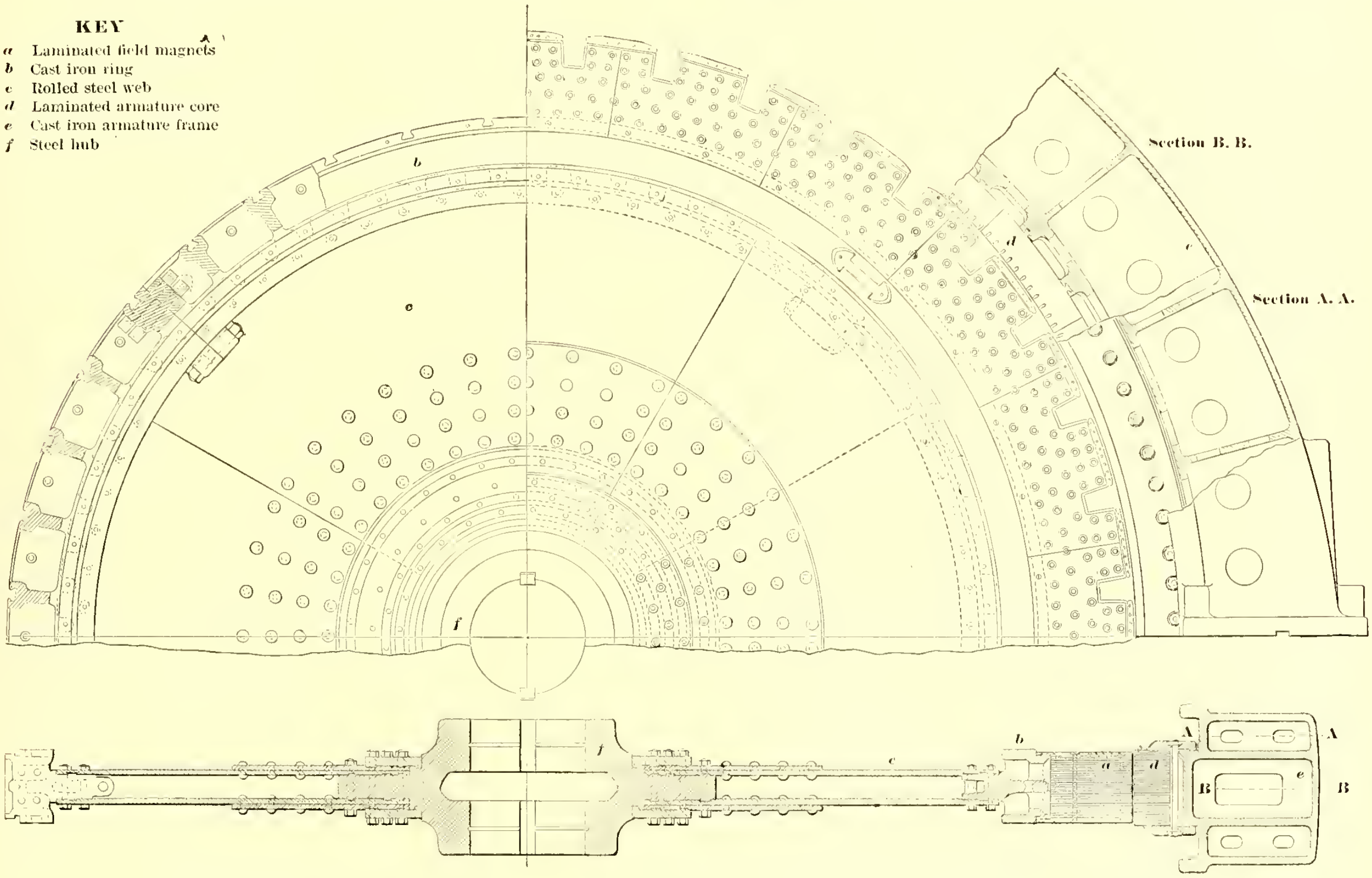


SIDE AND END ELEVATIONS OF THE 5000-KW ALTERNATOR AT THE POWER PLANT

The alternators have forty field poles and operate at 75 r. p. m. The field magnets constitute the periphery of the revolving field, the poles and rim of the field being built up by steel plates which are dovetailed to the driving spider. The heavy steel end plates are bolted together, the laminations breaking joints in the middle of the pole. The field coils are secured by copper wedges, which are subjected to shearing strains only. In the body of the poles, at intervals of approximately 3 ins., ventilating spaces are provided, these spaces registering with corresponding air ducts in the external armature. The field winding consists of copper strap on edge, one layer deep, with fibrous material cemented in place between turns, the edges of the strap being exposed.

The armature is stationary and exterior to the field. It consists of a laminated ring with slots on its inner surface and supported by a massive external cast-iron frame. The armature, as has been noted, comprises seven segments, the topmost segment being in the form of a small keystone. This may be removed readily, affording access to any field coil, which in this way may be easily removed and replaced. The armature winding consists of U-shaped copper bars in partially closed slots. There are four bars per slot and three slots per phase per pole. The bars in any slot may be removed from the armature without removing the frame. The alternators, of course, are separately excited, the potential of the exciting current used being 250 volts.

As regards regulation, the manufacturer's guarantee is that at 100 per cent power factor if full rated load be thrown off the electromotive force will rise 6 per cent with constant speed and constant excitation. The guarantee as to efficiency is as follows: On non-inductive load, the alternators will have an efficiency of not less than 90.5 per cent at one-quarter load; 94.75 per cent at one-half load; 96.25 per cent at three-quarters load; 97 per cent at full load, and 97.25 per cent at one and one-quarter load. These figures refer, of course, to electrical efficiency, and do not include windage and bearing friction. The machines are designed to operate under their rated full load with rise of temperature not exceeding 35 degs. C. after twenty-four hours.



SIDE ELEVATION AND CROSS SECTION OF THE REVOLVING FIELD OF THE MAIN ALTERNATOR

EXCITERS

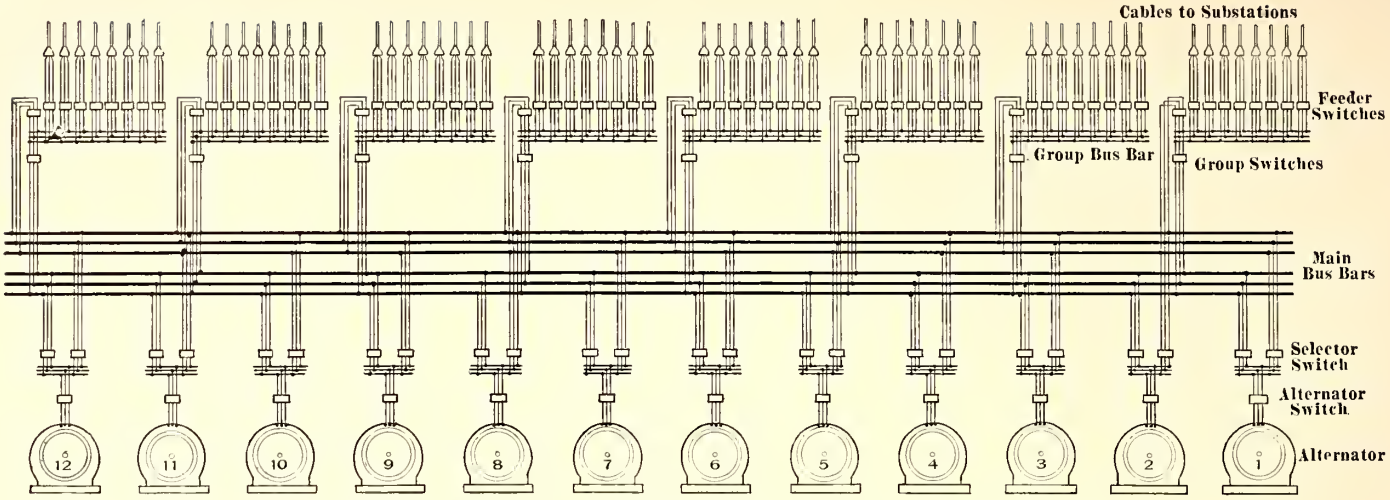
To supply exciting current for the fields of the alternators and to operate motors driving auxiliary apparatus, five 250-kw direct-current dynamos are provided. These deliver their current at a potential of 250 volts. Two of them are driven by 400-hp engines of the marine type, to which they are direct-connected, while the remaining three units are direct-connected to 365-hp three-phase induction motors operating at 400 volts. A storage battery capable of furnishing 3000 amps. for one hour is used in co-operation with the dynamos provided to excite the alternators. The five direct-current dynamos are connected to the organization of switching apparatus in such a way that each unit may be connected at will either to the exciting circuits or to the circuits through which auxiliary motors are supplied.

SWITCHING APPARATUS

Where the power to be controlled is so great, the potential so high, and the speed requirements in respect to synchronous operation so exacting, it is obvious that the perfection of control attained in some of our modern plants is not their least characteristic. The switch used for the 11,000-volt circuits is so constructed that the circuits are made and broken under oil, the switch being electrically operated. Two complete and independent sets of bus bars are used, and the connections are such that each alternator and each feeder may be connected to either of these sets of bus bars at the will of the operator. From alternators to bus bars the current passes, first, through the alternator switch, and then alternatively through one or the other of two selector switches which are connected, respectively, to the two sets of bus bars.

Provision is made for an ultimate total of twelve sub-stations, to each of which as many as eight feeders may be installed if the development of the company's business should require that number. But eight sub-stations are required at present, and to some of these not more than three feeders each are necessary. The aggregate number of feeders installed for the initial operation of the subway system is thirty-four.

Each feeder circuit is provided with a type H oil switch arranged to be opened and closed at will by the operator, and also to open automatically in the case of abnormal flow of current through the feeder. The feeders are arranged in groups, each group being supplied from a set of auxiliary bus bars, which in turn receives its supply from one or the other of the two sets of main bus bars; means for selection being



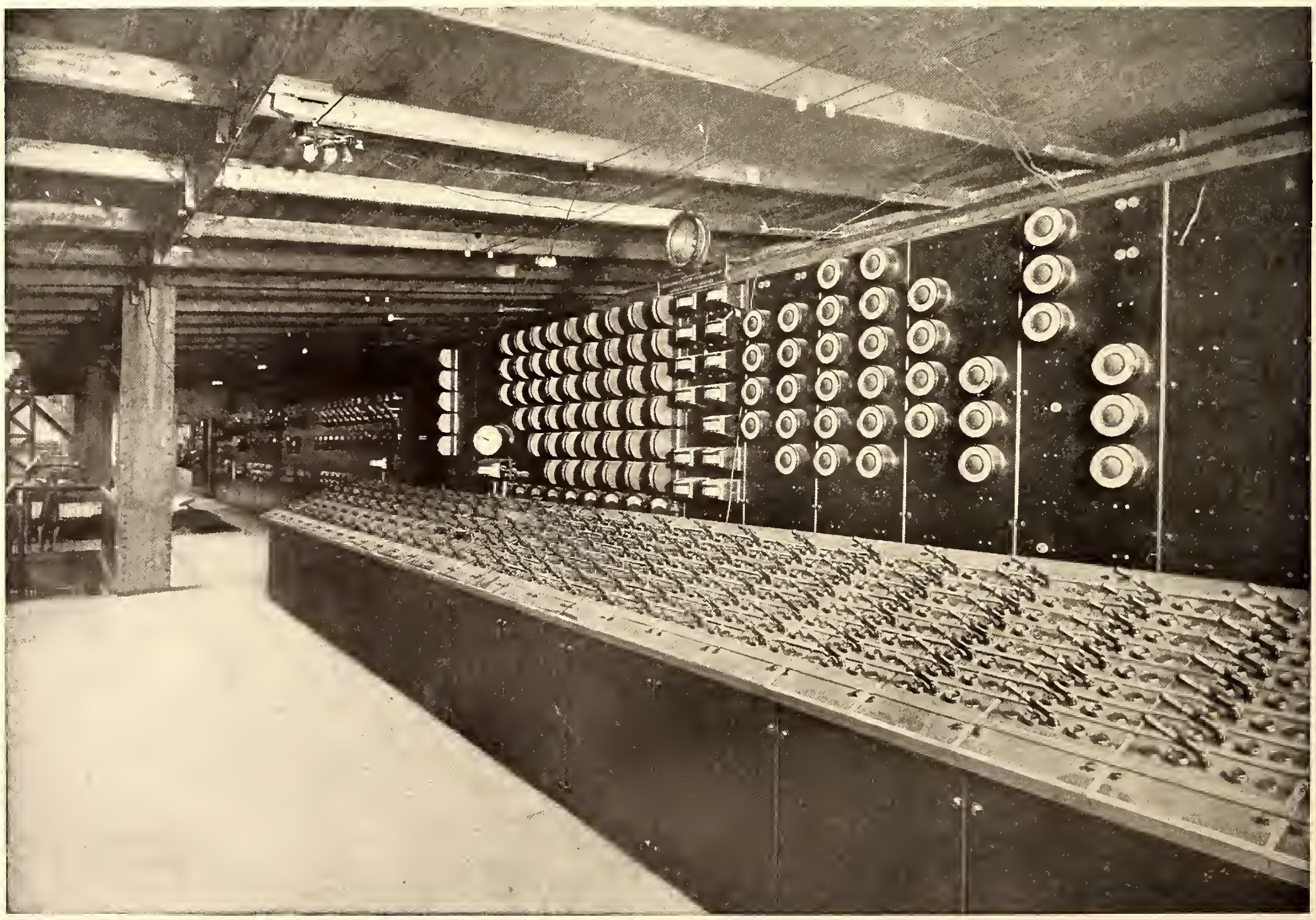
GENERAL DIAGRAM OF 11,000-VOLT CIRCUITS IN MAIN POWER STATION

provided as in the case of the alternator circuits by a pair of selector switches, in this case designated as group switches. The diagram above illustrates the essential features of the organization and connections of the 11,000-volt circuits in the power house.

Any and every switch can be opened or closed at will by the operator standing at the control board described. The alternator switches are provided also with automatic overload and reversed current relays, and the feeder switches, as above mentioned, are provided with automatic overload relays. These overload relays have a time attachment which can be set to open the switch at the expiration of a predetermined time ranging from .3 of a second to 5 seconds.

The type H-oil switch is operated by an electric motor through the intervention of a mechanism comprising powerful springs which open and close the switch with great speed. This switch when opened introduces in each of the three sides of the circuit two breaks which are in series with each other. Each side of the circuit is separated from the others by its location in an enclosed compartment, the walls of which are brick and soapstone. The general construction of the switch is illustrated on the opposite page.

Like all current-carrying parts of the switches, the bus bars are enclosed in separate compartments. These are constructed of brick, small doors for inspection and maintenance being provided opposite all points where the bus bars are supported upon insulators. The upper view on page 624 represents a part of the bus bar and switch compartments.



VIEW OF THE MAIN CONTROL AND INSTRUMENT BOARDS IN THE SWITCHBOARD GALLERY OF THE MAIN POWER STATION

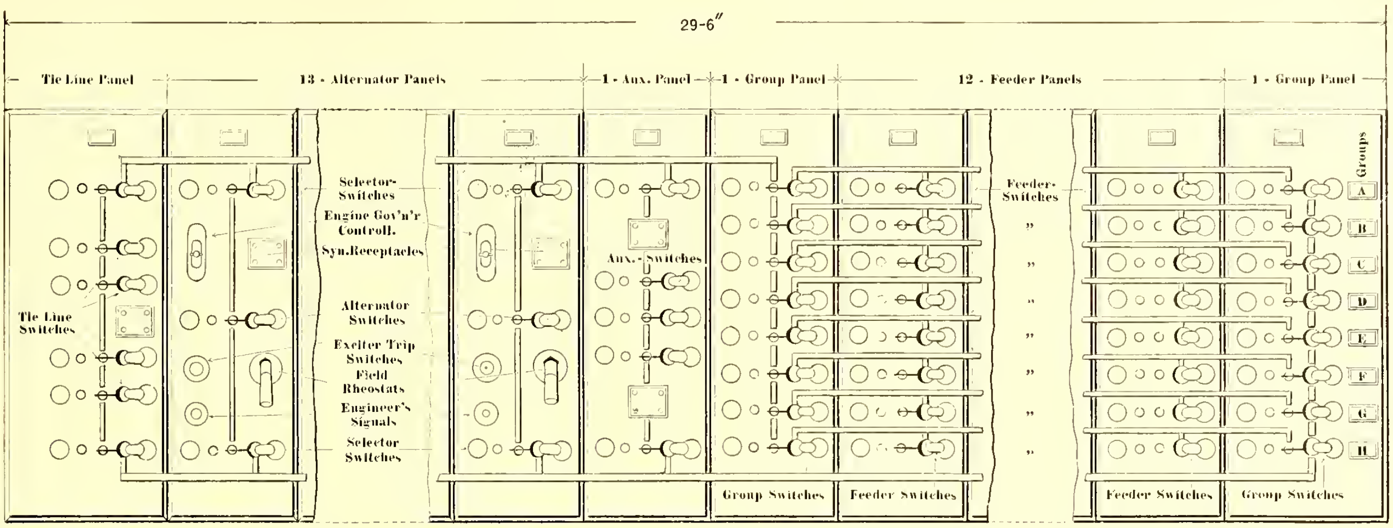
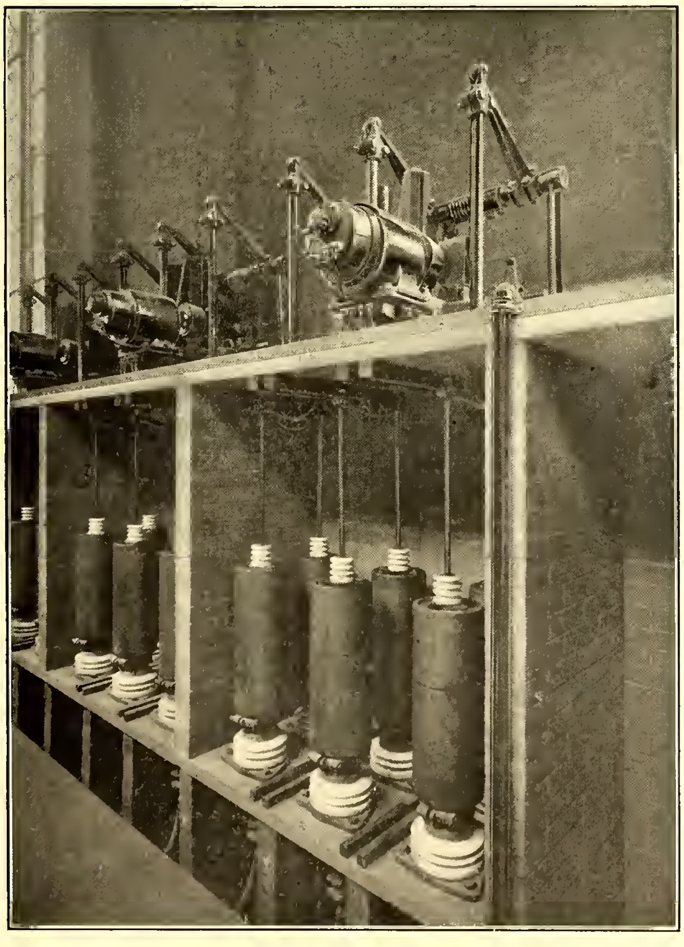


DIAGRAM OF THE MAIN CONTROLLING BOARD IN POWER STATION

The oil switches and group bus bars are located upon the main floor and extend along the Fifty-Ninth Street wall of the engine room, a distance of about 600 ft. The main bus bars are arranged in two lines of brick compartments, which are placed below the engine room floor. These bus bars are arranged vertically and are placed directly beneath the rows of oil switches located upon the main floor of the power house. Above these rows of oil switches and the group bus bars, galleries are constructed which extend the entire length of the power house, and upon the first of these galleries at a point opposite the middle of the power house are located the control board and instrument board, by means of which the operator in charge regulates and directs the entire output of the plant.



THE ARRANGEMENT OF OIL SWITCHES AT THE MAIN POWER STATION

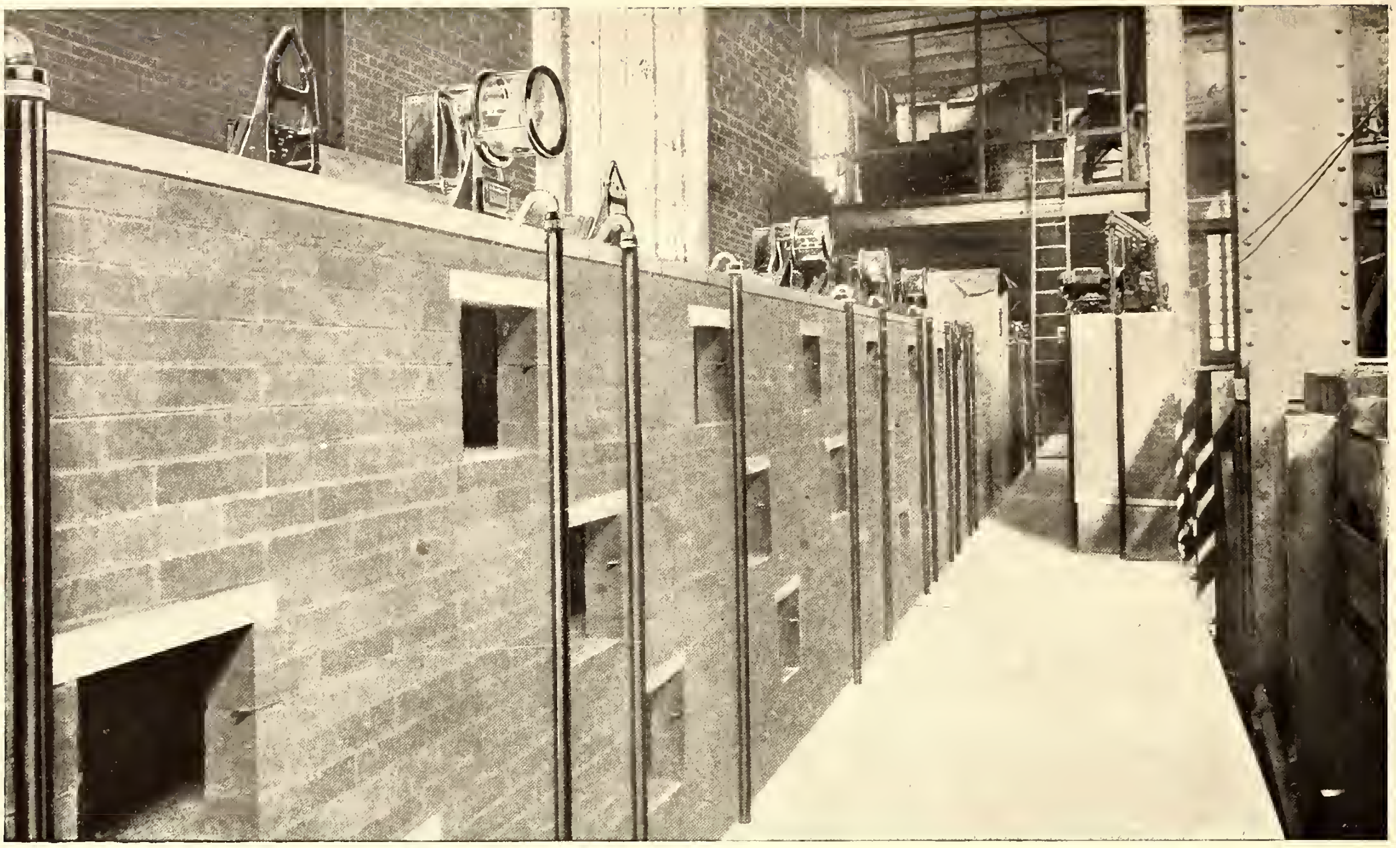
THE CONTROL BOARD

The control board is illustrated on the opposite page. Every alternator switch, every selector switch, every group switch, and every feeder switch upon the main floor is here represented by a small switch. The small switch is connected into a control circuit which receives its supply of energy at 110 volts from a small motor-generator set and storage battery. The motors which actuate the large oil switches upon the main floor are driven by this 110-volt control current, and thus in the hands of the operator the control switches make or break the relatively feeble control currents, which, in turn, close or open the switches in the main power circuits. The control switches are systematically assembled upon the control bench board in conjunction with dummy bus bars and other apparent (but not real) metallic connections, the whole constituting at all times a correct diagram of the existing connections of the main power circuits. Every time the operator changes a connection by opening or closing one of the main switches, he necessarily changes his diagram so that it represents the new conditions established by opening or closing the main switch. In connection with each control switch two small bull's-eye lamps are used, one red, to indicate that the corresponding main switch is closed, the other green, to indicate that it is open. These lamps are lighted when the moving part of the main switch reaches approximately the end of its travel. If for any reason, therefore, the movement of the control switch should fail to actuate the main switch, the indicator lamp will not be lighted.

The control board is divided into two parts—one for the connections of the alternators to the bus bars and the other for the connection of feeders to bus bars. The illustrations on accompanying pages show in plain view the essential features of the control boards.

THE INSTRUMENT BOARD

A front view of the instrument board is also shown on page 622. This board contains all indicating instruments for alternators and feeders. It also carries standardizing instruments and a clock. In the illustration the alternator panels are shown at the left and the feeder panels at the right. For the alternator panels, instruments of the vertical edgewise type are used. Each vertical row comprises the measuring instruments for an alternator. Beginning at the top and enumerating them in order these instruments are: Three ammeters, one for each phase, a voltmeter, an indicating wattmeter, a power factor indicator and a field ammeter. The round dial instrument shown



VIEW OF PART OF THE BUS-BAR COMPARTMENTS, BELOW THE SWITCHBOARD GALLERY

at the bottom of each row of instruments is a three-phase recording wattmeter.

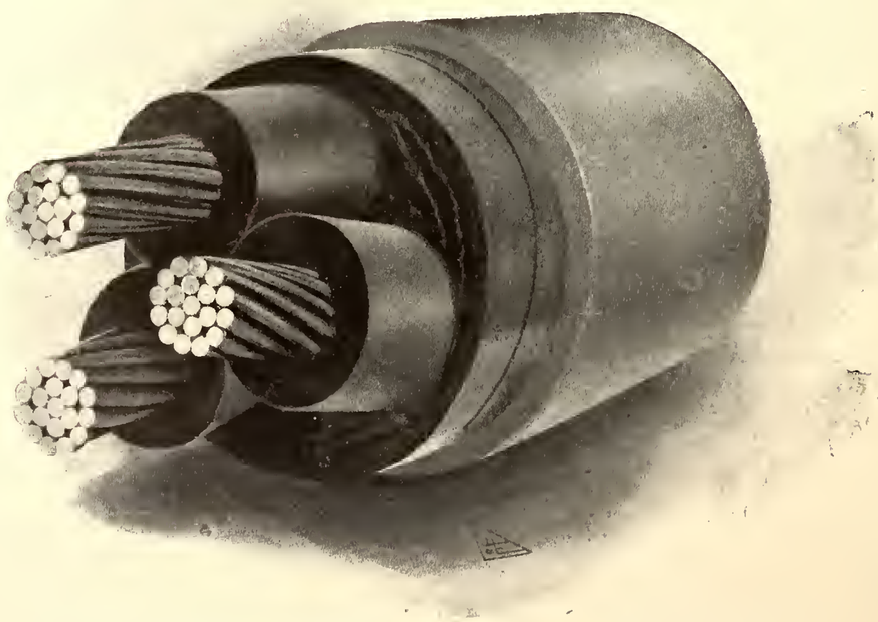
A panel located near the center of the board between alternator panels and feeder panels carries standard instruments used for convenient calibration of the alternator and feeder instruments. Provision is made on the back of the board for convenient connection of the standard instruments in series with the instruments to be compared. The panel which carries the standard instruments also carries ammeters used to measure current to the auxiliary circuits in the power house.

For the feeder board, instruments of the round dial pattern are used, and for each feeder a single instrument is provided, viz., an ammeter. Each vertical row comprises the ammeters belonging to the feeders which supply a given sub-station, and from left to right these are in order sub-stations Nos. 11, 12, 13, 14, 15, 16, 17 and 18; blank spaces are left for four additional sub-stations. Each horizontal row comprises the ammeter belonging to feeders which are supplied through a given group switch.

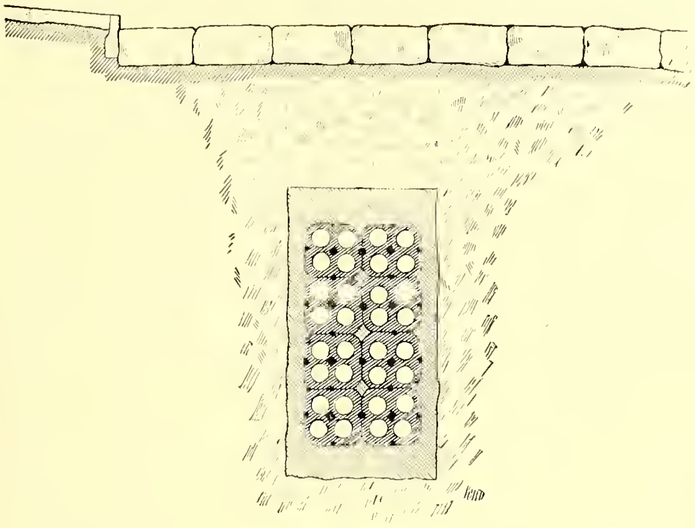
This arrangement in vertical and horizontal lines, indicating respectively feeders to given sub-stations and feeders connected to the several group switches, is intended to facilitate the work of the operator. A glance down a vertical row without stopping to read the scales of the instruments will tell him whether the feeders are dividing with approximate equality the load to a given sub-station. Feeders to different sub-stations usually carry different loads and, generally speaking, a glance along a horizontal row will convey no information of especial importance. If, however, for any reason the operator should desire to know the approximate aggregate load upon a group of feeders this systematic arrangement of the instruments is of use.

CABLES, DUCTS AND CONDUIT SYSTEM FOR DISTRIBUTION

From alternators to alternator switches the 11,000-volt alternating currents are conveyed through single conductor cables, insulated by oil cambric, the thickness of the wall being 12-32 of an inch. These conductors are installed in vitrified clay



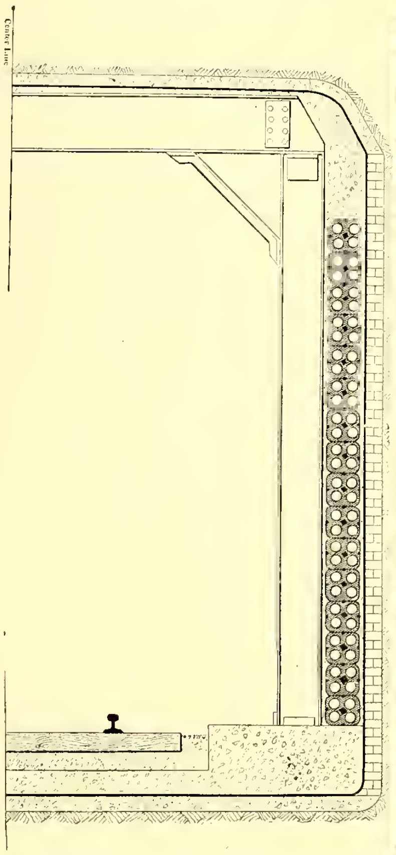
THE TYPE OF THREE-CONDUCTOR NO. 000 CABLE USED FOR THE 11,000-VOLT ALTERNATING-CURRENT DISTRIBUTION



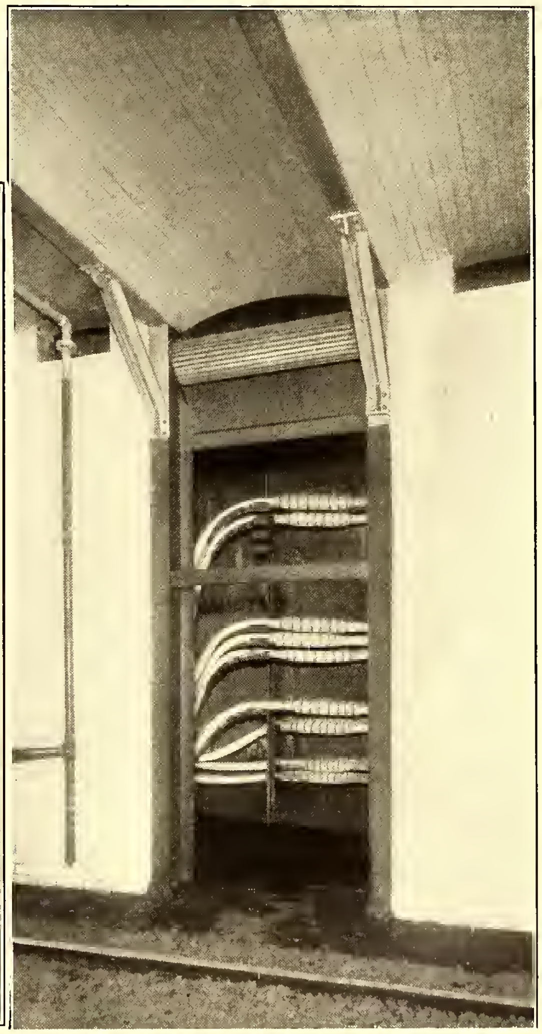
DUCT LINE ACROSS FIFTY-EIGHTH STREET—THIRTY-TWO DUCTS

ducts. From dynamo switches to bus bars and from bus bars to group and feeder switches, vulcanized rubber insulation containing 30 per cent pure Para rubber is employed. The thickness of insulating wall is 9-32-in. and the conductors are supported upon porcelain insulators.

From the power house to the subway at Fifty-Eighth Street and Broadway two lines of conduit, each comprising thirty-two



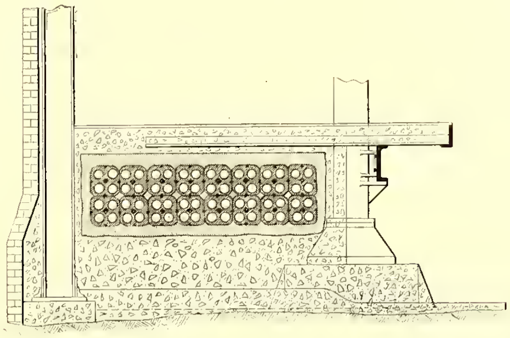
ARRANGEMENT OF DUCTS ALONG INSIDE WALL OF TUNNEL—SIXTY-FOUR DUCTS



VIEWS OF THE CABLE MANHOLES IN THE SIDE WALL OF THE TUNNEL, SHOWING ROLLING SHUTTER DOORS FOR READY ACCESS

ducts, have been constructed by the company. These conduits are located on opposite sides of the street. The arrangement of ducts is 8 x 4, as shown in the section above.

The location and arrangement of ducts along the line of the subway are also illustrated in the two diagrams herewith, which show respectively a section of ducts on one side of the subway, between passenger stations and a section of ducts and



CABLE DUCTS UNDER A PASSENGER STATION PLATFORM—SIXTY-FOUR DUCTS

one side of the subway, beneath the platform of a passenger station. From City Hall to Ninety-Sixth Street (except through the Park Avenue Tunnel) sixty-four ducts are provided on each side of the subway. North of Ninety-Sixth Street sixty-four ducts are provided for the west side lines and an equal number for the east side lines. Between passenger stations these ducts help to form the side walls of the subway, and are arranged thirty-two ducts high and two ducts wide. Beneath the platform of passenger stations the arrangement is somewhat varied because of local obstructions, such as pipes, sewers, etc., of which it was necessary to take account in the construction of the stations.

The necessity of passing the cables from the 32 x 2 arrangement of ducts along the side of the tunnel to 8 x 8 and 16 x 4

EXTERIOR OF SUB-STATION NO. 18

arrangements of ducts beneath the passenger platforms involves serious difficulties in the proper support and protection of cables in manholes at the ends of the station platforms. In order to minimize the risk of interruption of service due to possible damage to a considerable number of cables in one of these manholes, resulting from short circuit in a single cable, all cables except at the joints are covered with two layers of asbestos aggregating a full ¼-in. in thickness. This asbestos is specially prepared and is applied by wrapping the cable with two strips each 3 ins. in width, the outer strip covering the line of junction between adjacent spirals of the inner strip, the whole when in place being impregnated with a solution of silicate of soda. The joints themselves are covered with two layers of asbestos held in place by steel tape applied spirally. To distribute the strains upon the cables in manholes, radial supports of various curvatures, and made of malleable cast iron, are used. The photograph on page 625 illustrates the arrangement of cables in one of these manholes.

In order to further diminish the risk of interruption of the service due to failure of power supply, each sub-station south of Ninety-Sixth Street receives its alternating current from the power house through cables carried on opposite sides of the subway. To protect the lead sheaths of the cables against damage by electrolysis, rubber insulating pieces 1-6 of an inch in thickness are placed between the sheaths and the iron bracket supports in the manholes.

HIGH-TENSION CABLES

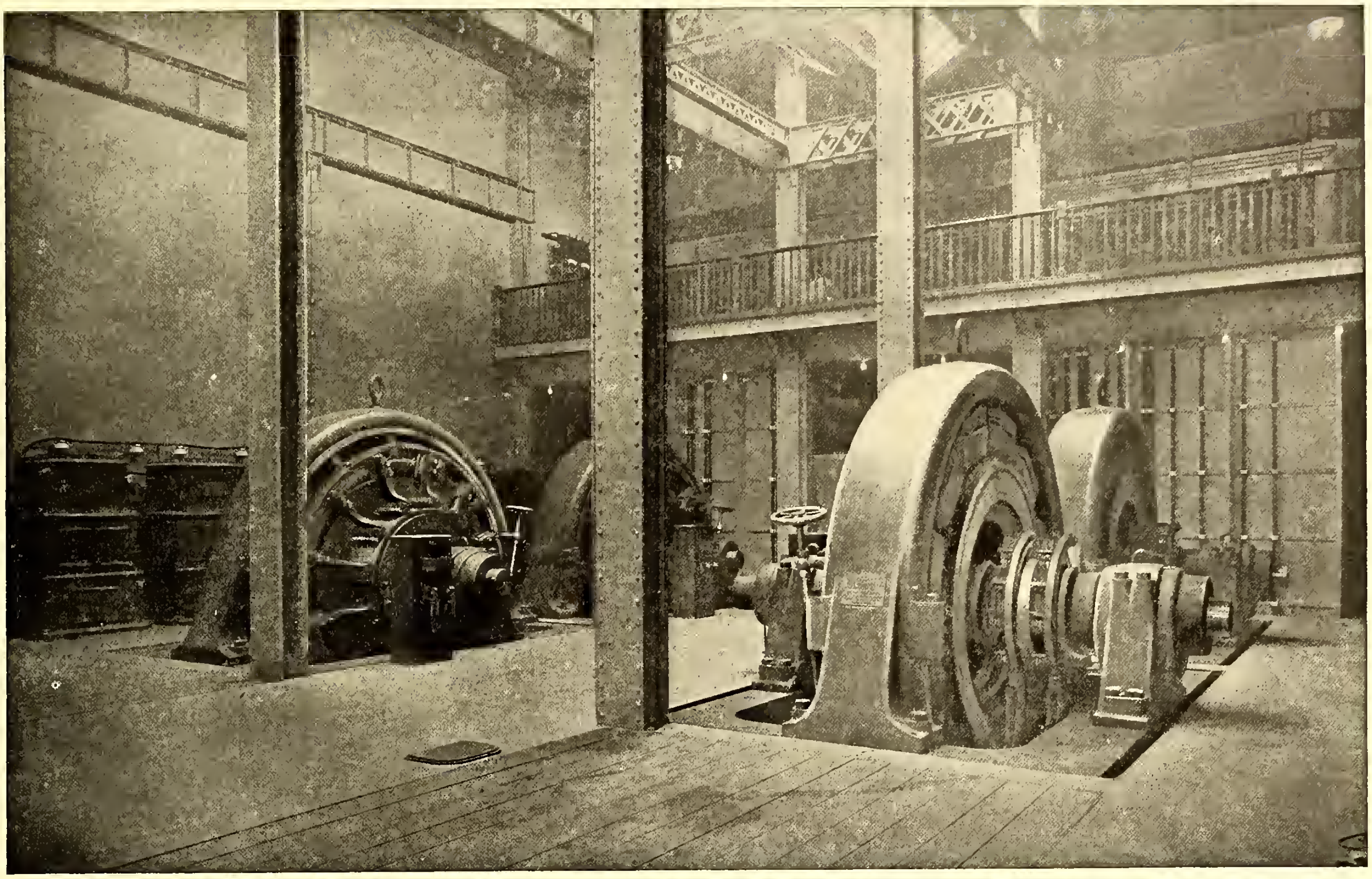
The cables used for conveying energy from the power house to the several sub-stations aggregate approximately 150 miles in length. The cable used for this purpose comprises three stranded copper conductors, each of which contains nineteen wires, and the diameter of the stranded conductor thus formed is 2-5 of an inch. Paper insulation is employed and the triple cable is enclosed in a lead sheath 9-64 of an inch thick. Each conductor is separated from its neighbors and from the lead sheath by insulation of treated paper 7-16 of an inch in thickness. The outside diameter of the cables is 2⅝ ins., and the weight 8½ lbs. per lineal foot. In the factories the cable as manufactured was cut into lengths corresponding to the distance between manholes, and each length subjected to severe tests, including application to the insulation of an alternating current potential of 30,000 volts for a period of thirty minutes. These cables were installed under the supervision of the Interborough Company's engineers, and after jointing, each complete cable from power house to sub-station was tested by applying an alternating potential of 30,000 volts for thirty minutes between each conductor and its neighbors, and between each conductor and the lead sheath.

SUB-STATIONS

The tri-phase alternating current generated at the power house is conveyed through the high-potential cable system to eight sub-stations containing the necessary transforming and converting machinery. These sub-stations are designed and located as follows:

Sub-station No. 11—31-33 City Hall Place.
Sub-station No. 12—108-110 East Nineteenth Street.
Sub-station No. 13—225-227 West Fifty-Third Street.
Sub-station No. 14—264-266 West Ninety-Sixth Street.

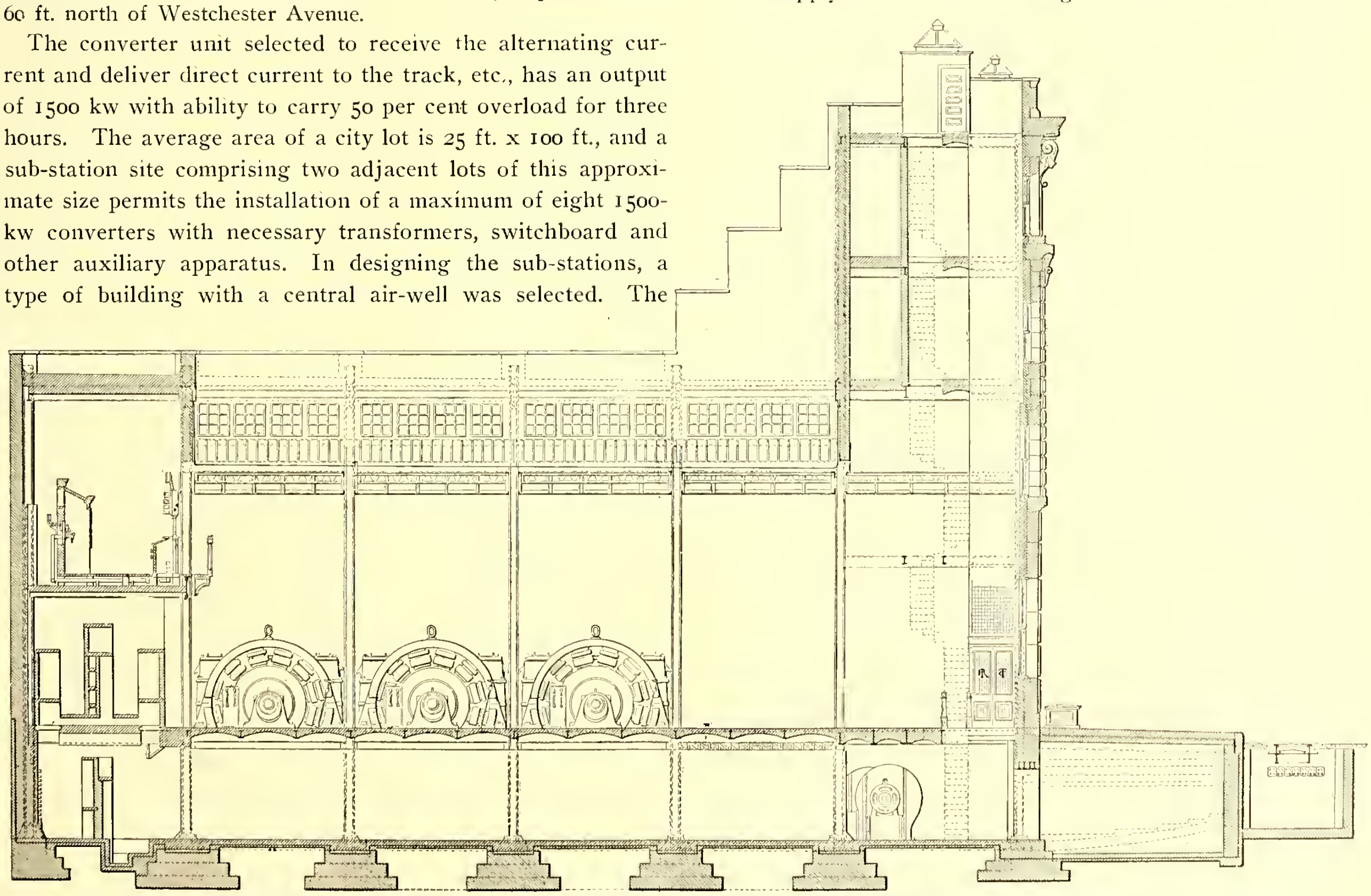
EXTERIOR VIEW OF SUB-STATION NO. 11, SHOWING ARTISTIC ARCHITECTURAL TREATMENT



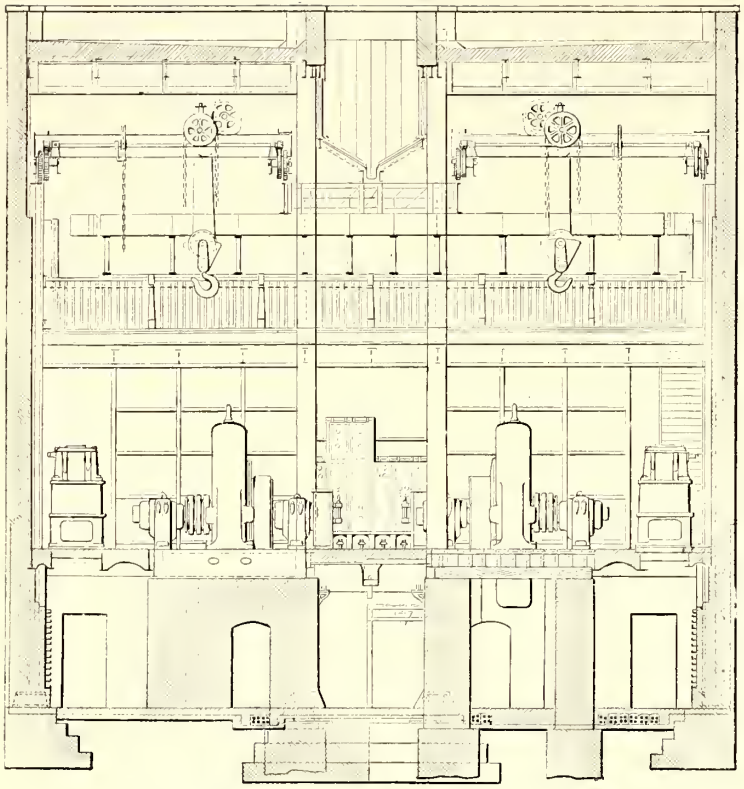
GENERAL INTERIOR VIEW OF SUB-STATION NO. 11, SHOWING ARRANGEMENT OF TRANSFORMERS, ROTARIES, SWITCHBOARD GALLERY, ETC.

Sub-station No. 15—606-608 West 143d Street.
Sub-station No. 16—73-77 West 132d Street.
Sub-station No. 17—Hillside Avenue, 301 ft. west of Eleventh Avenue.
Sub-station No. 18—South side of Fox Street (Simpson Street), 60 ft. north of Westchester Avenue.

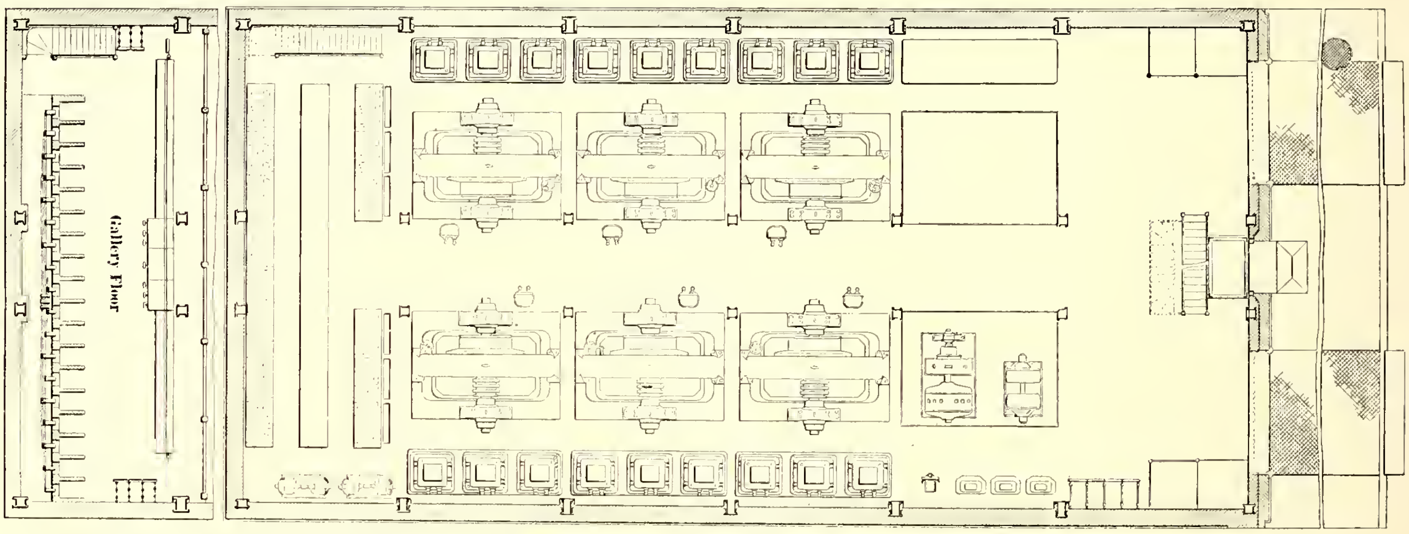
The converter unit selected to receive the alternating current and deliver direct current to the track, etc., has an output of 1500 kw with ability to carry 50 per cent overload for three hours. The average area of a city lot is 25 ft. x 100 ft., and a sub-station site comprising two adjacent lots of this approximate size permits the installation of a maximum of eight 1500-kw converters with necessary transformers, switchboard and other auxiliary apparatus. In designing the sub-stations, a type of building with a central air-well was selected. The typical organization of apparatus is illustrated in the ground plan and vertical section on this and the next page, and provides, as shown, for two lines of converters, the three transformers which supply each converter being located between it and the



LONGITUDINAL SECTION OF SUB-STATION NO. 14, TO SHOW BUILDING DETAILS AND ARRANGEMENT OF APPARATUS



CROSS SECTION OF SUB-STATION NO. 14



CONVERTER FLOOR PLAN AND PLAN OF SWITCHBOARD GALLERY—SUB-STATION NO. 14

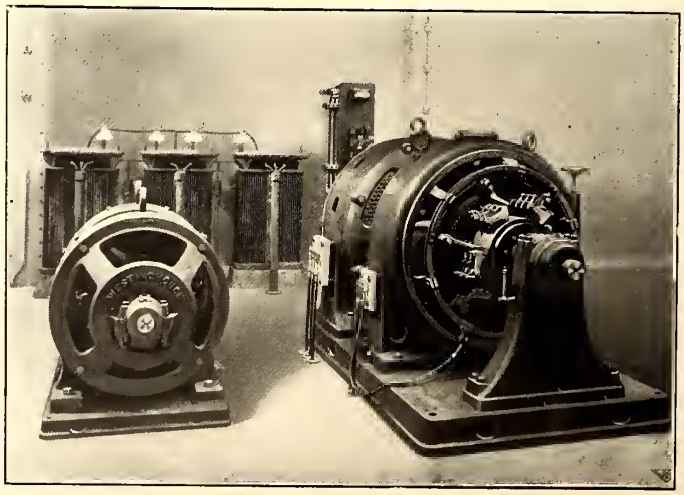
adjacent side wall. The switchboard is located at the rear of the station. The central shaft affords excellent light and ventilation for the operating room. The steel work of the substations is designed with a view to the addition of two storage-battery floors, should it be decided at some future time that the addition of such an auxiliary is advisable.

The necessary equipment of the sub-stations implies sites approximately 50 ft. x 100 ft. in dimensions, and sub-stations Nos. 14, 15, 17 and 18 are practically all this size. Sub-stations Nos. 11 and 16 are 100 ft. in length, but the lots acquired in these instances being of unusual width, these sub-stations are approximately 60 ft. wide. Sub-station No. 12, on account of wide limited ground space, is but 48 ft. and 92 ft. long. In each of the sub-stations, except No. 13, foundations are provided for eight converters; sub-station No. 13 contains foundations for the ultimate installation of ten converters.

The function of the electrical apparatus in sub-stations, as has been stated, is the conversion of the high-potential alternating-current energy delivered from the power house through the tri-phase cables into direct current adapted to operate the motors with which the rolling stock is equipped. This apparatus comprises transformers, converters and certain minor auxiliaries. The transformers, which are arranged in groups of three, receive the tri-phase alternating current at a potential approximating 10,500 volts, and deliver equivalent energy (less the loss of about 2 per cent in the transformation) to the converters at a potential of about 390 volts. The converters receiving this energy from their respective groups of transformers in turn deliver it (less a loss approximating 4 per cent at full load) in the form of direct current at a potential of 625 volts to the bus-bars of the direct-current switchboards, from which it is conveyed by insulated cables to the contact rails. A general view of the interior of one of the sub-stations is given on page 627.

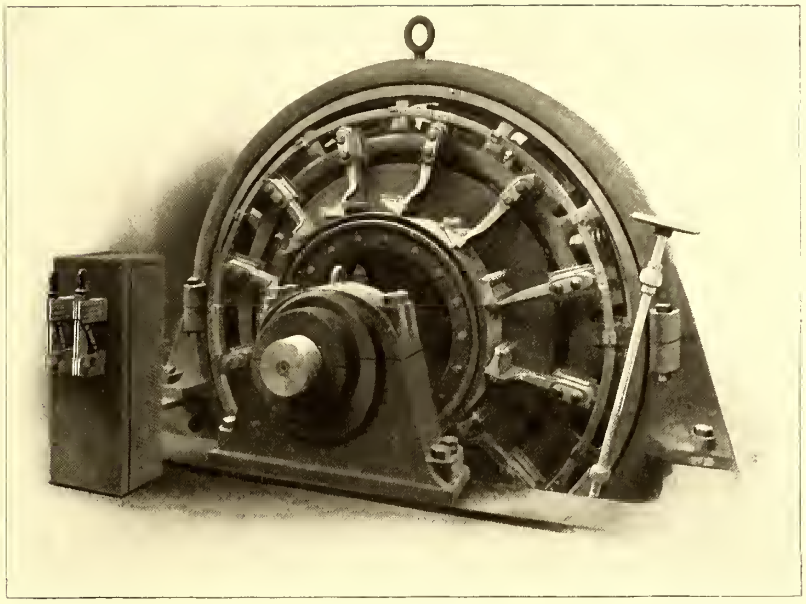
The illustration on page 630 is from a photograph taken on one of the switchboard galleries. In the sub-stations, as in the power house, the high-potential alternating-current circuits are opened and closed by oil switches, which are electrically operated by motors, these in turn being controlled by 110-volt direct-current circuits. Diagrammatic bench boards are used, as at the power house, but in the substations they are, of course, relatively small and free from complication.

The instrument board is supported by iron columns and is carried at a sufficient height above the bench board to enable



AUXILIARY SUB-STATION EQUIPMENT, COMPRISING MOTOR-GENERATOR SET FOR SUPPLYING ALTERNATING CURRENT FOR THE BLOCK SIGNALS AND A MOTOR-GENERATOR ROTARY-STARTER SET

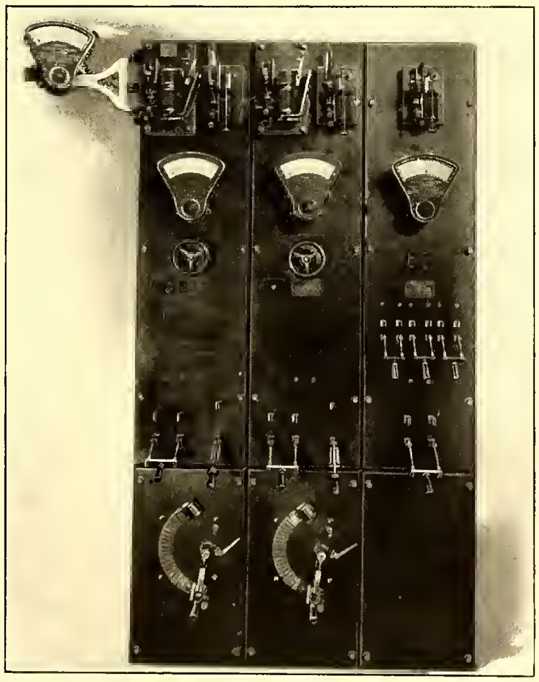
TWO GROUPS OF SUB-STATION STEP-DOWN TRANSFORMERS



THE STANDARD SUB-STATION ROTARY-CONVERTER—1500 KW CAPACITY

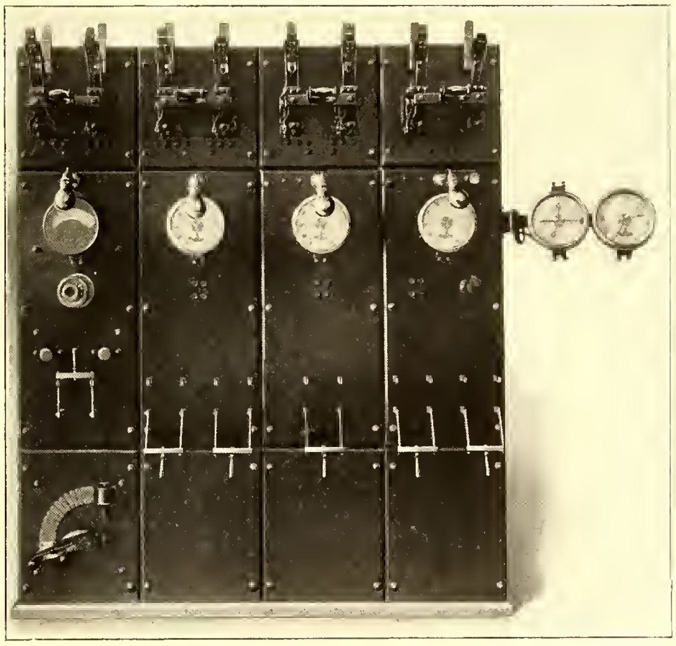
the operator, while facing the bench board and the instruments, to look out over the floor of the sub-station without turning his head. The switches of the direct-current circuits are hand operated and are located upon boards at the right and left of the control board.

A novel and important feature introduced (it is believed for the first time) in these sub-stations is the location in separate brick compartments of the automatic circuit breakers in the direct-current feeder circuits. These circuit-breaker compartments are shown in the lower photograph on page 630, and are in a line facing the boards which carry the direct feeder switches, each circuit breaker being located in a compartment directly opposite the panel which carries the switch belonging to the corresponding circuit. This plan will effectually prevent damage to other parts of the switchboard equipment when circuit breakers open automatically under conditions of short-circuit. It also tends to eliminate risk to the operator, and, therefore, to increase his confidence and accuracy in manipulating the hand-operated switches.



STANDARD SUB-STATION SWITCHBOARD FOR OPERATION OF THE MOTOR-GENERATORS AND BATTERIES FOR THE CONTROL CIRCUITS

The three conductor cables which convey tri-phase currents from the power house are carried through tile ducts from the manholes located in the street directly in front of each sub-station to the back of the station where the end of the cable is connected directly beneath its oil switch. The three conductors, now well separated, extend vertically to the fixed terminals of the switch. In each sub-station but one set of high-potential alternating-current bus-bars is installed, and between each incoming cable and these bus-bars is connected an oil switch. In like manner, between each converter unit and the bus-bars an oil switch is connected into the high-potential circuit. The bus-bars are so arranged that they may be divided into any number of sections not exceeding the number of converter units, by means of movable links which, in their normal condition, constitute a part of the bus-bars.



THE SUB-STATION SWITCHBOARD FOR THE ALTERNATING-CURRENT BLOCK-SIGNAL MOTOR-GENERATOR AND CIRCUITS

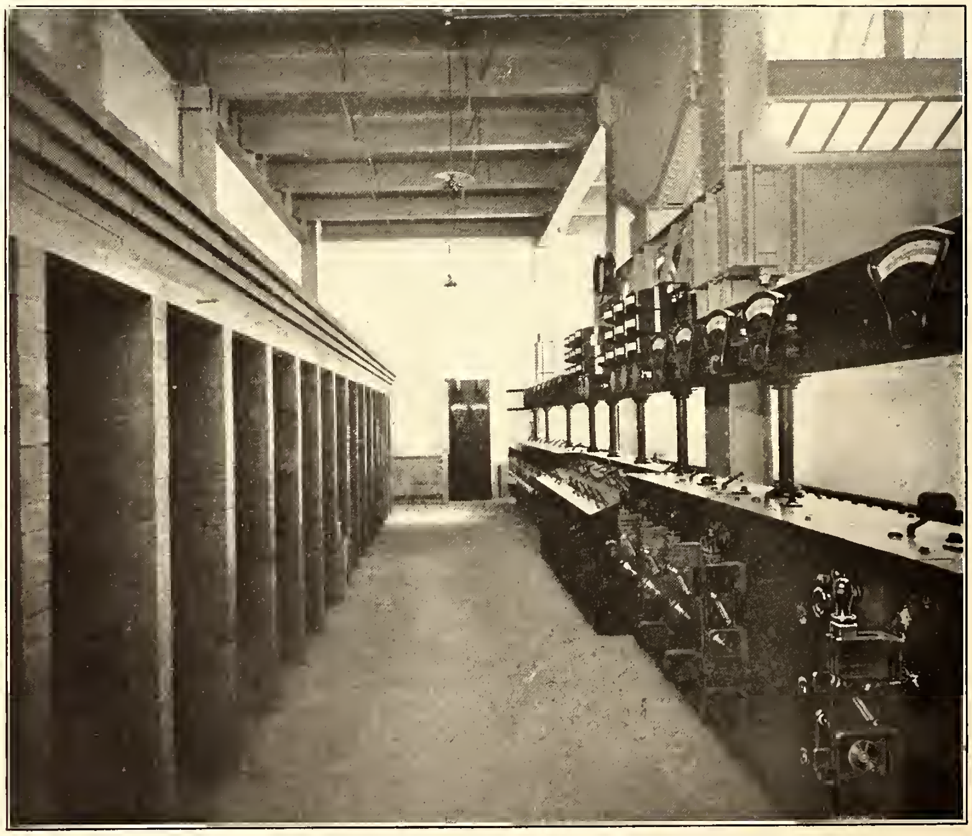
Each of the oil switches between incoming circuits and bus-

THE OPERATING SWITCHBOARD IN GALLERY—SUB-STATION NO. 11—SHOWING UNOBSTRUCTED VIEW ACROSS CONVERTER FLOOR BELOW

bars is arranged for automatic operation, and is equipped with a reversed current relay, which, in the case of a short-circuit in its alternating-current feeder cable opens the switch and so disconnects the cable from the sub-station without interference with the operation of the other cables or the converting machinery.

DIRECT-CURRENT DISTRIBUTION FROM SUB-STATIONS

The organization of electrical conductors provided to convey direct current from the sub-stations to the moving trains can be described most conveniently by beginning with the contact, or so-called third rail. South of Ninety-Sixth Street the average distance between sub-stations approximates 12,000 ft., and north of Ninety-Sixth Street the average distance is about 15,000 ft. Each track, of course, is provided with a contact rail. There are four tracks, and consequently four contact rails, from City Hall to Ninety-Sixth Street, three from Ninety-Sixth Street to 145th Street on the West Side, two from 145th Street to Dyckman Street, and three from Dyckman Street to the northern terminal of the West Side extension of the system. From Ninety-Sixth Street, the East Side has two tracks and two contact rails to Mott Avenue, and from that point to the terminal at 182d Street three tracks and three contact rails. Contact rails south of Reade Street are supplied from sub-station No. 11; from Reade Street to Nineteenth Street they are supplied from sub-stations Nos. 11 and 12; from Nineteenth

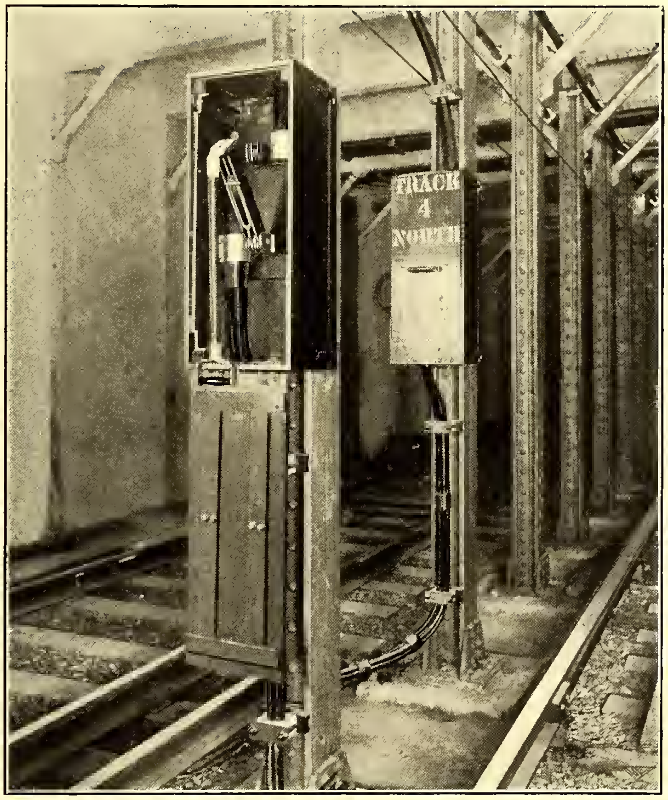


VIEW AT REAR OF OPERATING BOARD IN SWITCHBOARD GALLERY—SUB-STATION NO. 11—SHOWING COMPARTMENTS FOR THE DIRECT-CURRENT CIRCUIT BREAKERS

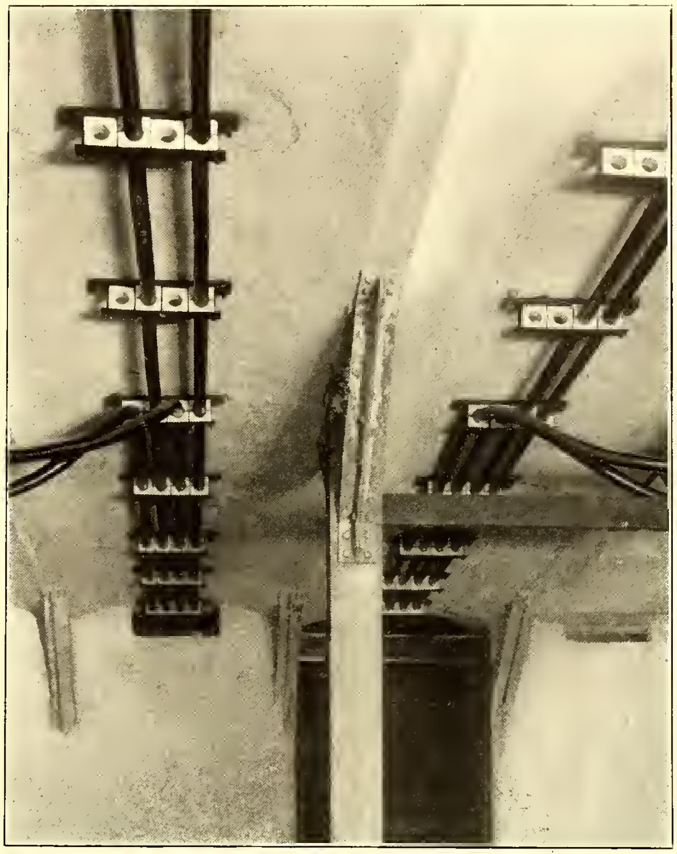
Street they are supplied from sub-stations Nos. 12 and 13; from the point last named to Ninety-Sixth Street they are supplied from sub-stations Nos. 13 and 14; from Ninety-Sixth Street to 143d Street, on the West Side, they are supplied from sub-stations Nos. 14 and 15; from 143d Street to Dyckman Street they are supplied from sub-stations Nos. 15 and 17, and from that point to the terminal they are supplied from sub-station No. 17. On the East Side branch contact rails from Ninety-Sixth Street to 132d Street are supplied from sub-stations Nos. 14 and 16; from 132d to 165th Streets they are supplied from sub-stations Nos. 16 and 18, and from 165th Street to 182d Street they are supplied from sub-station No. 18.

LIGHTING SYSTEM FOR PASSENGER STATIONS AND TUNNEL

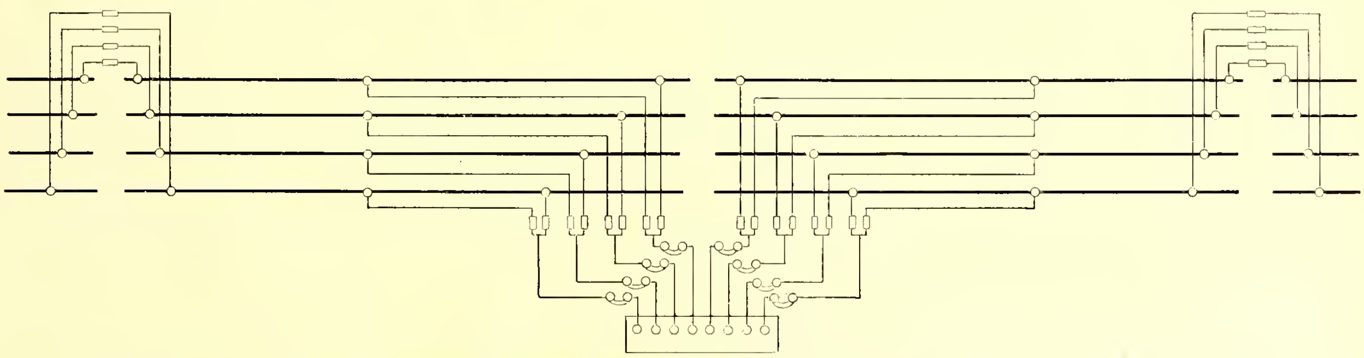
In the initial preparation of plans and more than a year before the accident which occurred in the subway system of Paris in August, 1903, the engineers of the Interborough Company realized the importance of maintaining lights in the subway independent of any temporary interruption of the power used for lighting the cars, and, in preparing their plans, they provided for lighting the subway throughout its length from a source independent of the main power supply. For this purpose three 1250-kw alternators direct driven by steam turbines are installed in the power house, from which point a system of primary cables, transformers and secondary conductors convey current to the incandescent lamps used solely to light the



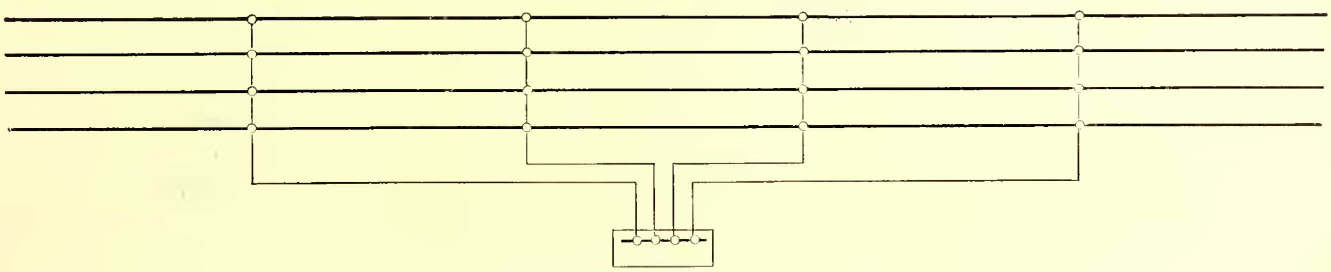
THE SWITCHES CONNECTING THE FEEDERS TO THE CONTACT RAIL, AND THEIR PROTECTING BOXES



THE SYSTEM OF RUNNING DIRECT-CURRENT FEEDERS FROM MANHOLES TO CONTACT-RAIL IN THE TUNNEL

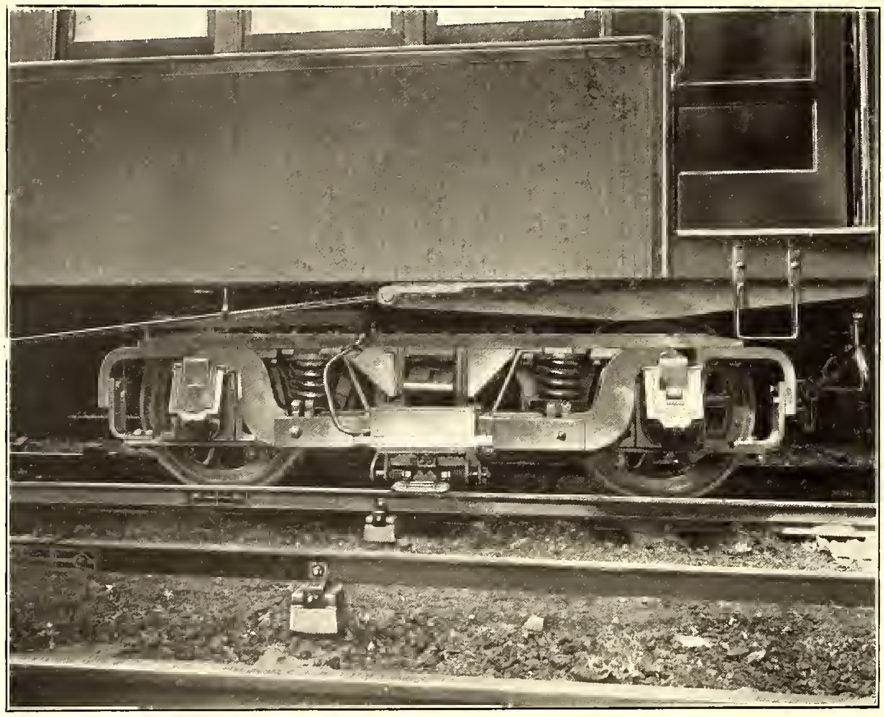


ARRANGEMENT OF DIRECT-CURRENT FEEDER CONNECTIONS IN FEEDING TWO SECTIONS OF CONTACT RAIL

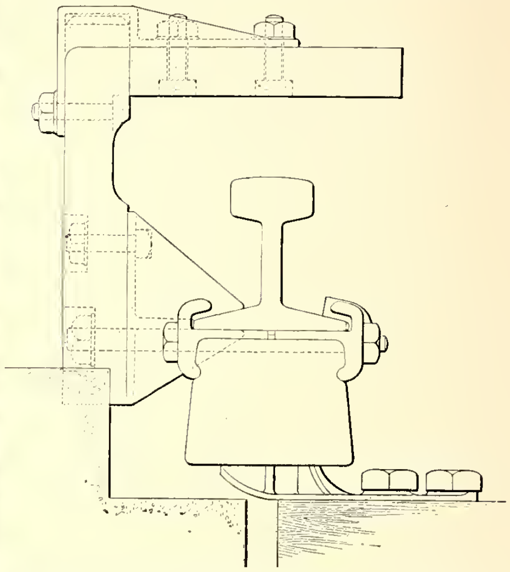


ARRANGEMENT OF NEGATIVE RETURN-CIRCUIT FEEDERS subway. The alternators are of the three-phase type, making 1200 r. p. m. and delivering current at a frequency of 60 cycles per second at a potential of 11,000 volts. In the boiler plant and system of steam piping installed in connection with these turbine-driven units, provision is made for separation of the steam supply from the general supply for the 5000-kw units and for furnishing the steam for the turbine units through either of two alternative lines of pipe.

The 11,000-volt primary current is conveyed through paper insulated lead-sheathed cables to transformers located in fire-proof compartments adjacent to the platforms of the passenger stations. These transformers deliver current to two separate systems of secondary wiring, one of which is supplied at a potential of 120 volts and the other at 600 volts.

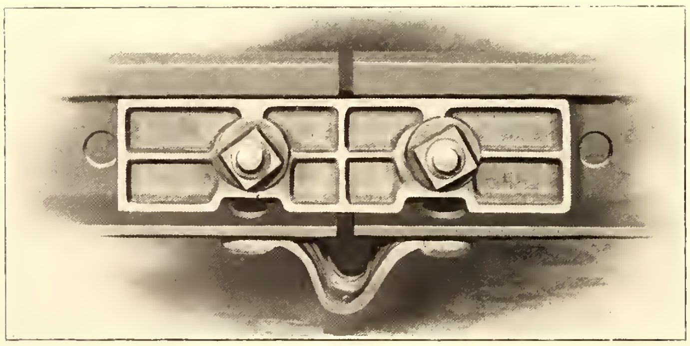


VIEW OF MOTOR-CAR TRUCK AND CONTACT RAIL, SHOWING TYPE OF CONTACT SHOE USED



TYPE OF PROTECTING COVERING USED OVER CONTACT RAIL

The general lighting of the passenger station platforms is effected by incandescent lamps supplied from the 120-volt secondary wiring circuits, while the lighting of the subway sections between adjacent stations is accomplished by incandescent lamps connected in series groups of five each, and connected to the 600-volt lighting circuits. Recognizing the fact that in view of the precautions taken it is probable that interruptions of the alternating-current lighting service will be infrequent, the possibility of such interruptions is nevertheless provided for by installing upon the stairways leading to passenger station platforms, at the ticket booths and over the tracks in front of the platforms, a number of lamps which are connected to the contact rail circuit. This will provide light sufficient to enable passengers to see stairways and the edges of the station platforms in case of temporary failure of the general lighting system.



TYPE OF FISH-PLATE CONNECTION USED AT CONTACT RAIL JOINTS

The general illumination of the passenger stations is effected by means of 32-cp incandescent lamps placed in recessed domes in the ceiling. These are reinforced by 14-cp and 32-cp lamps carried by brackets of ornate design where the construction of the station does not conveniently permit the use of ceiling lamps. The lamps are enclosed in sand-blasted glass globes, and excellent distribution is secured by the use of reflectors.

In lighting the subway between passenger stations it is desirable, on the one hand, to provide sufficient light for track inspection and to permit employees passing along the subway to see their way clearly and avoid obstructions; but, on the other hand, the lighting must not be so brilliant as to interfere with easy sight and recognition of the red, yellow and green signal lamps of the block-signal system. It is necessary also that the lights for general illumination be so placed that their rays shall not fall directly upon the eyes of approaching motormen at the head of trains nor annoy passengers who may be reading their papers inside the cars. The conditions imposed by these considerations are met in the four-track sections of the subway by placing a row of incandescent lamps between the north-bound local and express tracks and a similar row between the south-bound local and express tracks. The lamps are carried upon brackets supported upon the iron columns of the subway structure, successive lamps in each row being 60 ft. apart. They are located a few inches above the tops of the car windows and with reference to the direction of approaching trains the lamps in each row are carried upon the far side of the iron columns, by which expedient the eyes of the approaching motormen are sufficiently protected against their direct rays.

POWER-HOUSE LIGHTING

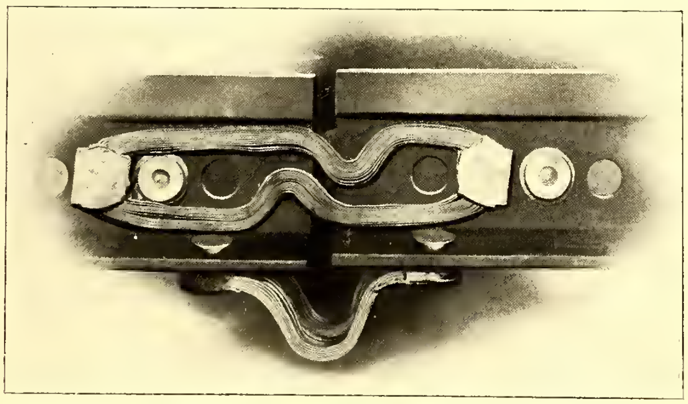
For the general illumination of the engine room, clusters of Nernst lamps are supported from the roof trusses, and a row of single lamps of the same type is carried on the lower gallery about 25 ft. from the floor. This is the first power house in America to be illuminated by these lamps. The quality of the light is unsurpassed and the general effect of the illumination most satisfactory and agreeable to the eye. In addition to the Nernst lamps, 16-cp incandescent lamps are placed upon the engines and along the galleries in places not conveniently reached by the general illumination. The basement also is lighted by incandescent lamps.

For the boiler room a row of Nernst lamps in front of the batteries of boilers is provided, and, in addition to these, incandescent lamps are used in the passageways around the boilers, at gages and at water columns. The basement of the boiler room, the pump room, the economizer floor, coal bunkers and coal conveyors are lighted by incandescent lamps, while arc lamps are used around the coal tower and dock. The lights on the engines and those at gage glasses and water columns and at the pumps are supplied by direct current from the 250-volt circuits. All other incandescent lamps and the Nernst lamps are supplied through transformers from the 60-cycle lighting system.

VIEW OF RUNNING AND CONTACT RAILS IN THE TUNNEL, SHOWING SPECIAL TYPE OF END INCLINE USED UPON CONTACT RAILS

EMERGENCY SIGNAL SYSTEM

In the booth of each ticket seller and at every manhole along the west side of the subway and its branches is placed a glass-covered box of the kind generally used in large American cities for fire-alarm purposes. In case of accident in the subway which may render it desirable to cut off power from the contact rails, this result can be accomplished by breaking the glass front of the emergency box and pulling the hook provided. Special emergency circuits are so arranged that pulling the hook will instantly open all the circuit breakers at adjacent sub-stations through which the contact rails in the section affected receive their supply of power. It will also instantly report the location of the trouble, annunciator gongs being located in the sub-stations from which power is supplied to the section, in the train despatchers' offices and in the office of the general superintendent, instantly intimating the number of the box which has been pulled. Automatic recording devices in train despatchers' offices and in the office of the general superintendent also note the number of the box pulled.



METHOD OF DOUBLE BONDING USED AT JOINTS IN THE CONTACT RAIL

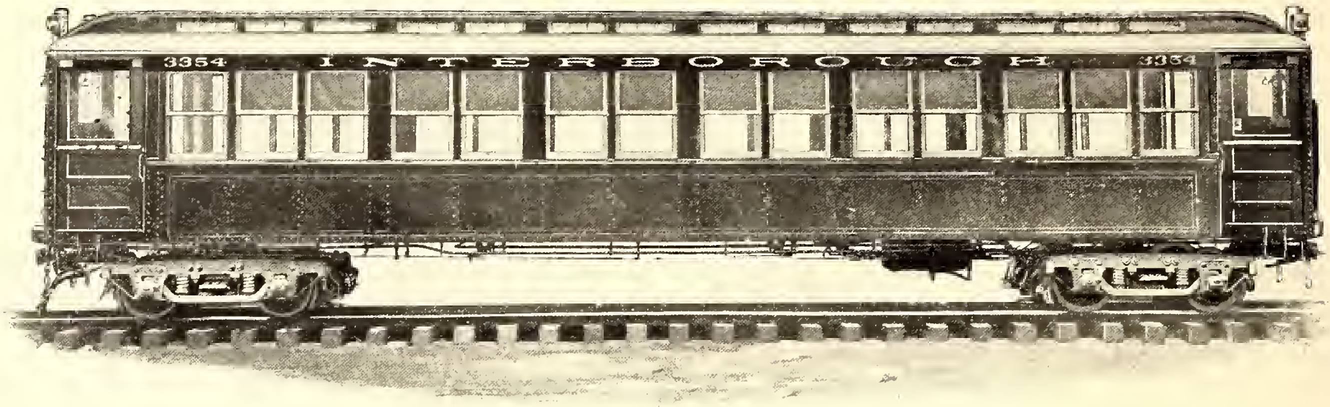
CONTRACTORS

The contractors for the equipment in the electrical department, including that in power plant and sub-stations for generation, transmission, conversion and distribution of power, for the feeder and third-rail construction, for the electrical-car equipment, and for the subway, station and power plant lighting system, are as follows:

American Steel & Wire Company, cable.
Bajohr, Carl, lightning rods.
Broderick & Company, contact shoes.
Cambria Steel Company, contact rail.
Columbia Machine Works & Malleable Iron Company, contact shoes.
Consolidated Car Heating Company, car heaters.
D. & W. Fuse Company, fuse boxes and fuses.
Electric Storage Battery Company, storage battery plant.
General Electric Company, motors, power house and sub-station switchboards, control apparatus, cable.
General Incandescent Arc Light Company, passenger station switchboards.
India Rubber & Gutta Percha Insulating Company, cables.
Keasby & Mattison Company, asbestos.
Malleable Iron Fittings Company, third-rail and other castings.
Mayer & Englund Company, rail bonds.
Mitchell Vance Company, passenger station electric light fixtures.
National Conduit & Cable Company, cables.
National Electric Company, air compressors.
Nernst Lamp Company, power station lighting.
Okonite Company, cables.
Prometheus Electric Company, passenger station heaters.
J. A. Roebling's Sons Company, cables.
Reconstructed Granite Company, third-rail insulators.
Standard Underground Cable Company, cables.
Tucker Electrical Construction Company, wiring for tunnel and passenger station lights.
Westinghouse Electric & Manufacturing Company, alternators, exciters, transformers, motors, converters, blower outfits.
Westinghouse Machine Company, turbo alternators.

THE NEW STEEL CARS FOR THE SUBWAY DIVISION OF THE NEW YORK INTERBOROUGH RAPID TRANSIT COMPANY

THE history of the development of the designs for the rolling stock equipment of the new subway system in New York City is one of great interest for the many difficulties introduced by the radical nature of the limiting conditions and service requirements. Probably no corps of railway engineers was ever before confronted with a problem of so great magnitude and involving so many difficulties, in the selection of a car equipment, not only on account of the peculiarly special nature of the designs, but also the short length of time given in which to prepare the plans. But the determination of the builders of the road to improve upon the best practice previously known in electrical railroading and to provide an equipment unequaled on any interurban line, is nowhere better illustrated than in the careful study given to the types of cars and trucks used on other lines before a selection was made of those to be employed on the subway.



THE NEW DESIGN OF STEEL CAR FOR THE INTERBOROUGH SUBWAY SYSTEM, INVOLVING THE ENTIRE ELIMINATION OF THE ELEMENT OF WOOD IN CONSTRUCTION

All of the existing rapid transit railways in this country and many of those abroad were visited, and the different patterns of cars in use were considered in this investigation, which included a study of the relative advantages of long and short cars, single and multiple-side-entrance cars, end-entrance cars and all of the other varieties which have been adopted for rapid transit service abroad and at home.

The service requirements of the New York subway introduced a number of unprecedented conditions and limitations as to car clearance, and required a complete redesign of all the existing models. The general considerations to be met included the following:

Limited subway heights and clearances on curves.

High-schedule speeds with frequent stops.

Maximum carrying capacity for the cars, especially at times of rush hours, morning and evening.

Maximum strength combined with smallest permissible weight.

Adoption of all precautions calculated to reduce possibility of damage from either the electric circuit or from collisions.

The clearance and length of the local station platforms limited the length of trains, and tunnel clearances the length and width of the cars.

The speeds called for by the contract with the city introduced motive power requirements which were unprecedented in any existing railway service, either steam or electric, and demanded a minimum weight consistent with safety. As an example, it may be stated that an express train of eight cars in the subway, to conform to the schedule speed adopted, will require a nominal capacity of motors on the train of 2000 hp, in starting from a station stop, with an average accelerating current at 570 volts, of 325 amps. This rate of energy absorption, which corresponds to 2500 hp, is not far from double that taken by the heaviest steam trains on trunk line railroads when starting from stations at the maximum rate of acceleration possible with the most powerful modern locomotives.

Such exacting schedule conditions as those mentioned necessitated the design of cars, trucks, etc., of equivalent strength to that found in steam railroad car and locomotive construction, so that, while it was essential to keep down the weight of the train and individual cars to a minimum owing to the frequent stops, it was equally as essential to provide the strongest and most substantial type of car construction throughout. A happy solution of the problem seemed to lay in the use of steel car construction, but the limitations of car building facilities prevented a sufficiently early production in steel at first.

Owing to the two essentials of lightest weight consistent with strength, however, which were embodied in their con-

END VIEW OF THE STEEL CAR

struetion, it can safely be asserted that the ear construction finally adopted for use in the subway represents the highest type of the car building art as it exists to-day, and that all available appliances for securing strength and durability in the cars and immunity from accidents have been introduced.

After having ascertained the general type of cars which would be best adapted for the subway service, and before placing orders, it was decided to build sample cars embodying the approved principles of design. From these the management believed that the details of construction could be more perfectly determined than in any other way. Consequently, in the early part of 1902, two sample cars were built and equipped with a variety of appliances and furnishings so that the final type could be intelligently selected. From the tests conducted on these cars, the final type of car which is described in detail below was evolved.

In view of the peculiar traffic conditions existing in New York City and the restricted siding and yard room available in the subway, it was decided that one standard type of car for all classes of service would introduce the most flexible operating conditions, and for this reason would best suit the public demands at different seasons of the year and hours of the day. In order, further, to provide cars, each of which would be as safe as the others, it was essential that there should be no difference in constructional strength between the motor cars and the trail cars. All cars were therefore made of one type, and can be used interchangeably for either motor or trail-car service.

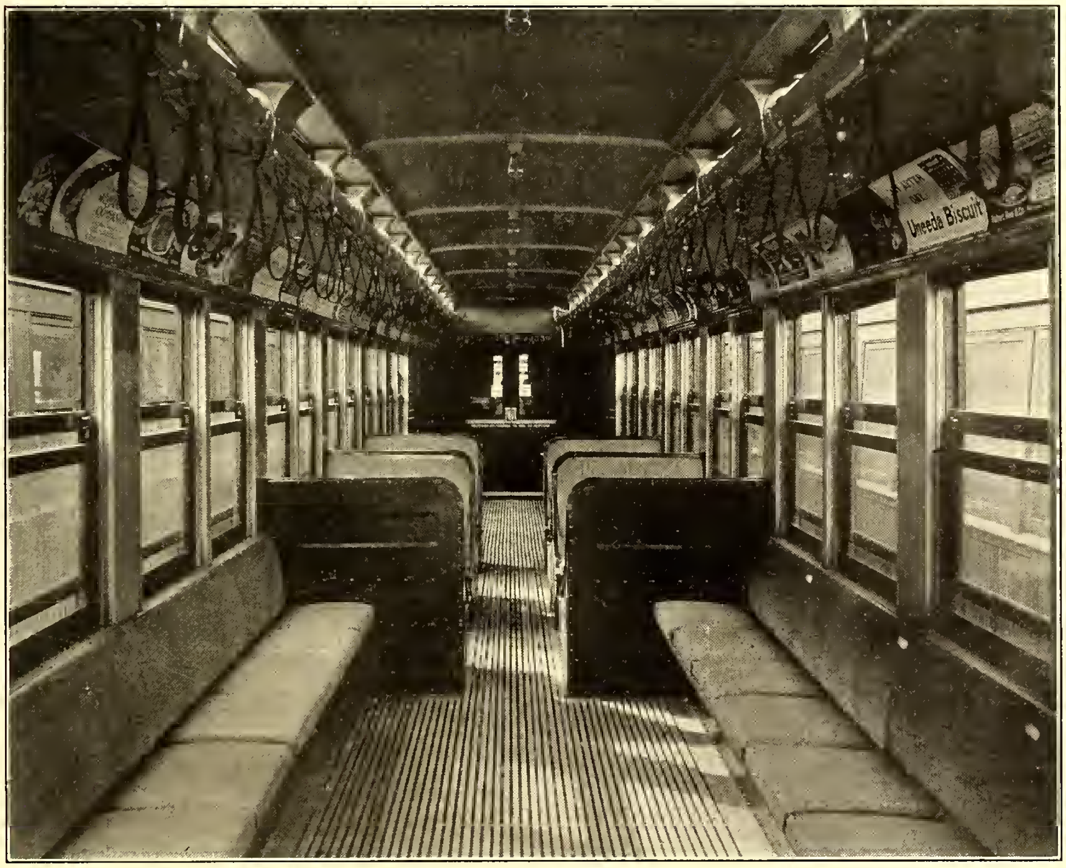
As the multiple-unit system of train operation is used, trains will be made up as required for either express or local service by varying the number and proportion of motor and trail cars. Thus, the eight-car express trains, which will be the standard length of an express train, will be made up of five motor cars and three trail cars, the motor cars being either cars 1, 3, 5, 6 and 8, or else numbers 1, 3, 4, 6 and 8. The five-car local trains will be made up of three motor cars and two trail ears, the motor cars being 1, 3 and 5; while the three-car trains will be equipped with a motor car at each end.

GEORGE GIBBS

The motor cars will each be equipped with two propelling motors, both of whieh are carried on the same truck; that is, each motor car has a motor truck at one end carrying two motors, one geared to each axle, while the truck at the other end of the car is a "trailer" and carries no motive power.

THE WOODEN CARS

After the design had been worked out, a great deal of difficulty was encountered in securing satisfactory contracts for proper deliveries, on account of the congested condition of the car building works in the country at that time. Contracts were finally closed, however, in December, 1902, for 500 cars, and orders were distributed between four car-building firms. Of these cars, some 200, as fast as delivered, were placed in operation on the Second Avenue line of the elevated railway division of the company, in order that they might be thoroughly tested during the winter of 1903-4.



INTERIOR OF THE NEW STEEL CAR, SHOWING ALUMINUM INTERIOR FINISH AND METAL SEAT CONSTRUCTION

The first shipment of these cars was received by the company in August, 1903, at which time a complete description of the construction and principal details of equipment was given in the Street Railway Journal (page 264, Aug. 22, 1903). For details of this wooden car construction, reference may be had to the above-mentioned article. Some of the leading distinctive features of the wooden cars may, however, be here enumerated as follows:

(1) The length is 51 ft., and provides seating capacity for fifty-two passengers. This length is about 4 ft. more than those of the existing Manhattan Elevated Railroad cars, and enables a five-car local train, seating 260 people, to load at the local station platforms.

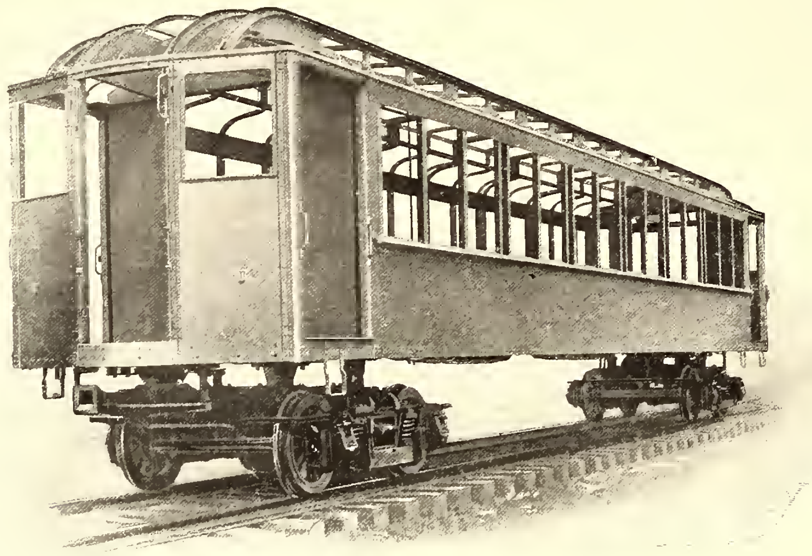
(2) The slope of the car outside, above the window sill, which was made necessary in order to obtain a wide and long car on account of the limiting curve clearances in the subway.

(3) The enclosed vestibule platforms with sliding doors instead of the usual gates. The enclosed platforms will con-

tribute greatly to the comfort and safety of passengers under subway conditions.

(4) The anti-telescoping car bulkheads and platform posts. This construction is similar to that in use on Pullman cars, and has been demonstrated in steam railroad service to be an important safety provision against the disastrous results of collisions.

(5) The steel underframing of the car, which provides a rigid and durable bed structure for transmitting the heavy motive power stresses.



VIEW OF THE FRAMEWORK OF THE CAR WITH THE GIRDER SIDE-PLATES IN PLACE

(6) The numerous protective devices against defects in the electrical apparatus.

(7) Windows, having stationary lower sash, to guard against drafts.

(8) Emergency brake valve on truck, operating in connection with the block-signal system.

(9) Emergency brake valve in connection with master controller.

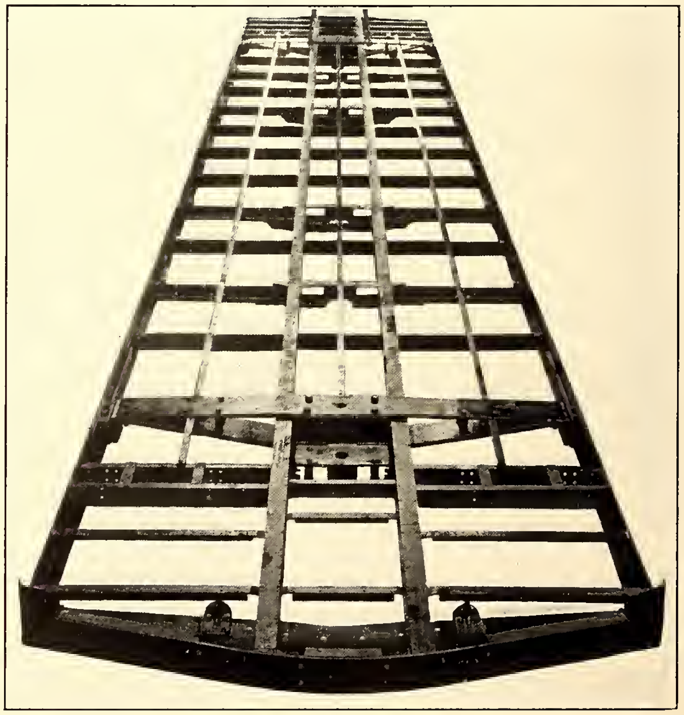
(10) Copper sheathing on outside of car.

Some features of interest and of novelty in electric car construction were introduced in the form of wooden frame members, reinforced heavily by structural steel shapes. The side sills are of 6-in. channels, which are enclosed on both sides by white oak timbers, and the center sills are 5-in. I-beams, faced on both sides with Southern pine. The car-body end sills are also of steel shapes, securely attached to the side sills by steel castings and forgings, the end-sill channel being faced with a white-oak filler, mortised to receive the car-body end posts, and braced at each end by gusset plates. The body bolster is made up of two rolled-steel plates bolted together at their ends and supported by a steel-draw casting, the ends of which form a support for the center sills. The flooring inside the car is double and of maple, with asbestos fire-felt between the layers, and is protected below by steel plates and "transite" (asbestos) board.

The side framing of the car is of white ash, doubly braced and heavily trussed. There are seven composite wrought-iron carlines forged in shape for the roof, each sandwiched between two white ash carlines, and with white ash intermediate carlines. The platform posts are of compound construction, with anti-telescoping posts of steel bar sandwiched between white ash posts at corners and centers of vestibuled platforms. These posts are securely bolted to the steel longitudinal sills, the steel anti-telescoping plate below the floor, and to the hood of the bow, which serves to reinforce it. This bow, it might be mentioned in this connection, is a heavy steel angle in one piece, reaching from plate to plate, and extending back into the car 6 ft. on each side. By this construction it is believed that the car framing is practically indestructible. In case of accident, if one platform should ride over another, 8 sq. ins. of metal would have to be sheared off the posts before the main body of the car would be reached, which would afford an effective means of protection.

The precautions to secure safety from fire consist generally in the perfected arrangement and installation of the electrical apparatus and the wiring. For the lighting circuits a flexible steel conduit is used, and a special junction box. On the side and upper roofs, over these conduits for the lighting circuits, a strip of sheet iron is securely nailed to the roof boards before the canvas is applied. The wires under the floor are carried in ducts of asbestos compound (electrobestos) molded into suitable forms.

Special precautions have been taken with the insulation of the wires, the specifications calling for, first, a layer of paper; next, a layer of rubber, and then a layer of cotton saturated with a weather-proof compound, and outside of this a layer of asbestos. The hangers supporting the rheostats under the car body are insulated with wooden blocks, treated by a special



VIEW OF THE UNDERFRAME UNIT FOR THE STEEL CAR, TO SHOW SIMPLICITY AND LIGHTNESS MADE POSSIBLE BY SIDE FRAME GIRDER CONSTRUCTION

process, being dried out in an oven and then soaked in an insulating compound, and covered with ¼-in. "transite" board. The rheostat boxes themselves are also insulated from the angle iron supporting them. Where the wires pass through the flooring they are hermetically sealed to prevent the admission of dust and dirt.

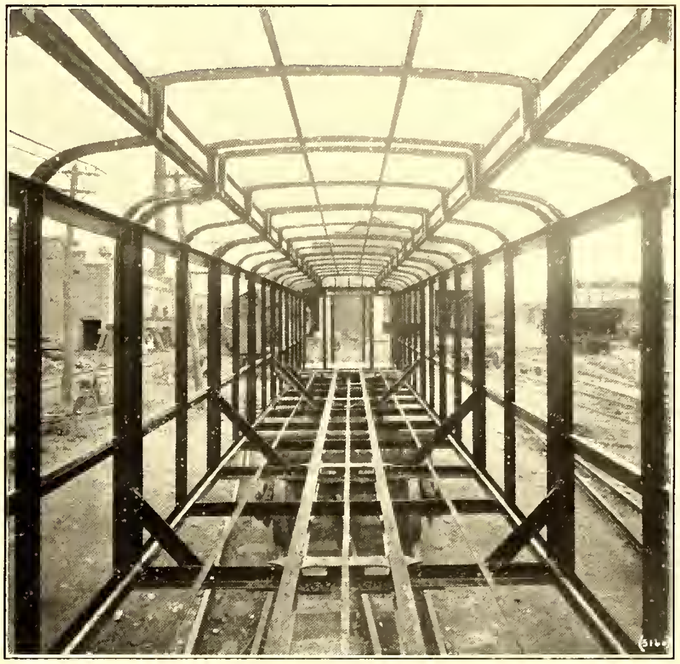
At the forward end, or what is known as the No. 1 end, of each motor car, all the wires are carried to a slate switchboard in the motorman's cab. This board is 44 ins. x 27 ins., and is mounted directly back of the motorman. The window space occupied by the board is ceiled up with mahogany panels, and the space back of it is boxed in and provided with a door of steel plate, forming a box, the cover, top, bottom and sides of which are lined with electrobestos ½ in. thick. All of the switches and fuses, except the main trolley fuse and bus-line fuse, which are encased and placed under the car, are carried on this switchboard. Where the wires are carried through the floor or any partition, a steel chute, lined with electrobestos, is used to protect the wires against mechanical injury. It will be noted from the above, that no power wiring, switches or fuses are placed in the car itself, all such devices being outside in special steel insulated compartments.

THE STEEL CARS

At the time of placing the first contract for the rolling stock of the subway, the question of using an all-steel car was carefully considered by the management. Such a type of car, in many respects, presented desirable features for subway work as representing the ultimate of absolute incombustibility. Certain practical reasons, however, prevented the adoption of an all-steel car in the spring of 1902, when it became necessary to place the orders mentioned above for the first 500 cars.

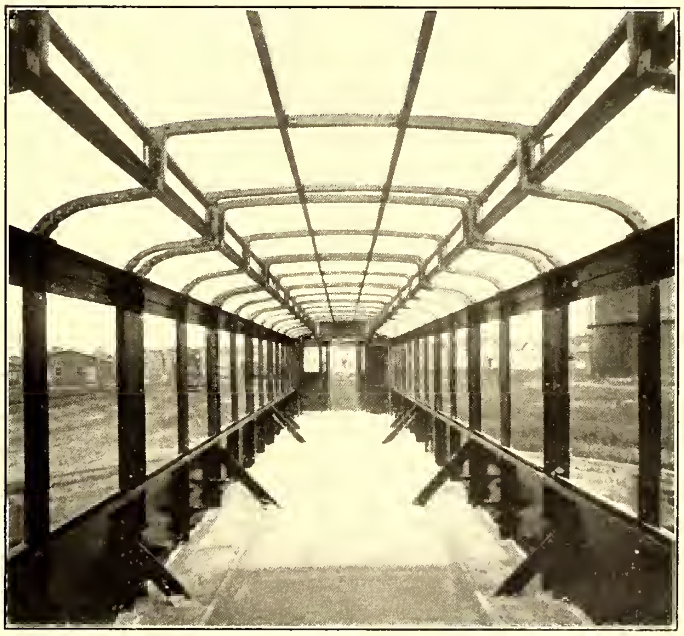
Principal among these reasons was the fact that no cars of this kind had ever been constructed, and as the car building works of the country were in a very congested condition, all of the larger companies declined to consider any standard specifications, even for a short-time delivery; while, for cars involving the extensive use of metal, the question was impossible of immediate solution. Again, there were a number of very serious mechanical difficulties to be studied and overcome in the construction of such a car, such as avoidance of excessive weight—a serious element in a rapid transit service—insulation from the extremes of heat and cold, and the prevention of undue noise in operation. It was decided, therefore, to bend all energies at that time to the production of a wooden car with sufficient metal for strength and protection from accident, i. e., a stronger, safer and better constructed car than had heretofore been put in use on any electric railway in the world. These properties, it is believed, are embodied in the car which has just been described.

The plan of an all-metal car, however, was not abandoned, and, although none was in use in passenger service anywhere, George Gibbs, the consulting engineer of the company, took immediate steps to design a car of this type and conduct the necessary tests to determine whether it would be suitable for railway service. None of the car building companies were willing to undertake the work, but the courteous co-operation of the Pennsylvania Railroad Company was secured in placing its manufacturing facilities at Altoona at the disposal of the Interborough Rapid Transit Company. Plans were prepared



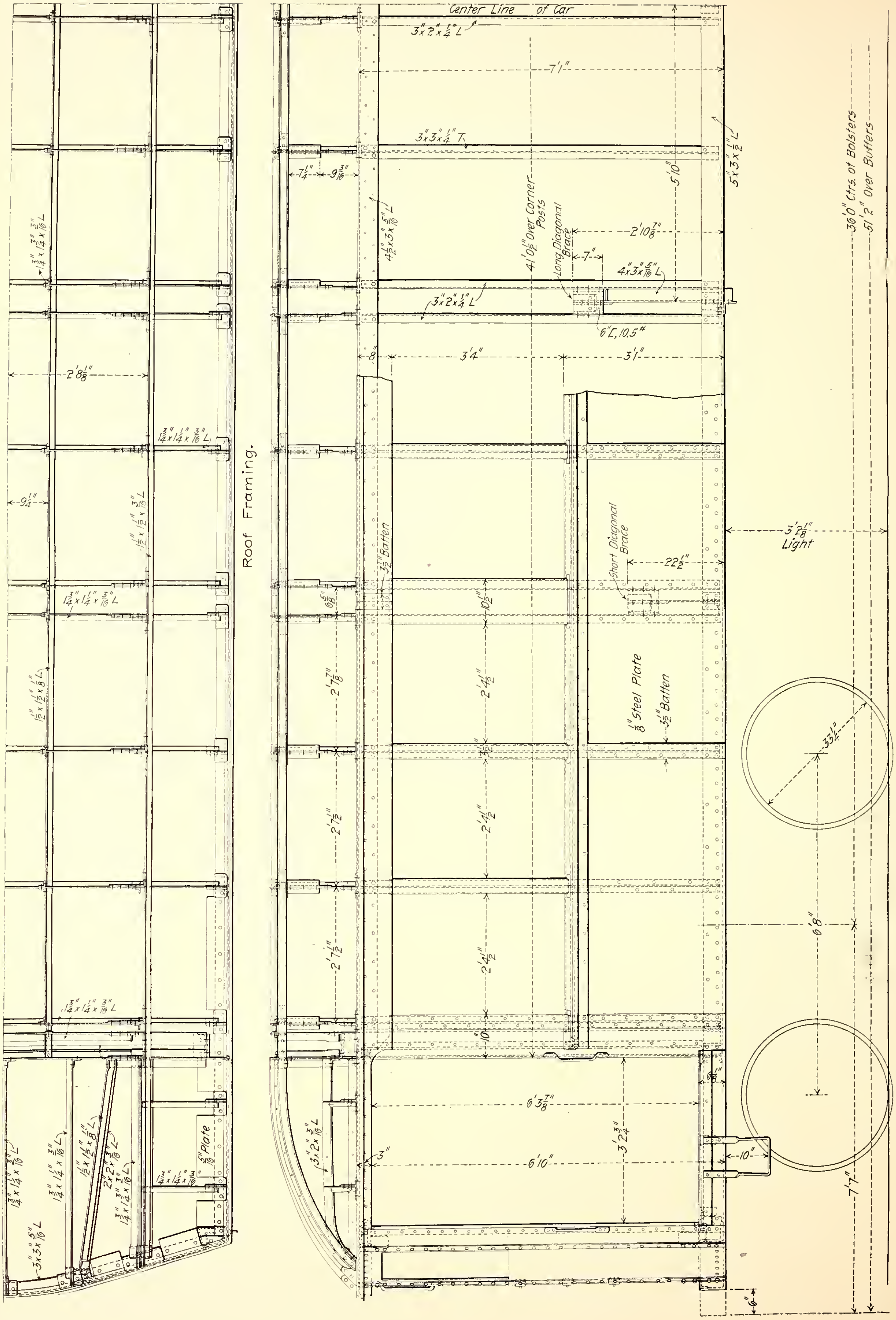
The Skeleton Framework of the Car

Side Plates and Corrugated Flooring in Place

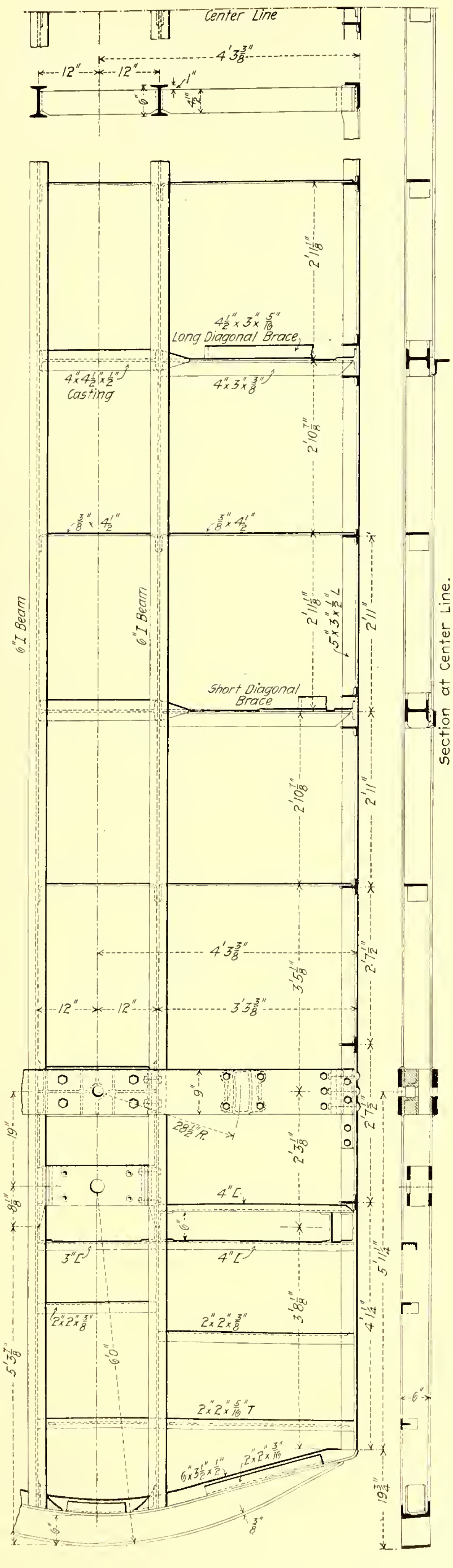


Framework Completed and Monolithic Floor Laid

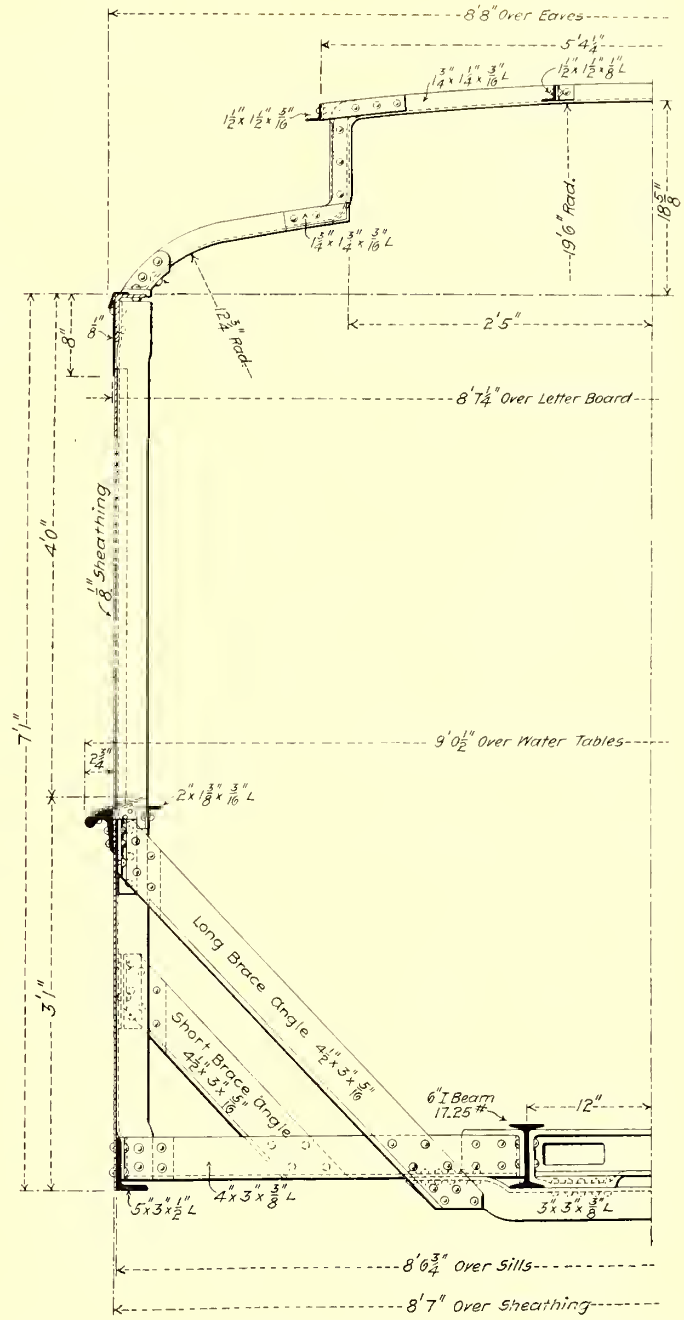
THREE STAGES IN CONSTRUCTION OF THE STEEL CAR



PART SIDE ELEVATION AND ROOF DETAILS OF THE FRAMEWORK OF THE STEEL CAR, SHOWING ALSO PLATFORM CONSTRUCTION



PART PLAN AND SECTION OF THE UNDERFRAME OF THE CAR, SHOWING THE RADICAL DEPARTURE IN CAR UNDERFRAME CONSTRUCTION



HALF SECTION OF THE STEEL FRAMING TO SHOW ARRANGEMENT OF THE ANGLE BRACES BY WHICH THE FLOOR LOAD IS TRANSFERRED TO THE GIRDER SIDE FRAME

for construction as quickly as the novel character permitted, and after about fourteen months of work a sample type was completed in December, 1903.

The sample car naturally embodied some faults which only experience could correct, the principal one being that the car was not only too heavy for use on the elevated lines of the company, but attained an undesirable weight for subway operation. From this original design, however, Mr. Gibbs has worked out a second one, containing many radical departures, and a contract was given to the American Car & Foundry Company, by the Interborough Company, for 200 of these all-steel cars. Deliveries under this contract have already been given thorough test, and the car appeared to meet expectations so admirably that a supplementary order has been placed with the American Car & Foundry Company, the builders of the first lot, for an additional 100 cars. It may be said that the result of careful designing has been to produce a new type of railway passenger car of absolutely fire-proof qualities, and one which weighs practically the same as the old wooden car; further, the car has admirable riding qualities, is durable in construction, and as may be judged from the views on page 634, sightly in appearance.

SPECIFICATIONS

The general dimensions of the all-steel car differ only slightly from those of the wooden cars, and also that of the Manhattan Railway cars:

	Wooden Cars		All Steel Cars		Manhattan Cars	
	ft.	ins.	ft.	ins.	ft.	ins.
Length over body corner posts	42	7	41	½	39	10
Length over buffers	51	2	51	2	47	1
Length over draw-bars	51	5	51	5	47	4
Width over side sills	8	8⅜	8	6¾	8	6
Width over sheathing	8	10	8	7	8	7
Width over window sills	8	11⅞	9	½	8	9
Width over battens	8	10¾	8	7¼	8	7⅞
Width over eaves	8	8	8	8	8	9½
Height from under side of sill to top of plate	7	3⅛	7	1	7	3
Height of body from under side of center sill to top of roof	8	9⅞	8	9⅞	9	5⅞
Height of truck from rail to top of truck center plate (car light)	2	8	2	8	2	5¾
Height from top of rail to under side of side sill at truck center (car light)	3	1⅛	3	2⅛	3	3¼
Height from top of rail to top of roof not to exceed (car light)	12	¾	12	0	12	10½

The details of construction finally decided upon and specified for the steel cars involves some very interesting departures from usual methods of car construction, and the many radically new features warrant a careful study by all interested in heavy electric railroad service. The desire of eliminating the element of wood as far as possible, in order to secure absolutely incombustible construction, led to the incorporation of many novel ideas, such as, in addition to the metal frame work, the use of plastic flooring, metal door and window framing, metal interior trim throughout, etc. Even the types of seat and cushion construction used, present examples of the extreme to which this desire has been carried.

It early became evident, especially from the experience gained in the construction of the experimental car, that in order to carry the car and live load, a radical departure from usual methods of supporting the car body, namely, by the center and side sills with the usual under-trussing, would be necessary. Any attempt at carrying the weight of the car by the sill members would have required very heavy construction of under-framing, as has been the general experience in modern steel freight and gondola-car construction. Eventually the idea of carrying the weight of the car by the side framing, which is being very largely introduced into modern heavy steel-car construction, was made use of, with the result that in the subway steel car the side-framing sections of each car are made to serve as plate girders, from which the floor load of the car is carried. The novelty embodied in this principle makes a careful description of its application in this case—the first of the kind which has been attempted in passenger-car construction—of more than usual interest. Its application to this form of car construction is the invention of Mr. Gibbs, by whom it has been patented.

FRAMING

The principal features of the new construction are well illustrated in the accompanying drawings and photographs. The framing detail drawing illustrates the arrangement of the sills as related to the side framing, and shows the special diagonal struts or girders, long and short, which are used, not only to tie the two together, but also to transfer to the side-frame girders the floor load. As may be noted, the center sills consist of two 6-in. I-beams, while the side sills are 5-in. x 3-in. steel angles; each of these sill members extends in one piece from platform end sill to platform end sill. This under-frame construction is in reality very light, and would in itself be far from sufficient to carry even the weight of a car of this size; in fact, the frame work of the car alone is not self-supporting.

The actual load-carrying member of the car is to be seen in the section of the side framing beneath the special belt rail. This member, as built up, serves to form a plate girder 36 ins. in height, the lower member of which is the 3-in. x 5-in. angle side sill, and the upper member of which is the special 3¾-in. x 4-in. bulb angle, which serves as the belt rail. The web is of ⅛-in. steel plate, having been applied in lengths corresponding to the distances between the single side posts of the car; here the plates are joined with butt-strap joints, heavily riveted to the single posts. The plates are also similarly riveted to the double posts, as indicated. This forms a girder of such unusual strength that no truss rods beneath the car are required for keeping the car in alignment, and it is used to carry the entire floor load of the car, transferring the same to the trucks through the special body bolsters. The novel idea of placing the upper truss member outside and making it serve also as the window belt rail enables the upper frame posts to be made continuous from the lower side sills to the top plate.

UNDERFRAMING

The underframing construction of the car was, of course, greatly simplified by the absence of steps, the station platforms in the subway having been arranged, in conformity to elevated railway practice, on levels with the car floors. This permitted the side sills to extend to the end sills, which are located adjacent to the buffer beams. Thus in reality no special construction was necessary in the underframing for the platform, which extends as a solid member throughout the length of the car. The car-body end sill is formed of a 6-in. x 3½-in. steel angle, bent to radius of 5½ ft., to conform to the shape of the buffer. It is secured to the side and center sills of the underframe by special cast-steel brackets, as shown in the drawings, and in addition by a heavy steel anti-telescoping plate, which is strongly riveted to the under sides of the sill members, producing an immensely strong frame-end construction.

A construction corresponding to that of a body-end sill is applied in the form of two 4-in. channels, fitted in between the longitudinal sills, and heavily riveted by means of corner brackets of 3-in. x 3-in. angles, as shown in the drawings. These members carry the end bulkheads of the car between the platform and interior. They are faced on top with a fireproof ash member, to which the malleable iron threshold plate is fastened. Cross members of steel angles are also riveted between the longitudinal sills at various spacings to correspond with usual needle-beam construction of wooden cars; these, besides stiffening the underframe, assist in carrying the floor. The buffer beam is of white oak bolted to the platform end sill and faced with a ⅜-in. steel plate, as shown in the draft rigging drawing.

Other important features of the steel framing construction are to be seen in additional drawings. The methods of fastening provided for mounting the body-end posts and vestibule posts in the underframing are novel. The vestibule posts are set in and riveted fast to the special cast-steel pocket castings which serve to join the side and end sills of the underframe, as above referred to. The body-end posts are similarly secured in place by pressed-steel brackets, which, when riveted up, furnish enormously strong construction. The tieing of these posts to the roof framing is similarly provided for, as shown.

The body bolster is made up of two rolled-steel plates, each ¾ in. x 9 ins., shaped as shown in the detailed drawing of the draft-rigging system. The top and bottom members are machined on their outer ends, so as to fit perfectly, and are bolted together at their ends and to the side steel of the car, as shown; a filler casting is used in joining the ends to the side sill of the car. The filler casting between the top and bottom members of the bolsters is of malleable iron, which is planed on top, bottom and end surfaces so as to perfectly fit the bolster. This casting is bolted to the bolster, as shown, the four vertical bolts used being also made use of to secure the center-bearing plate to the lower side of the bolster frame. The body bolster, filler casting and center plate are drilled for a 2 3-32-in. king bolt. The side and center bearings provided are of types which are in general use, the side bearings being spaced with centers 28½ ins. from the king bolt.

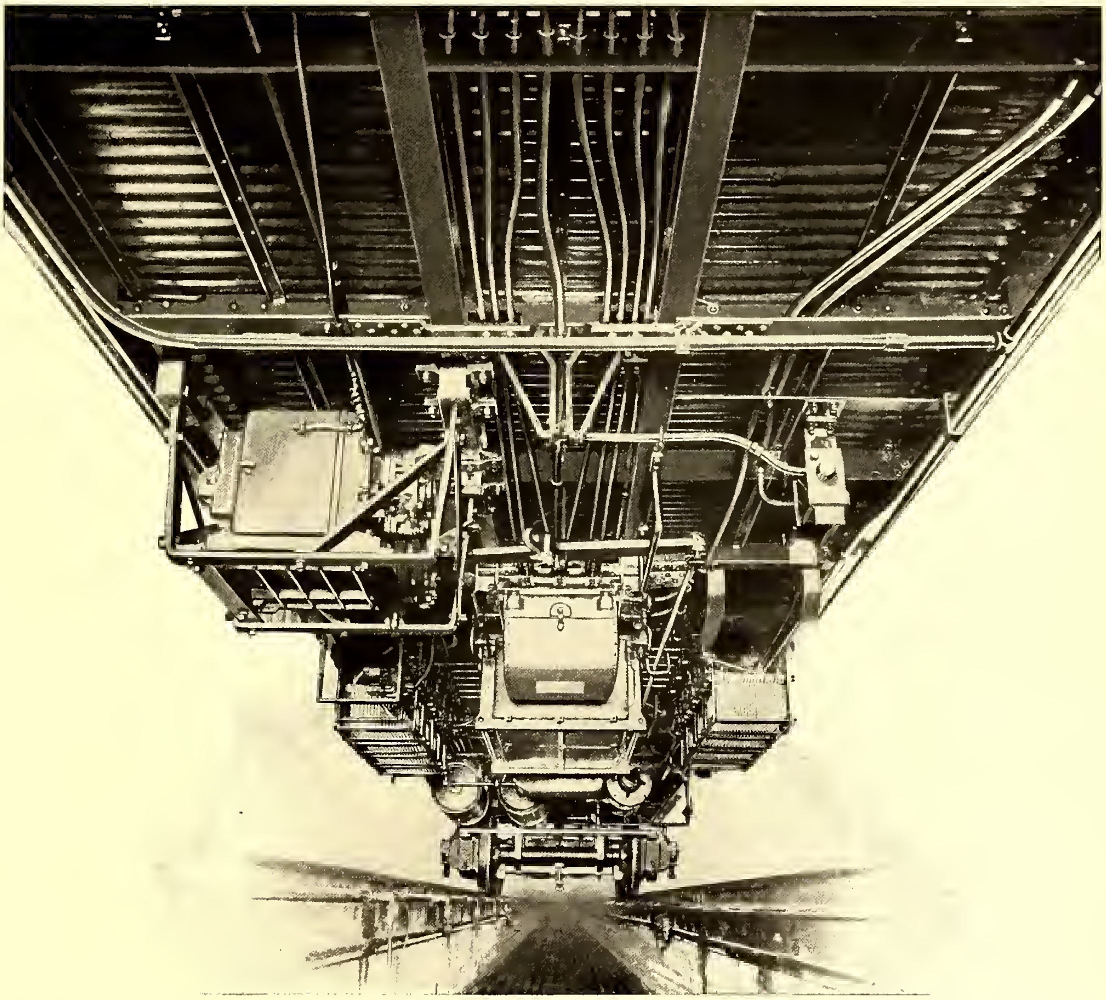
SIDE AND ROOF FRAMING

The drawings given of the car framing show the principal features of the side and end framing of the car and its roof construction. The window posts, which form a part of the side-plate girder construction, previously referred to, extend up and are riveted to the steel angle side plates, which extend from end bow to end bow. The body-corner posts and the vestibule posts are also rigidly connected to the side plates by special steel castings, thus forming a rigid base for the roof frame.

The roof frame details are well illustrated in an accompanying photograph, in addition to the drawings. The roof is built up in a unit of a series of malleable iron carlines, each attached to the side plate above a window post, and all tied together by the longitudinal purlins to which they are riveted by special angle brackets. All carlines and purlins are faced with furrings of fire-proof ash, and also similar blocks are bolted to the side plates, upon which the roof covering of fire-proof composite board and the head-linings are fastened. Special forged brackets are also provided on each carline to carry the clerestory eaves molding, while the deck plate and sills are of fire-proof ash pieces.

DRAFT RIGGING

The draft rigging for the steel cars involves interesting features, as shown in the accompanying drawing. The arrangement of apparatus provides for new improved type of automatic coupler, built by the W. T. Van Dorn Company, which is the standard of the Interborough Company. The coupler head is attached to the draw-bar through the Van Dorn standard type of spring buffer casting, to the top of which is riveted the main draw-bar, 8 ins. x 1½ ins. in section. Limitations of construction prevented this main draw-bar being carried through to the king bolt, so that a special form of auxiliary bolster construction was necessary to permit the desired radial movement



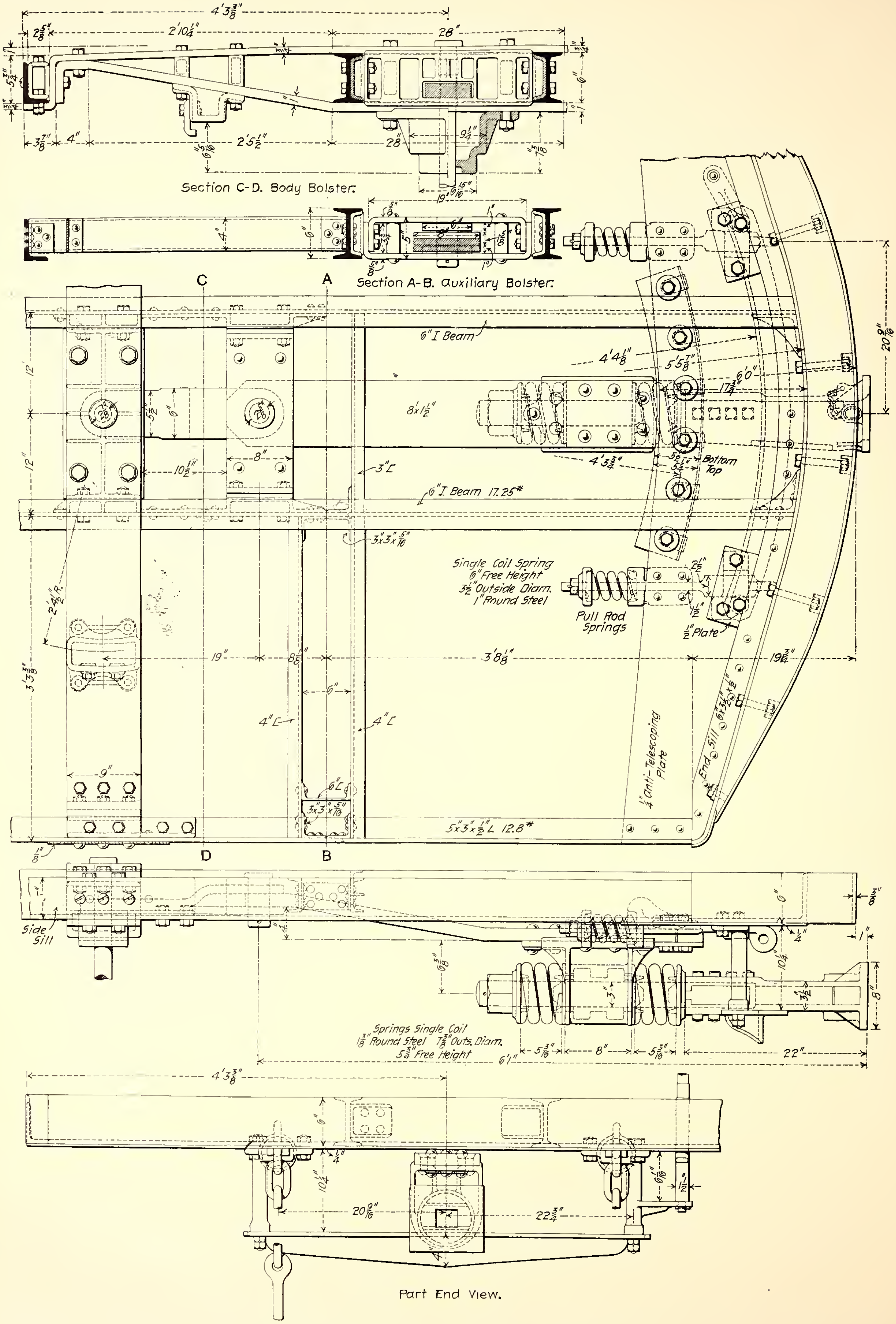
VIEW TAKEN FROM PIT BENEATH ONE OF THE STEEL CARS, SHOWING ARRANGEMENT OF APPARATUS

or swing for the coupler. An auxiliary draw-bar, 8 ins. x 2 ins. in section, is carried from the opening in the main body bolster filler casting forward a distance of 19 ins., where it ends in a special type of auxiliary bolster, bolted in between the center sills, as shown. This auxiliary draw-bar is forged in clevis shape, into which the end of the main draw-bar is secured by an auxiliary king bolt, 2⅝ ins. in diameter.

This provides a main draw-bar radius of 6 ft. 1 in., while a transverse swing movement of the coupler of 36 ins. is thereby secured. The weight of the main draw-bar is carried by a special sector plate above the spring buffer casting, which assists in taking care of the buffing strains from the draft rigging. The main sector plate upon which the draw-head itself slides, is built up of a 4-in. angle, curved to correspond with the movement of the draw-head, as shown. This drawing also shows the arrangement of the safety chain and anchor rods, and also the spring buffer devices upon the anchor rods by which shocks upon the chains will be transferred to the sills. The safety chains are built up of 2⅞-in. links of ⅞-in. round iron.

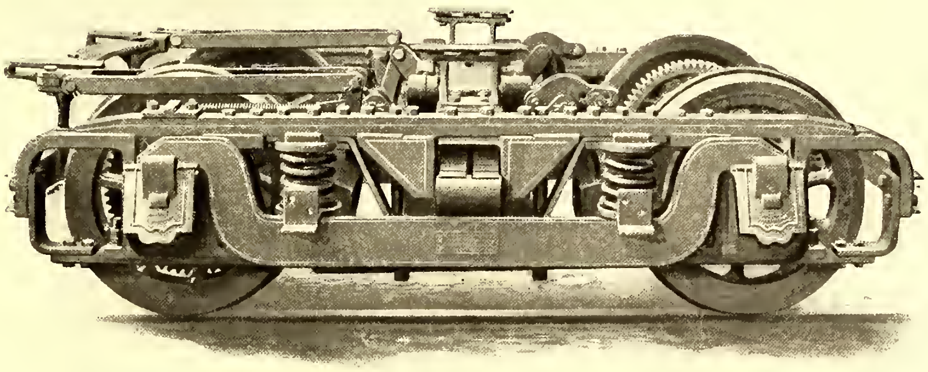
TRUCKS

The trucks which will be used for the steel cars are identical



DETAILS OF THE PLATFORM CONSTRUCTION AND ARRANGEMENT OF DRAFT RIGGING, SHOWING ALSO THE TYPE OF BODY BOLSTER CONSTRUCTION USED with those previously ordered for use under the wooden cars. The type of truck adopted was illustrated and described in the Aug. 15, 1903, issue of the Street Railway Journal, in which article the types of wheels and axles to be used were referred to. As may be seen from the accompanying photograph, the truck resembles in general design the usual standard designs which have been used successfully in heavy high-speed electric railroading. It embraces the many Master Car Builders' standards, which tend toward conformity to the latest steam railroad practice, while the latest improvements as dictated by electric railway practice are incorporated. A special design of truck bolster and spring plank was worked out to give the necessary space for motors.

The trucks were built to the designs of Mr. Gibbs and Mr. Thompson, of the Interborough Company, by the Baldwin Locomotive Works, Philadelphia, the motor trucks being designed in part for the Westinghouse No. 86 railway motors, and the remainder for the General Electric No. 69 railway motors. They are all arranged for nose suspension. The wheels and axles were furnished by the Standard Steel Works, the wheels being of the steel-tired type, with 2⅝-in. steel tires held in place by retaining rings. The bearings are of Damascus bronze, while the brake-shoes are the "Diamond S" type, made by the American Brake Shoe & Foundry Company. The following specifications for both the motor and the trail trucks indicate their general dimensions and important features:



THE TYPE OF TRUCK USED UNDER THE SUBWAY CARS

MOTOR TRUCKS

Gage of track .... 4 ft. 8½ ins.
Distance between backs of wheel flanges .... 4 ft. 5¾ ins.
Height of truck center plate above rail, car body loaded with 15,000 lbs. .... 30 ins.
Height of truck side bearings above rail, car body loaded with 15,000 lbs. .... 34 ins.
Wheel base .... 6 ft. 8 ins.
Weight of truck without motors .... 12,500 lbs.
Weight on center plate with car body loaded .... About 27,000 lbs.
Side frames, wrought-iron forged .... 2½ ins. x 4 ins.
End frames, steel channel .... 5 ins.—11.5 lbs. per ft.
Pedestals, wrought-iron forged ....
Center transom, steel channel .... 10 ins.—30 lbs. per ft.
Truck bolster, cast steel ....
Equalizing bars, wrought iron .... 1¼ ins. x 6½ ins.
Center plate, cast steel ....
Spring plank, wrought iron .... 1 in. x 3 ins.
Bolster springs, double coil, outside dimensions. 4⅞ ins. x 7½ ins.
Equalizing spring, duplicate elliptic, length .... 30 ins.
Brakes, inside hung ....
Wheels, cast-steel spoke center, steel tired, diameter ...... 33¾ ins.
Tires, tread M. C. B. standard .... 2⅝ ins. x 5¼ ins.
Axles, diameter at center .... 6½ ins.
Axles, diameter at gear seat .... 7 13-16 ins.
Axles, diameter at wheel seat .... 7¾ ins.
Journals .... 5 ins. x 9 ins.
Journal boxes, M. C. B. type, of malleable iron, bearings, M. C. B. type ....
Motor equipment, designed for two Westinghouse No. 86 motors...
Suspension, nose types ....

TRUCK TRAILERS

Height of center plate above rail, car body loaded .... 30 ins.
Height of side bearings above rail, car body loaded .... 30 ins.
Wheel base .... 5 ft. 6 ins.
Side and end frames, wrought iron .... 1½ ins. x 3 ins.
Pedestals, wrought iron ....
Center transom, wrought iron ....
Truck bolster, wood and iron .... 9-ins. x 12 ins.
Center plate, cast steel ....
Equalizing bars, wrought iron .... 1 in. x 5 ins.
Spring plank, white oak .... 2½ ins. 12 ins.
Bolster springs to be triple elliptic, width over bands.... 11¼ ins.
Length of bands to be .... 33¾ ins.
Length between centers .... 32 ins.
Equalizing springs, double coil, diameter .... 6 ins x 3⅝ ins.
Wheels, spoke center, steel tired, diameter .... 3 ins.
Tires, tread M. C. B. standard .... 2½ ins. x 5¼ ins.
Axles, diameter at center .... 4¾ ins.
Axles, diameter at wheel seat .... 5¾ ins.
Journals, with end collars, bearings .. 4¼ ins. diameter x 8 ins. long
Journal boxes, M. C. B. type, of malleable iron, berings, M. C. B. type ....

FLOORING

Another drawing shows the method of flooring construction which is used. The entire underframing is covered with a sheathing of No. 22 galvanized corrugated sheet iron, which is laid across the longitudinal sills and secured to the floor angles, which are especially arranged for this purpose by rivets and special clips of 1-in. band iron, as shown in the drawing. This corrugated sheathing serves as a base upon which the "Monolith" flooring is laid. The Monolith flooring is a cement-like material, made up in the following proportions:

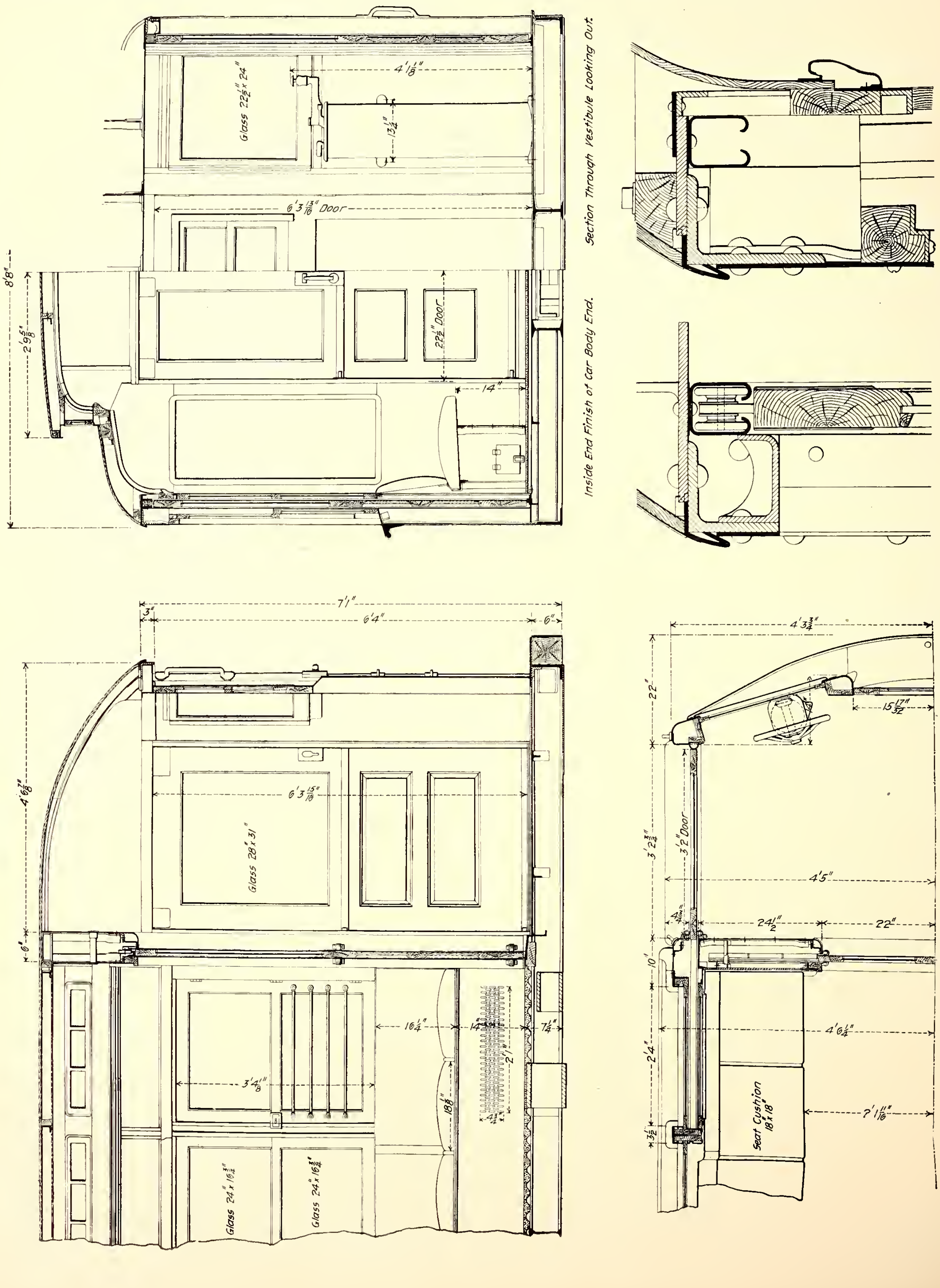
5½ gallons monolith.
¾ lb. raw sienna.
1-5 lb. burnt umber.
½ lb. Tuscan red.
37½ lbs. Monolith cement.

These constituents are mixed with a sufficient quantity of hardwood sawdust to give the material the consistency of mortar, and it is spread evenly upon the corrugated flooring and finished smooth on top. The special clips used in riveting the flooring assist in securing the monolith to the corrugated metal and holding it in place.

When finished, hardwood strips are laid upon the floor along the aisles of the car to provide the necessary wearing surface. It was found that these strips could be easily fastened to the Monolith cement by wood screws after first boring small leading holes, without cracking it. The floors of the platform are of ⅛-in. steel plate riveted to the platform frame. They are covered with pebbled rubber matting, which is cemented upon the steel plate. Special threshold metal treads are provided at the passageways between car and platform. Those at the side and end vestibule door openings are the well-known safety treads of the American Mason Safety Tread Company, Boston, Mass.

FINISH

The outside finish of the car is applied by the steel plate of the side-frame girder construction, upon which the paint finish of Tuscan red is applied. Similar sheathing of special rolled steel plate is applied to the car ends and platform framing, presenting a smoothly finished surface, which is exceedingly attractive. The window posts are covered with extruded metal, of which the inside and outside window stops and also the eaves molding are formed, as shown in the following engravings of window construction. The roof covering is of fireproofed composite board, fastened to the roof framing and furring, as above stated, and, after receiving a heavy coat of

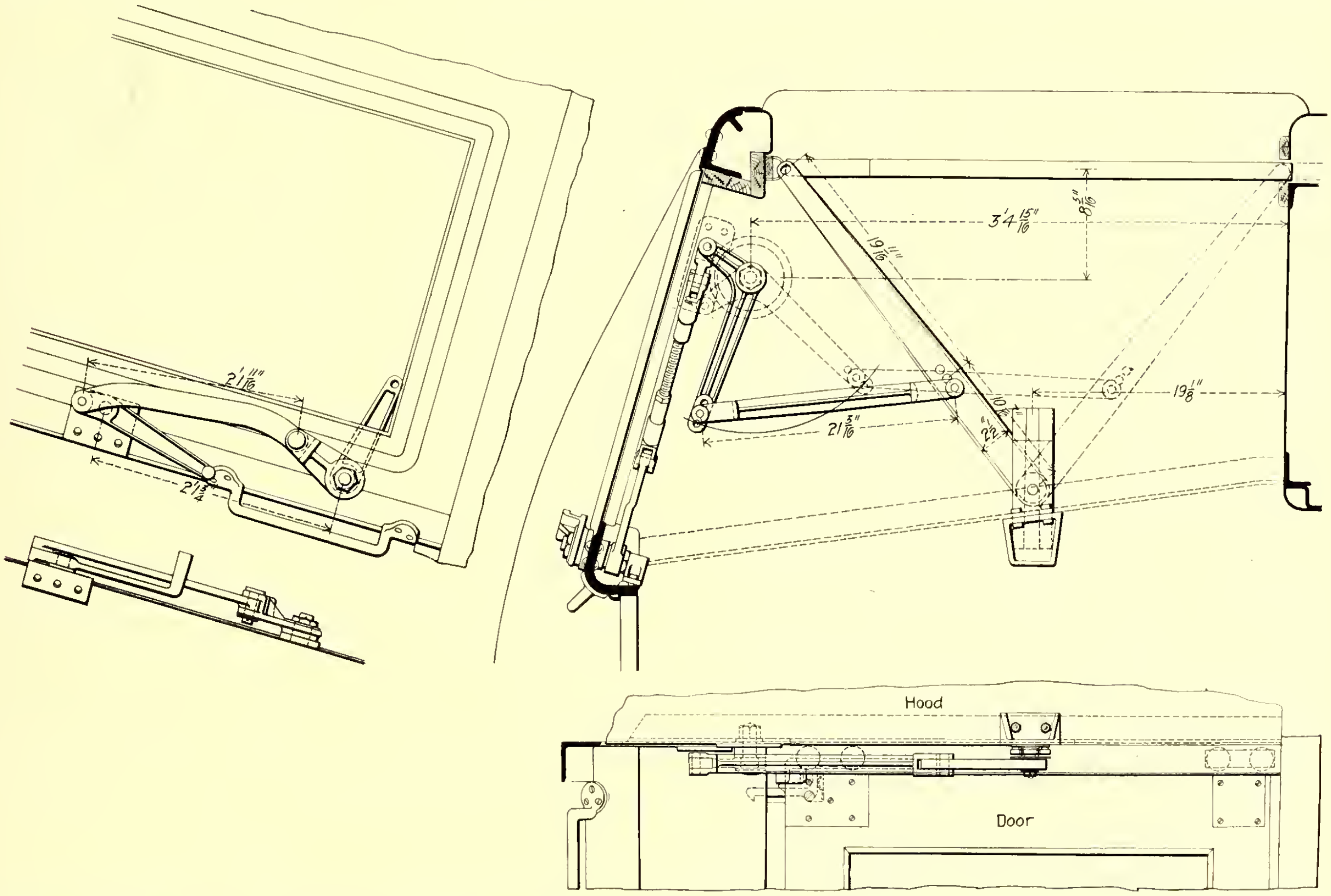


DRAWING OF PLATFORM CONSTRUCTION, SHOWING ARRANGEMENT OF ROLLING CENTER AND SIDE DOORS AND DETAILS OF SIDE-DOOR TRACK MECHANISM white lead, is covered with No. 6 cotton duck. The fire-proofed board, which is used for the roof sheathing, as well as for sheathing the sides of the car within the outside plate finish, is the well-known "transite" (asbestos) board, made by the H. W. Johns-Manville Company, New York. It is applied in the $\frac{3}{4}$-in. thickness, and is heavily painted with Sterling varnish.

The window construction is well shown in accompanying detail drawings, and is worthy of careful study on account of the interesting method of almost exclusive use of metal. The side windows have double sash, as shown, of mahogany, the lower being stationary and the upper arranged to drop. Aluminum ratchet racks are provided, in which the window locks may be caught in any position; the ratchet provision allows the upper sash to be closed without manipulation of the window catch or lock, while in lowering, the catch must be opened. The arrangement of sash, stops and curtain fixtures and runways are well shown in the drawings. Also details of the completed post construction and the application of the "transite" wainscoting appear in the lower half.

The interior finish of the car corresponds to the general construction in the use of metal, sheet aluminum having been adopted. The wainscoting surface between longitudinal seats, all the end interior panels and the window panels are covered with No. 14 gage sheet aluminum, being fastened in place over the inner sheathings of the "transite" (asbestos) board by nickel-plated round-head screws; the headlinings are also similarly faced with No. 14 sheet aluminum. All moldings used throughout the car for finished are of aluminum, pressed to shape, as shown in the drawings. The result is a very light and cheerful interior appearance, and from a practical standpoint, it is a finish that will remain bright and clean with a minimum of deterioration.

The style of deck construction, arrangement of deck windows and finish inside are shown in a transverse drawing of the roof. This shows also the arrangement of hand rail, which is of $1\frac{1}{2}$-in. aluminum tubing, for carrying the hand straps. This rail is carried upon aluminum brackets fastened to the deck, as shown, and is equipped with thirty-eight hand straps. In accordance with the latest practice in lighting, three rows of lamps are used, one of six lamps under the upper roof, and the others, each having ten lamps, under the side roofs, as shown; this drawing also indicates the arrangements of wiring molding for the light wiring. These moldings are also of aluminum, thus blending with the general interior finish of the car. The deck sashes are operated by an approved mechanical operating device by which various degrees of opening may be obtained with facility.

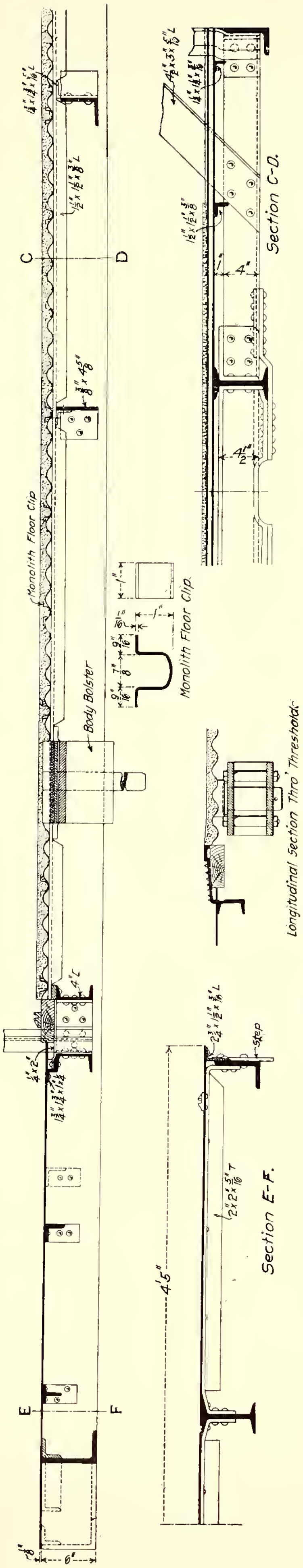


THE SPECIAL DESIGN OF DOOR-OPERATING MECHANISM FOR OPENING AND CLOSING THE SIDE DOORS FROM OUTSIDE OF THE END DOORS

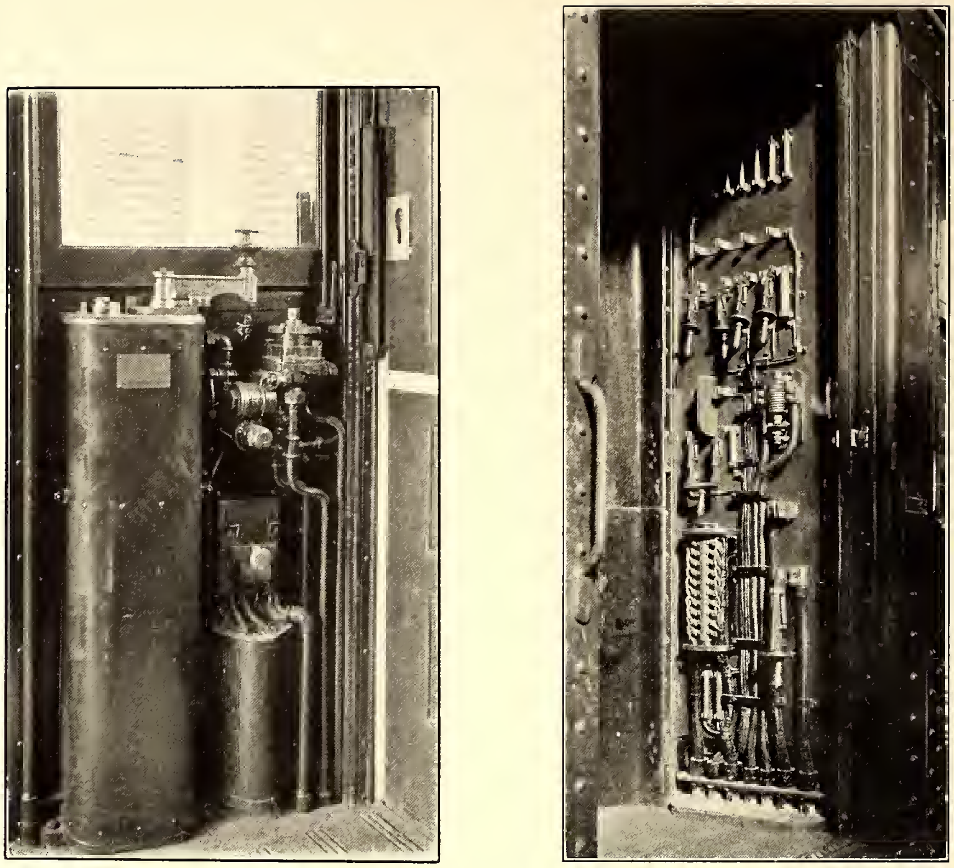
PLATFORM DETAILS

A large detail drawing is reproduced to show the interesting details of platform construction upon these cars. The platforms, vestibules and door mechanisms embody the improvements which were originated and patented by Mr. Gibbs. As may be noted, the platforms themselves are not equipped with gates, but with doors arranged to slide into pockets in the side framing, thereby giving up the entire platform to the passengers. These doors are closed and opened by an overhead lever system. The sliding doors of the motor cars may be partly opened and secured in that position by a bar, and thus serve as an arm rest for the motorman when used as the motorman's compartment.

The detail drawing shows the method of hanging the sliding side doors. They are supported upon brass sheaves when anti-friction rollers which run upon Coburn door tracks. They slide back into a compartment in the side framing, which is en-



DETAILS OF THE SPECIAL COMPOSITE FLOORING USED IN THE CAR, AND OF THE FLOOR-SUPPORT CONSTRUCTION

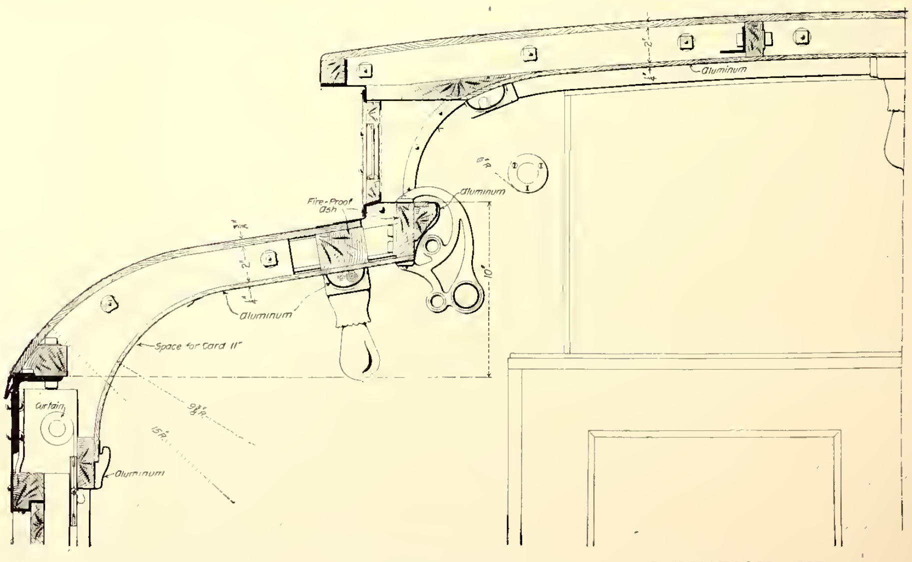


VIEWS OF THE MOTORMAN'S CONTROL APPARATUS AND THE CAR SWITCHBOARD LOCATED UPON THE PLATFORM

closed by the first outside window and an inside window for protection to passengers. Rubber door steps of tubular shape are provided to cushion the shock of closing the door and, furthermore, to prevent catching of clothing of passengers when the door is closed.

The end doors between vestibules and bodies of cars are of the double type, hung on nickel-plated sheaves with hard fibre anti-friction rollers, and also provided with the Coburn patent steel tracks enclosed over the doors. These doors are provided with rubber stop cushions, and like the side doors, with anti-rattlers consisting of rubber rolls. This construction is well illustrated in the drawings. These end doors are also provided with horizontal curtains, for use when the vestibule is occupied by the motorman; the curtains are automatically raised or lowered as the door is opened or closed, to shut the light away from the motorman. Another interesting attachment is the improved handle on the sliding door. This door is made to latch so that it cannot slide open with the swaying of the car, but the handle is so constructed that when pressure is applied upon it to open the door the same movement will unlatch it.

The details of the Gibbs side vestibule door operating device are shown in a separate



HALF CROSS-SECTION OF CAR ROOF, SHOWING CONSTRUCTION AND INTERIOR FINISH drawing. The handle outside the vestibule is arranged to operate like those upon the present elevated cars; it serves to give movement to the mechanism within through the bell crank above, from which another bell crank is operated, as shown. The movement of the cross-wise door-opening arm is provided with an interesting shifting anti-friction pivot, to facilitate the opening. The door itself is provided with a spring latch to hold it shut, which, however, is automatically unlatched by the opening arm in the movement of opening the door. These door opening mechanisms, as well as the pantagraph safety gates, were built for these cars by the Pitt Car Gate Company, New York.

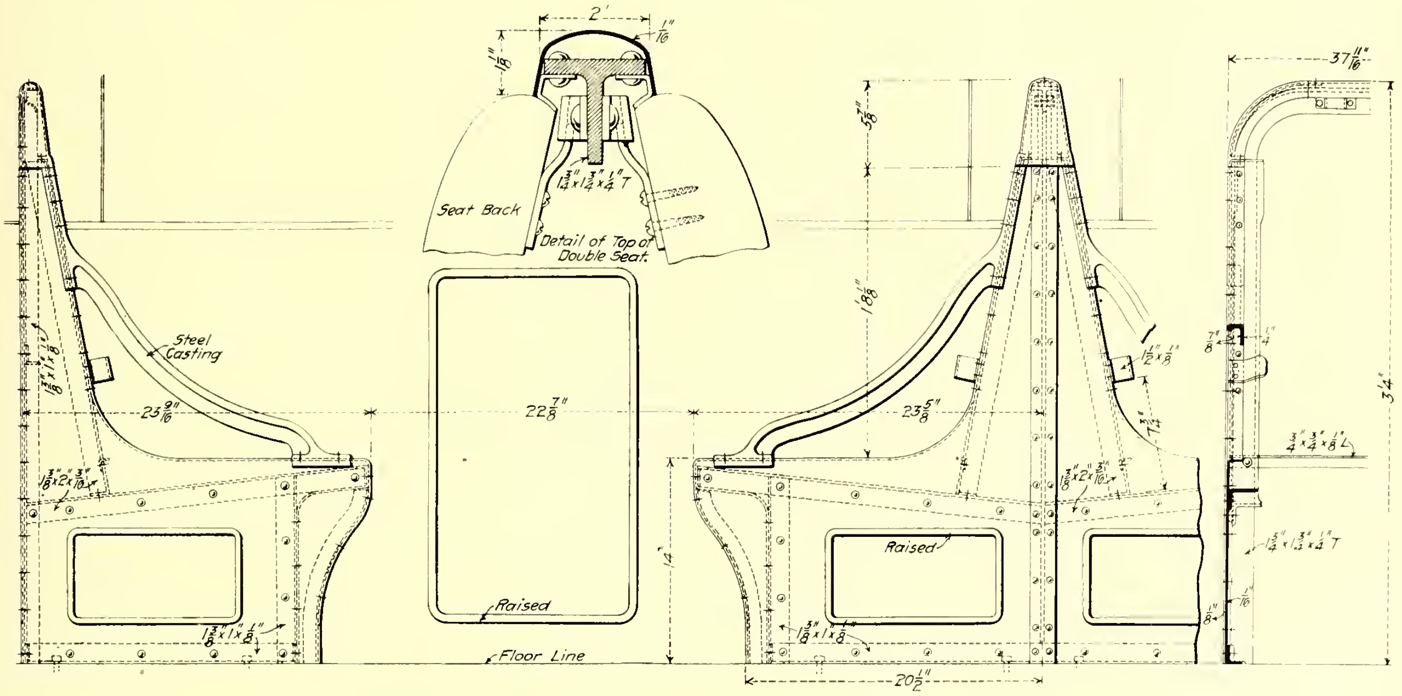
MOTORMAN'S CAB

A novel feature in the construction of these cars is the provision for the motorman's compartment and vestibule, which differs essentially from anything used heretofore. The cab is arranged to be located on the platform, so that no space within the car is required; at the same time the entire platform space is available for ingress and egress except that on the front platform of the first car, when occupied by the motorman, on which the passengers would not be allowed in any case. The side of the cab is formed by a door, which can be placed in any one of three positions. When in its mid position, it encloses a part of the platform so as to furnish a cab for the motorman at one side, but when swung parallel to the end sills it encloses the entire end of the platform, and this would be its position on the rear platform of the rear car. The third position is when it is swung around to an arc of 180 degs., when it can be locked in position against the corner vestibule post enclosing the master controller. This would be its position on all platforms, except on the front of the front car or the rear of the rear car of the train.

A novel arrangement of car switchboard has been provided for, for the control of all electrical circuits upon each car. The details of construction and arrangement of apparatus upon one of these boards are shown by an accompanying photograph. It is located in one of the end panels of the car, the compartment door opening out toward the platform. The door is of concaved outline, to provide sufficient room for the switch handles, fuses and other apparatus. The switchboard proper consists of a slab of slate, 1¼ ins. thick and 17 ins. x 65 ins. in size. Its equipment embraces all the fuses and switches for the lighting and heater circuits, the switch controlling the Christensen air compressor, the main power-circuit switch (single pole), the limit magnet for the type M control system, and a 10-point control cut-out switch for disconnecting the control system upon the car.

INSIDE DETAILS

The concluding drawings illustrate the methods of construction adopted by the longitudinal and cross seats. As before stated, the frames of these seats will all be of metal, thus making the equipment the extreme of non-combustibility. The styles of cushions used correspond to those in general use, and the seating arrangements are similar to the elevated cars, but as the subway coaches are longer, two additional seats are gained on each end. The seats are all finished in canvas-backed, fire-proofed rattan. Stationary cross-wise seats are provided after the Manhattan pattern at the center of the car. The longitudinal seats are 17¾ ins. deep. The space between the longitudinal seats is 4 ft. 5 ins., giving a much greater clearance than the Manhattan type.



DETAILS OF THE SPECIAL ALL-METAL CONSTRUCTION FOR THE CENTER CROSS-SEATS OF THE CAR

The windows, in having two sashes—the lower one being stationary, while the upper one is a drop sash—are in reverse of the ordinary practice, but this is desirable in subway operation to insure safety to the passengers. The side windows in the body of the car, also the end windows and end doors, are provided with roll shades with pinch-handle fixtures. The floor covering of hard maple strips, securely fastened to the floor with oval-head brass screws, provides a dry, clean floor for all conditions of weather.

EQUIPMENT

As noted in former articles upon the rolling stock equipment of the Interborough Company, the motor-control system which has been adopted is the Sprague-General Electric type described in the March 14, 1903, issue of this journal. The Christensen air compressor has been adopted as standard for the subway cars, while the Westinghouse system of air brakes is used.

THE BLOCK SIGNAL AND INTERLOCKING SYSTEMS OF THE SUBWAY DIVISION OF THE INTERBOROUGH RAPID TRANSIT COMPANY

EARLY in the development of plans for the subway rapid transit system in New York City, it was foreseen that the efficiency of operation of a road with so heavy a traffic as is expected would depend largely upon the completeness of the block signaling and interlocking systems which should be adopted for facilitating the spacing of trains and the protection of train movements. The consideration of provision of signals at once appeared to be rivaled in importance only by that of the provision of the proper motive power. Not only for the safety of passengers, but also for facilitating the operation under such heavy and exacting schedules, it was decided to install the most complete and effective signaling system which was to be had.

Early in 1901, a careful study of available systems of signaling and interlocking signaling was instituted in order to develop a system for the subway which should be especially adapted to the conditions of operation and fulfil the particular requirements met in the subway. The problem involved three prime considerations:

First, safety and reliability.

Second, greater capacity of the line consistent with safety and reliability.

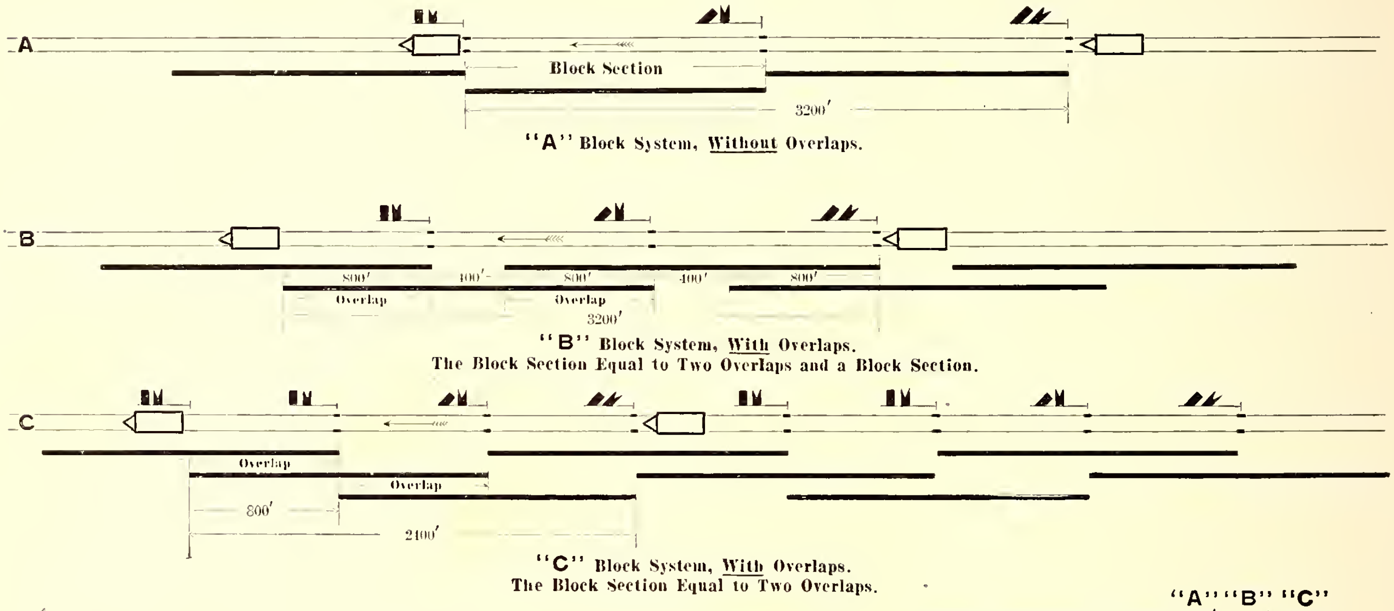
Third, facility of operation under necessarily restricted yard and track conditions.

In order to obtain the above desiderata, with special reference to the question of safety of train movement, it was decided to install a complete automatic block-signaling system for the high-speed express lines in the subway, block operation for all obscure points on the low-speed routes, and to operate all switches, both for line movement and in yards, by power from central points, through interlocking plants. This necessarily involved the interconnection of the block and switch movements at many locations and made the adoption of the most flexible and compact plans essential.

The study of modern signaling and methods of protecting train movements indicated that the Westinghouse electro-pneumatic block and interlocking system promised the most satisfactory results if used under such exacting and severe conditions of operation as are to be experienced in the subway. The electro-pneumatic system has been thoroughly tested and tried, and found reliable under all conditions of weather and service. By it power can be readily conducted in small pipes in any quantity and to any distance, and utilized in compact apparatus in the most restricted spaces. The movements can be made with the greatest promptness and certainty, and interconnected for the most complicated situations to provide absolute safety of train movement.

One of the most important features of the considerations in favor of the electro-pneumatic system is, moreover, that all essential details of the system have been worked out in years of practical operation on the important trunk lines of steam railroads, so that its reliability and efficiency were beyond question. It has rendered perfect service under some of the most difficult conditions that are to be found in railroad operation; at such terminals as those at Jersey City, Philadelphia and Pittsburg, upon the Pennsylvania Railroad, at the terminal stations in Boston, Mass., and elsewhere, this system has operated successfully for many years in most complicated track and switching conditions that can be imagined.

This system has also been applied to heavy electric railway service with marked success. It has been in use upon the Boston Elevated Railway system since its opening to the public, this being the first electric railway system to adopt a complete system of block signaling. In a more recent installation of block signaling which has been made upon the North Shore Road, an important third-rail electric system terminating at San Francisco, Cal., a system of electrically operated signals has been installed and has been in operation for nearly a year, which embodies the essential features of track circuits and signal control involved in the electro-pneumatic system.



	"A"	"B"	"C"
Distance Between Signals	1600'	1200'	800'
" " Trains	3200'	3200'	2400'
Headway at 25 M. P. H.	96 sec.	96 sec.	78 sec.

DIAGRAM OF THE THREE PRINCIPAL METHODS OF BLOCK SIGNALING, INDICATING THE USE OF OVERLAPS

TRAFFIC CONDITIONS

The New York subway operation as proposed contemplated traffic of unprecedented density and consequent magnitude of propulsion currents employed, and experience with existing track-circuit control systems led to the conclusion that some modification in apparatus was essential to prevent derangement, which might occasion traffic delays. On account of this consideration, and others, the application of the signaling system to the subway conditions has evolved an elaboration of detail not before attempted upon any railway line of similar length, and it is believed that the contract for this installation is the largest single order ever given to a signal manufacturing company.

As elsewhere noted, the proposed operation contemplates two tracks loaded with local trains at one-minute intervals, and two tracks with eight-car express trains at two-minute intervals, the latter class of trains requiring at times as much as 2000 hp for each train in motion. It is readily seen, then, that combinations of trains in motion may at certain times occur which will throw enormous demands for power upon a given section of the road. The electricity conveying this power flows back through the track rails to the power station, and in so doing is subject to a "drop" or loss in the rails which varies in amount according to the power demands. This causes disturbances in the signal-track circuit in proportion to the amount of "drop," and it was believed that under the extreme condition above mentioned the ordinary form of track circuit might prove unreliable and cause delay in traffic.

A solution of the difficulty was suggested, consisting in the employment of a current in the signal-track circuit which would have such characteristic differences from that used to propel the trains as would operate selectively upon an apparatus which would in turn control the signal. Alternating current supplied this want on account of its inductive properties, and was adopted, after a demonstration of its practicability under similar conditions on another electric railway.

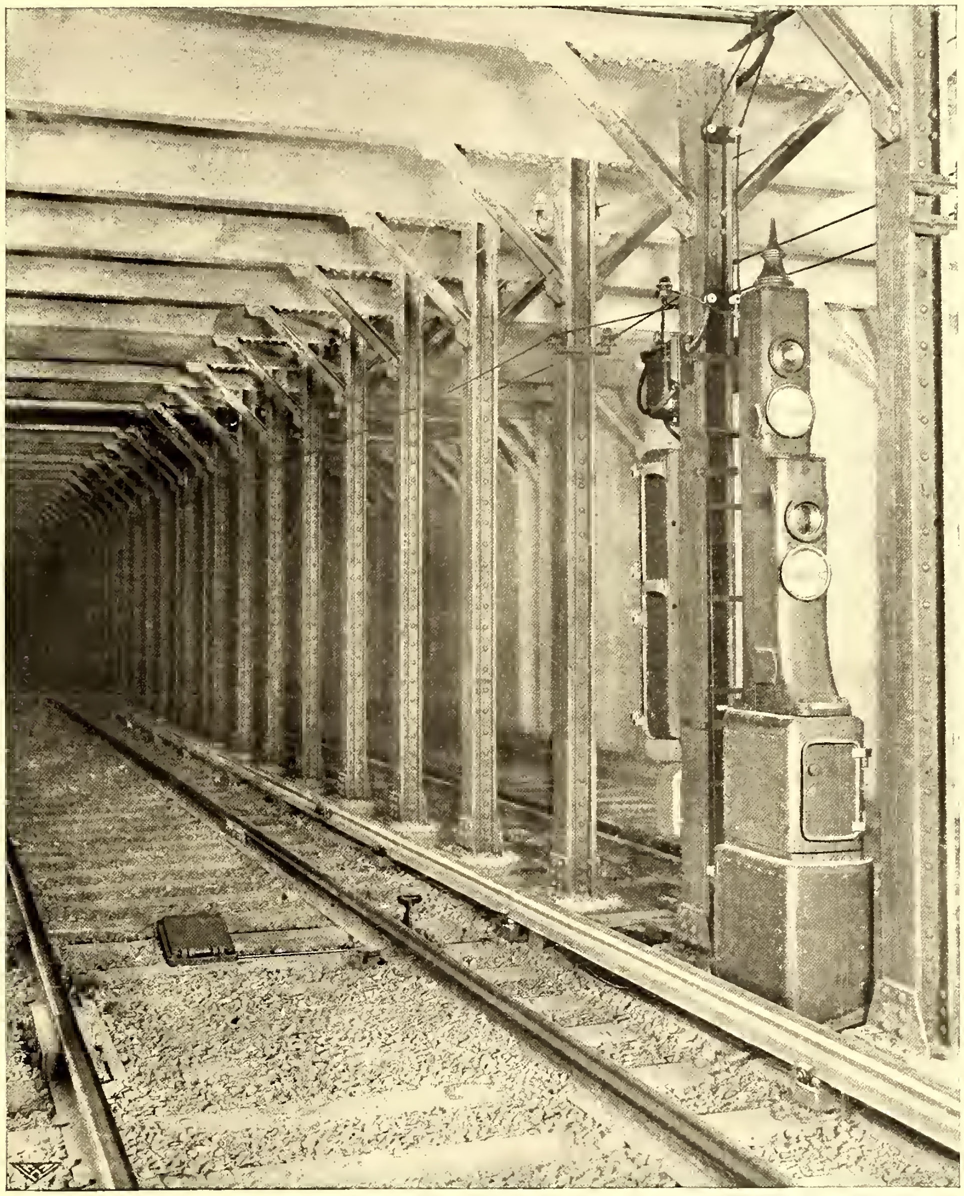
Aside from the above modification, the system follows the general lines of that which was worked out for the Boston Elevated Railroad, the first electric railway operating under heavy traffic conditions, which adopted a complete automatic block-signal system with track-circuit control, and in which one of the track rails is devoted to the signal-control system and the other to the propulsion-current return. The use of the alternating-current track circuits involved the adaptation of specially designed alternating-current relays, which should in turn control the signal circuits, and at the same time be entirely unaffected by direct-current disturbances. The system designed, it is thought, provides for all possible disturbing conditions and will be representative of the latest and best practice in railway signaling.

THE SYSTEM OF OVERLAPS

After a decision was reached as to the system to be employed, the arrangement of the block sections was considered from the standpoint of maximum safety and maximum traffic capacity, as it was realized that the rapidly increasing traffic of Greater New York would almost at once tax the capacity of the line to its utmost.

The usual method of installing automatic block signals in the United States is to provide home and distant signals with the block sections extending from home signal to home signal; that is, the block sections end at the home signals and do not overlap each other. The telegraph block system, the controlled-manual system and the English block system, however, all employ overlaps. Without the overlap, a train in passing from one block section to the other will clear the home signals for the section in the rear, as soon as the rear of the train has passed the home signal of the block in which it is moving. It is thus possible for a train to stop within the block and within a few feet of this home signal. If then a following train should for any reason overrun this home signal, a collision would result. With the overlap system, however, a train may stop at any point in a block section and still have the home signal which protects it, at a safe stopping distance in the rear of the train.

Conservative signaling is all in favor of the overlap, on account of the safety factor in case the signal is accidentally



FRONT VIEW OF A TYPICAL BLOCK SIGNAL IN THE SUBWAY, SHOWING LIGHTS, POSITION INDICATORS, INSTRUMENT CASE UPON THE POST IN ADVANCE, AND ALSO THE TRACK TRAIN STOP overrun. Another consideration was the use of automatic train stops. These stops, which act by applying the air brakes automatically upon a train attempting to run past it, are placed at the home signals, and it is thus essential that a stopping distance should be afforded in advance of the home signal to provide for stopping the train to which the brake had been applied by the automatic stop.

The arrangement of overlap sections, as ordinarily used, increases the length of block sections by the length of the overlap, so that, as the length of the section fixed the minimum spacing of trains, it was imperative to make the blocks as short as consistent with safety in order not to cut down the carrying capacity of the railway. This led to a study of the special problem presented by subway signaling and a development of a blocking system upon lines which it is believed are distinctly in advance of anything heretofore done in this direction.

Block section lengths are governed by speed and interval between trains. Overlap lengths are determined by the distance in which a train can be stopped at a maximum speed. Usually the block section length is the distance between signals plus the overlap; but where maximum traffic capacity is desired the block section length can be reduced to the length of two overlaps, and this was the system adopted for the Interborough. The three systems of blocking trains, with and without overlaps, is shown in the diagram on page 648, where two successive trains are shown at the minimum distances apart for "clear" running for an assumed stopping distance of 800 ft. The system adopted for the subway is shown in line "C," giving the least headway of the three methods.

The length of each overlap was given very careful consideration by the Interborough Company, who instituted a series of tests of the braking power of trains. From these tests and others made by the Pennsylvania Railroad Company, curves were computed so as to determine the distance in which trains could be stopped at various rates of speed on a level track, with corrections for rising and falling grades to 2 per cent. Speed curves were then plotted for the trains on the entire line, showing at each point the maximum possible speed, with the gear ratio of the motors adopted. A joint consideration of the speeds, braking efforts and profile of the road were then used to determine at each and every point on the line the minimum allowable distance between trains, so that the train in the rear could be stopped by the automatic application of the brakes before reaching a train which might be standing at a signal in advance; in other words, the length of the overlap section was determined by the local conditions at each point.

In order to provide for adverse conditions, the actual braking distances were increased by 50 per cent—for example, the braking distance of a train moving 35 miles an hour is 465 ft.; this would be increased 50 per cent and the overlap made not less than 697 ft. With this length of overlap home signals could be located 697 ft. apart, and the block section length would be double this, or 1394 ft. The average length of overlaps, as laid out, is about 800 ft., and the average length of block sections double this, or about 1600 ft.

The protection provided by this unique arrangement of signals is illustrated in the above diagram. Three positions of train are shown:

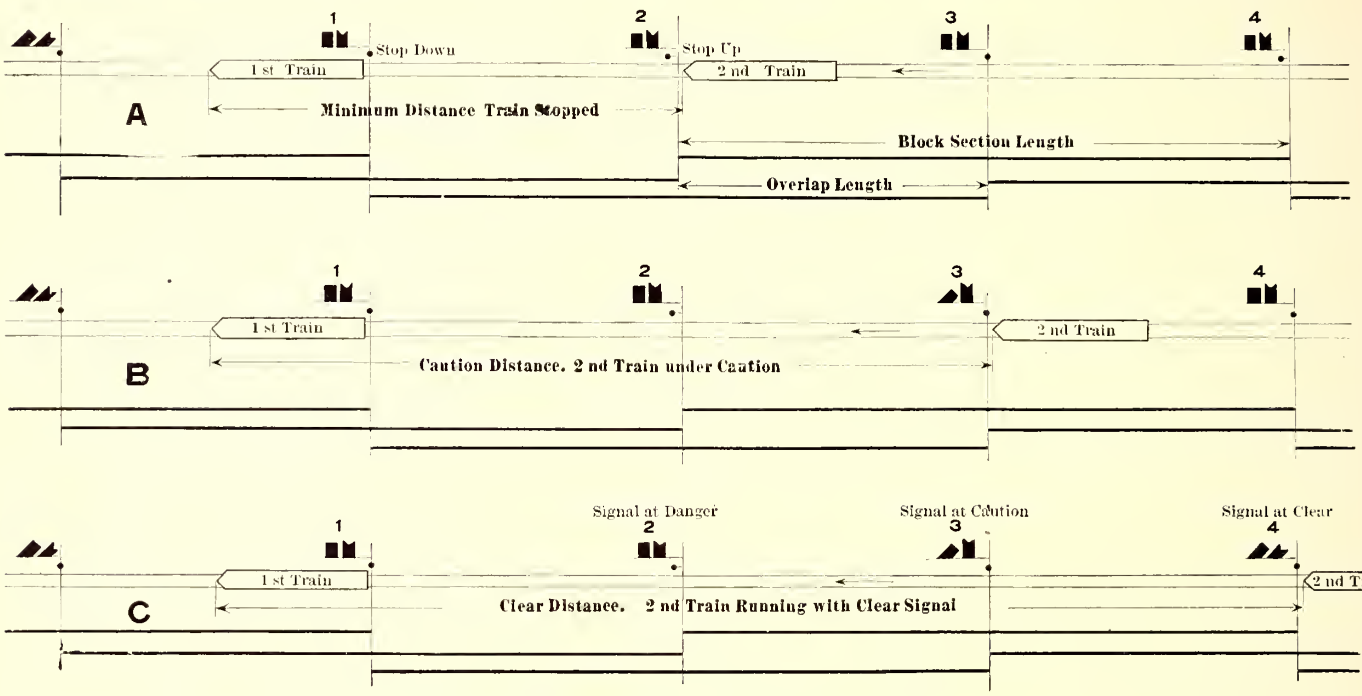


DIAGRAM OF THE OVERLAPPING BLOCK-SIGNAL SYSTEM ADOPTED, ILLUSTRATING POSSIBLE POSITIONS OF TRAINS RUNNING UNDER SAME

"A." Minimum Distance Between Trains—The first train has just passed the home signal; the second train is stopped by the home signal in the rear—if this train had failed to stop at this point, the automatic stop would have applied the air brake and the train would have had the overlap distance in which to stop before it could reach the rear of the train in advance. Therefore, under the worst conditions, no train can get closer to the train in advance than the length of the overlap, and this is in all cases a safe stopping distance.

"B." Caution Distance Between Trains—The first train in same position as in "A;" the second train at the third home signal in the rear. The latter signal can be passed under caution. This distance between trains is the caution distance, and is always equal to the length of the block section or two overlaps.

"C." Clear Distance Between Trains—First train in same position as in "A;" second train at the fourth home signal in the rear. At this point both the home and distant signals are clear, and the distance between the trains is now the clear running distance; that is, when the trains are one block section plus an overlap apart, they can move under clear signal, and this distance is used in determining the running schedule. It will be noted in "C" that the first train has the following protection: Home signals 1 and 2 in stop position, together with the automatic stop at signal 2 in position to stop a train; distant signal 1, 2 and 3 all at caution; or, in other words, a train that has stopped is always protected by two home signals in its rear, and by three caution signals, in addition to this an automatic stop placed at a safe stopping distance in the rear of the train.

The application of continuous train speed curves, in combination with braking curves, to the line profile for the purpose of regulating safe overlap lengths, is believed to be entirely novel and to constitute an important advance in signaling lines for dense traffic. This system was suggested by Mr. Gibbs, and the tests for its adaptation were carried out under his direction.

DESCRIPTION OF BLOCK-SIGNALING SYSTEM

The block-signaling system as installed consists of the automatic overlapping system above described, applied to the two middle express tracks between City Hall and Ninety-Sixth Street, a distance of 6½ miles, or 13 miles of track; and to the third track between the Ninety-Sixth Street junction and 145th Street on the west side branch, a distance of 2½ miles. This third track, which is placed between the two local tracks, and will be used for express traffic in both directions, trains moving toward the City Hall in the morning and in the opposite direction at night, will be equipped with a special single-track system for indicating in either direction. Also the two tracks from 145th Street to Dyckman Street, a distance of 2½ miles, or 5 miles of track, and the portion of the tunnel under Central Park, for a distance of 1½ miles, or 3 miles single track, will be protected by signals. The total length of track to be protected by signals is 27½ miles. The local tracks of the system will also be provided with block signals at important places, such as curves, stations, cross-overs, etc., and at the Harlem River tunnel.

The apparatus used differs little in general principle from that employed in earlier automatic systems of block signaling, the substitution of alternating current in place of battery current for the track circuits, and the necessary alternating-current auxiliary apparatus, constituting the principal change. In detail of application to the peculiar requirements under subway conditions, however, the system embodies many radical features which are of unusual interest and importance. Great care has been given to the design, construction and installation of the signal apparatus, so as to insure reliability of operation under the most adverse conditions, and to provide for accessibility to all the parts for convenience in maintenance. From the accompanying diagram presented above may be seen the general arrangement of circuits as used in connection with the overlapping feature of this system.

In the study of this system of signaling, it is important to note that, in accordance with the latest practice in block signaling for electric railway conditions, one of the running rails of each track is insulated from the propulsion-current return system and is devoted to the signal system. Thus, the other rail performs the novel function of serving simultaneously as conductor for the direct-current return for the propulsion system, as well as that of one of the conductors for the alternating current track circuit for controlling the signals. In accordance with the usual manner of arranging track circuits in block signaling, the current is fed into each block at the end from which the passing train leaves it, the connections to the signal-control apparatus being made from the opposite, or entering, end of the block, as shown in the accompanying wiring diagram. The track connections at the signal end of the block lead from the track circuit to the special alternating-current signal-control relay, which operates secondary connections in the various circuits of the signaling system. This relay apparatus by means of its moving element, operates double contacts, so that when the block is clear and current is thus passing through it, two separate circuits are closed; one of these is the circuit leading to the automatic train stop at the entrance to the block in the rear. These magnets, which are thus operative only when the block is clear, actuate controlling air valves to the compressed-air cylinders operating the signals: the effect of the magnets becoming inoperative, due to the presence of a train in the block and consequent stoppage of the track-circuit current, is to set the signals to danger, which makes the system thus, in effect, the "normal clear" type.

The distant, or caution, signals are operated by an auxiliary circuit as the result of the setting of the home signal. When the home signal of a block is clear, current is passing through the control mechanism of the distant signal of the preceding block, thus holding it at clear also. When the home signal is thrown to danger, the current flowing in the auxiliary circuit is interrupted by a special circuit breaker in the block signal, which causes the distant signal to indicate caution.

The alternating current for the track circuits is supplied by special high-voltage alternating-current mains which run the entire length of the tunnel. These deliver current to the signal blocks at 500 volts potential, from which it is transformed down at each block by a special double-secondary oil transformer, one coil of which feeds the track circuit and the other the signal-lamp circuit. In this way the most economical method of current supply is secured, while at the same time absolute independence of the various circuits is obtained by the use of the transformers. The various magnet-control apparatus, which is used for operating the controlling air valves for the signal cylinders, receive current from a storage-battery main which also runs the length of the subway. This main is fed by several sets of 16-volt storage batteries in duplicate, which batteries are located at the various interlocking towers and are charged by motor generators.

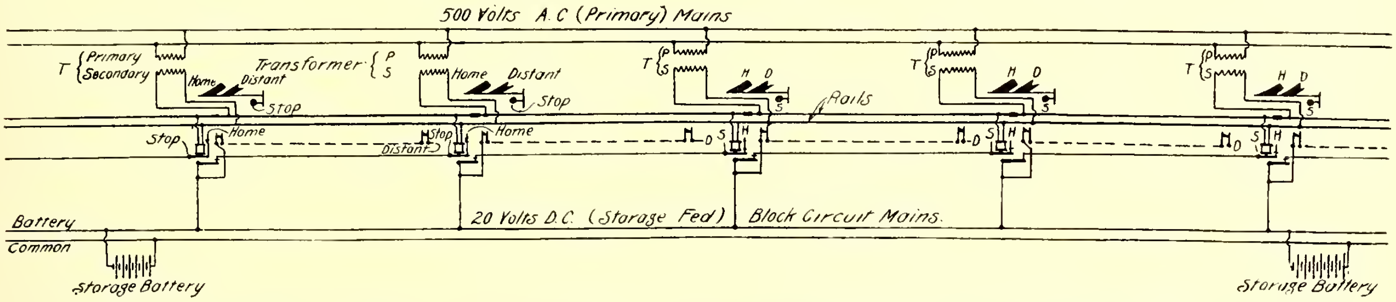
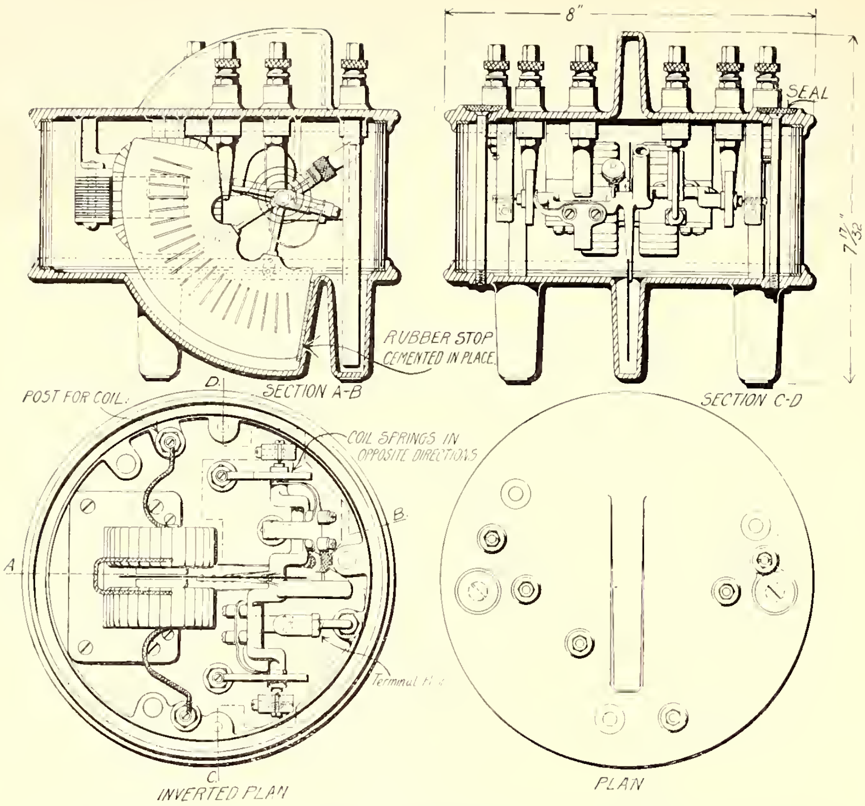


DIAGRAM OF THE BLOCK SIGNAL AND AUTOMATIC TRACK STOP CIRCUITS OF THE INTERBOROUGH SIGNAL SYSTEM



DETAILS OF THE NEW TYPE OF TRACK CIRCUIT RELAY USED, WHICH IS DESIGNED TO RESPOND TO ALTERNATING CURRENT ONLY

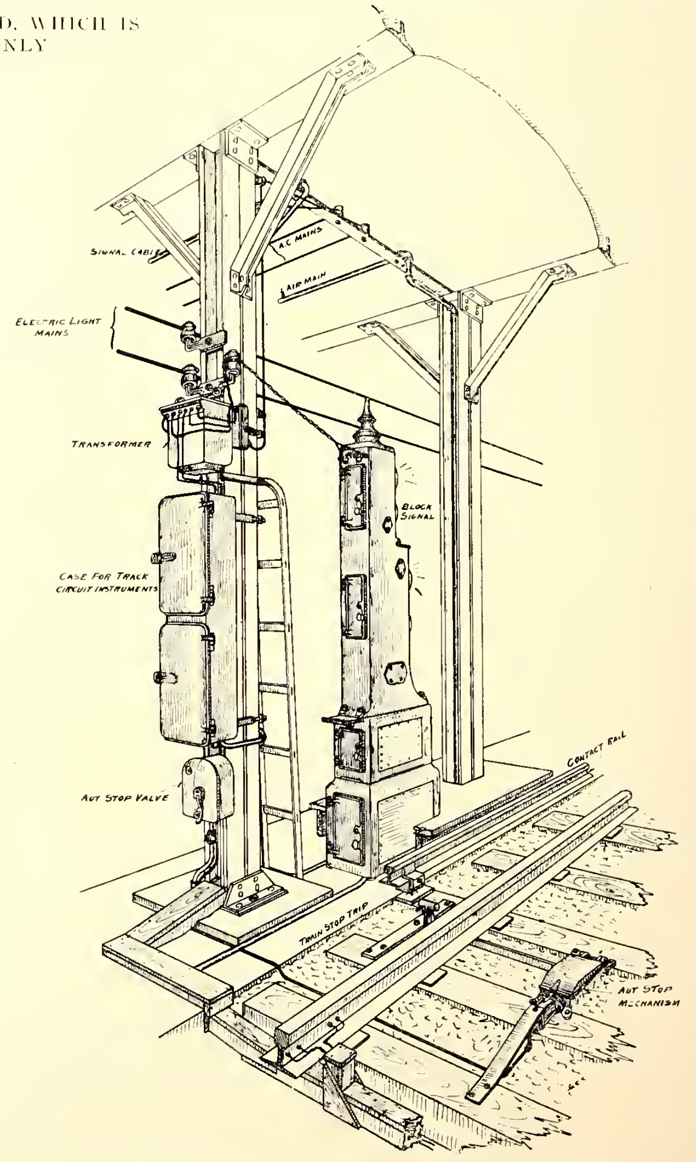
THE SIGNAL MECHANISM

In the sketch at the right is shown in perspective the arrangement of the apparatus installed at a block-signal station. As may be seen from the diagrammatic arrangement of this apparatus in the tunnel, it consists of, first, the block signal and then a transformer, a case for the track-circuit instruments and the automatic stop-valve box. The purpose of the transformer has already been referred to; it takes current from the 500-volt main through 3-amp. enclosed fuses to the primary coil; its secondary contains two coils, one of which delivers current at 50 volts for use in the 4-cp incandescent lamps used in the signal, while the other coil delivers current at the lower voltage of 10 volts for use in the track circuit. As may be noted, the leads to the track circuits pass down the instrument case and thence to the rail connections at the exit end of the block; in the instrument case they pass through non-inductive resistances of 1 ohm, which serve to prevent any magnitude of current from flowing through these circuits in case of abnormal disturbing conditions in the propulsion-return current, and also prevent an excessive alternating current passing from the transformer when short-circuited by the presence of a train in the track circuit which it feeds.

The details of the special transformer for supplying the current to the track circuits and also to the incandescent lamps used in the signals are simply worked out; it is an oil transformer of the usual type of construction, with the exception that it is equipped with two separate secondary windings. The primary winding is wound for the 500-volt alternating current which is supplied from the mains leading through the tunnel, while the secondary coil operating the track circuits is wound to deliver alternating current at 10 volts, and the secondary coils supplying current to the signal lamps deliver current at 50 volts. These transformers embody the latest principles of transformer design and are very carefully insulated. A special grade of transformer oil is used, and the test voltage to which they are submitted before use consists of a "break-down" test of 5000 volts between the primary and secondary coils and the core.

The special alternating-current relay is of an entirely new design and introduces an interesting departure from the preceding methods in signal work. The principle of operation involved is that of the action of an alternating-current field upon a slotted metallic (non-magnetic) vane, which is caused to move in such a way as to close the two circuit contacts. The alternating-current field is supplied by a magnet of laminated field-core construction, with the field coils arranged very close to the pole faces. The vane, which is of aluminum, is pivoted in a vertical position on jewel bearings, being held in a down position by a hair spring. The effect of current passing through the field coils is that of causing the aluminum vane to rise to its upper position. Its general construction is well shown in the accompanying drawing.

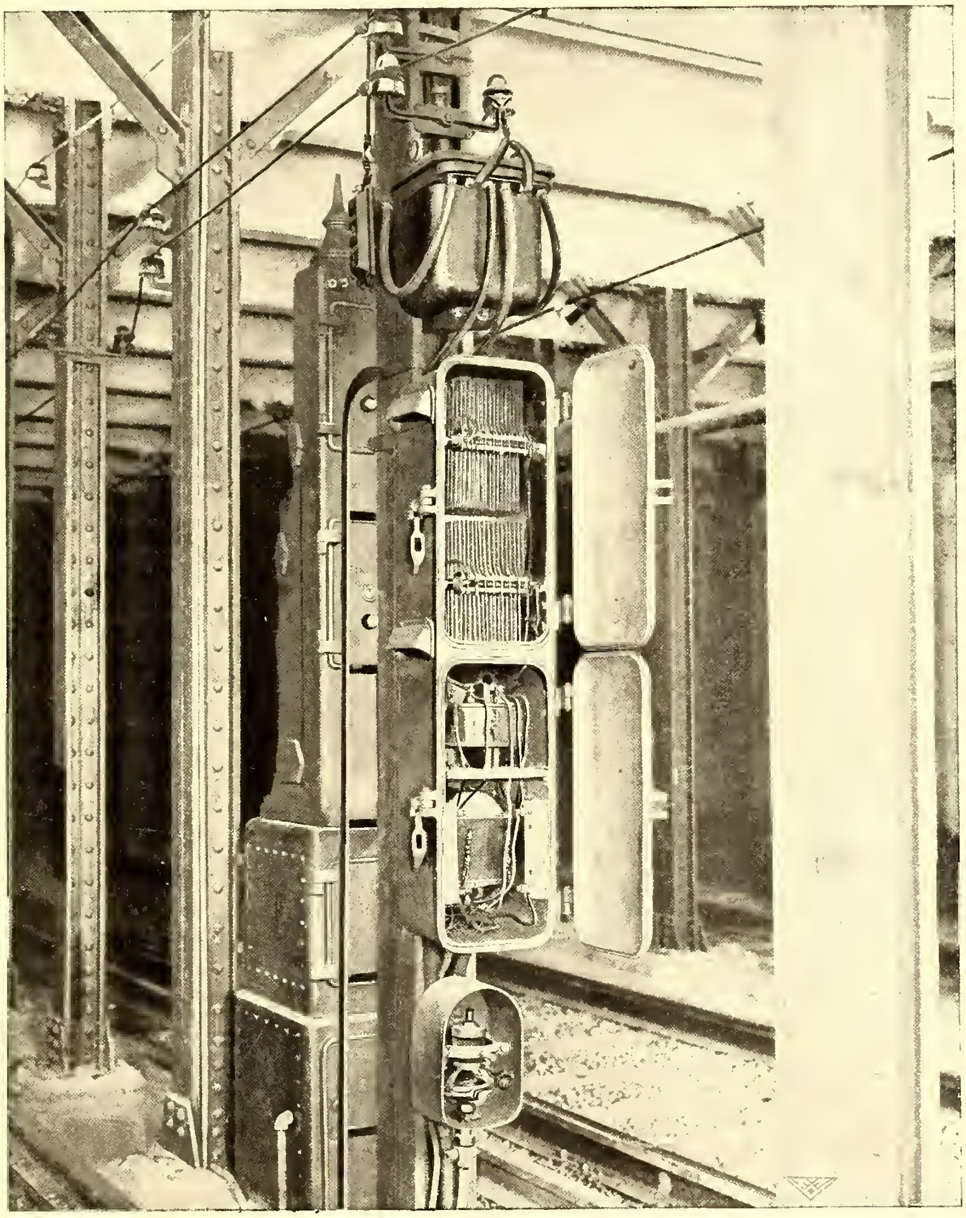
The alternating-current relay and associated apparatus are housed in a neat and compact cast-iron instrument case of water-tight construction, as shown in the accompanying half-



DIAGRAMMATIC VIEW OF ARRANGEMENT OF THE TRACK-CIRCUIT TRANSFORMER, THE INSTRUMENT CASE AND STOP-VALVE BOX, UPON A POST IN ADVANCE OF THE BLOCK SIGNAL tone. This consists of two sections, the lower part containing the relay and connections, and the upper part the grid resistances, which are, as above stated, connected in series with the circuits supplying alternating current to the track circuits, and that of the connections between the tracks and the relay. These cases are secured to steel posts in the subway directly in advance of each signal, as shown on the opposite page. The wiring arrangements in these instrument cases are very carefully provided for; outlets for cables are provided for, and all the wiring is made through cables as thus arranged. A seven-conductor cable leads to the signal nearby, while another seven-conductor cable leads to a junction box of the signal wiring nearby, from which connections are made to the distant signal mechanism in the preceding block and to the automatic stop, as well as to the storage-battery mains for the direct-current supply for the signal mechanism. Four conductors lead out to make the necessary connections with the rails on either side of the insulating section.

THE SIGNALS

The small amount of space available in the subway portion of the system made it necessary to design a special type of signal involving radically new features. Clearances would not permit of a "position" signal indication, and, further, a position signal purely was not suitable for the lighting conditions of the subway. A color signal was therefore adopted, conforming to the adopted rules of the American Railway Association. It consists of a vertical iron case fitted with two white lenses, the upper being the home signal and the lower the distant. Suitable colored glasses are mounted in slides, which are operated by pneumatic cylinders placed in the base of the case. Home and dwarf signals show a red light for the danger or "stop" indication. Distant signals show a yellow light for the "caution" indication. All signals show a green light for the "proceed" or clear position. The design of signal finally adopted is illustrated in the drawing upon page 654.

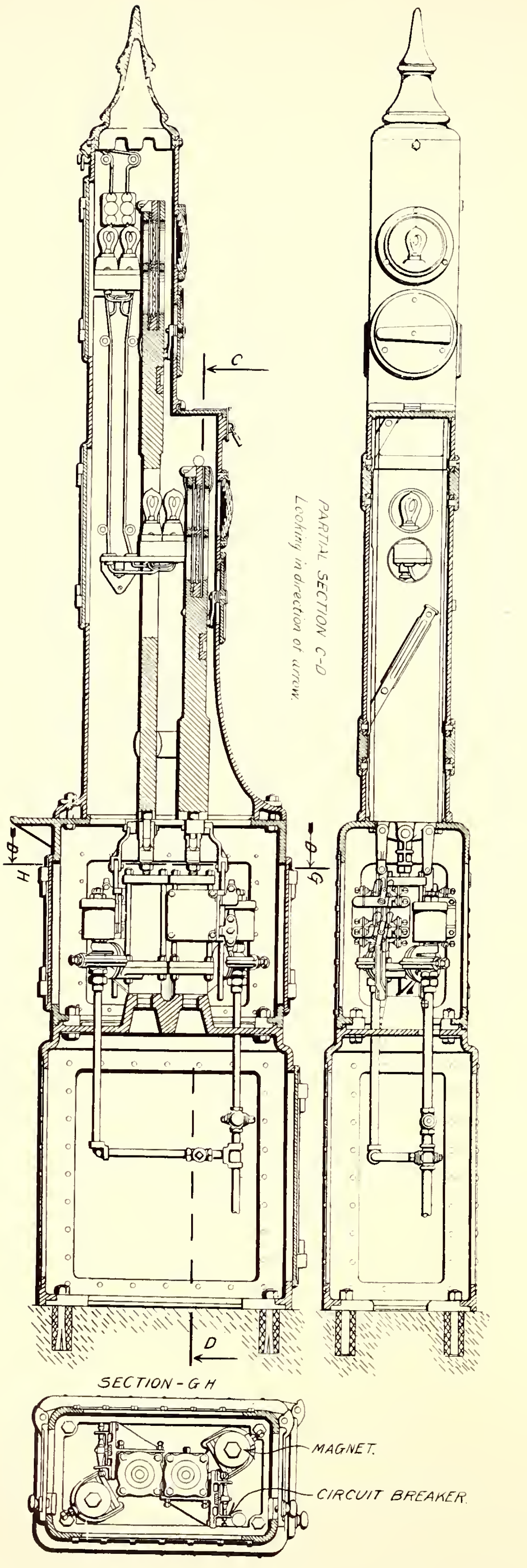


VIEW OF THE INSTRUMENT CASE IN ADVANCE OF THE BLOCK SIGNAL, WITH DOORS OPEN TO SHOW ARRANGEMENT OF RESISTANCE GRIDS, ALTERNATING-CURRENT TRACK-CIRCUIT RELAY AND ASSOCIATED APPARATUS

Although the limitations of space prohibited the use of semaphore arms or similar means of position indication, a position indication has, however, been provided for, as an auxiliary to the color indications, in the form of the small arm immediately beneath the lenses. A small blade appears in a horizontal position when a danger or caution signal is displayed, and at an inclination of 60 degs. when safety is displayed, this being provided in addition to the color indications for use in case of failure of the lamps for the color indications.

The signal consists of two sections; the upper and rear portion contains the lenses and position indicator for the home signal, the colored glasses showing red for the danger or stop position, and green for the proceed or clear position. The front and lower portion of the case contains the distant signal mechanism, which is arranged to show yellow for the caution indication and green for the clear position. Thus it may be seen that color indications are depended upon, the position indication, which is provided by the small blade under each lense, being added merely as a tell-tale. Each lense is constantly lighted by two 4-cp incandescent lamps at the rear, the two lamps being connected in parallel for a safeguard in order that one may be always lighted even if the other burns out; in this way the lighting is made as nearly absolutely reliable as possible. These lamp circuits are, as above stated, operated from the local block transformers, the special double coils delivering 50 volts, alternating current, for this purpose.

The mechanism of the signal is clearly shown in the accompanying drawing of the signal. The pneumatic cylinders, which operate the heavy vertical sliding frames carrying the color lenses for the signal indications, are located in the base portion of the case. As may be seen, the controlling magnets for the air valves of both the home and the distant signal cylinder mechanism are located conveniently for access, as are also the various portions of the cylinders and slides. It should be



DETAILS OF THE STANDARD SUBWAY BLOCK SIGNAL, SHOWING ARRANGEMENT OF MECHANISM AND THE ACTUATING VALVES FOR CHANGING THE COLOR INDICATIONS

here noted that the slides exhibit the green color for the "clear" or proceed indication only when held in its upper position by the pneumatic cylinder; in this way any accident to the apparatus, cutting off the compressed air, will permit the heavy slides to drop and indicate the red color for "danger." The details of the lamp arrangements and wiring are also clearly shown in the drawing; the method of operation of the small blade position indicator is also here made clear. This blade has a crank extending within the case and ending in a pin which plays in an inclined groove in such a way as to turn the blade through an angle of 60 degs. as it passes from upper to lower position.

The signals which are used on the exterior elevated portions of the system are of the position indication type, although operated similarly to those in the subway sections and by a similar construction of mechanism; the position indication of semaphore arms, which is depended upon in the main, is supplemented by the color system for night work. The design of the signal of this type differs little from the subway type; the base portion of these signals is identical with that used for the tunnel signals, and the two pneumatic cylinders and their magnet controlling valves are similar, but in this case the cylinders operate semaphore arms instead of the heavy sliding frames. In these signals the color indications for night purposes are provided by incandescent lamps, also in duplicate, which burn continuously. These lamps are located in a specially designed water-proof case with white lenses pointing toward the colored glasses, as is shown. Their current supply is also taken from the local block transformers of the block system, and are thus independent of the power and general lighting circuits of the subway system.

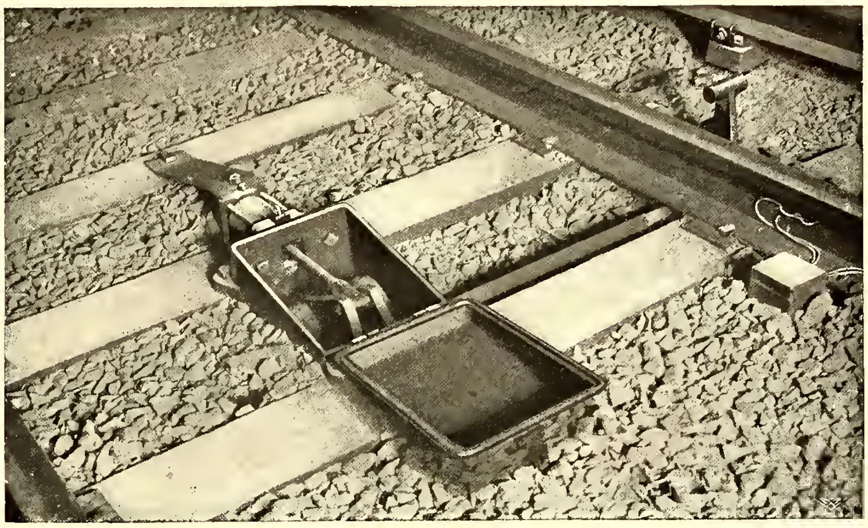
AUTOMATIC TRAIN STOP

A train stop or automatic stop is used at all block signals, and at many interlocking signals. This device automatically applies the air brakes to the train if it should pass a signal in the stop position, being an additional safeguard only to be brought into action when the danger indication has for any reason been disregarded; it insures the maintenance of the minimum distance between trains as provided by the overlaps established.

The construction of the automatic train stop mechanism, which is the Kinsman form of track stop, is shown on the opposite page. It consists of a trip located at the side of the running rail, which is normally raised to such a position that it will come in contact with the special brake valve arrangement upon the trucks of each subway car and throw the air brakes to full emergency in case the train attempts to pass the stop. This trip is operated by a pneumatic cylinder located in a closed box between the ties and the middle of the track opposite. The arrangement of this stop in relation to the block signal is shown in the sketch on page 652. The controlling wires for the stop, as well as also the compressed air connections to its cylinder, are also clearly shown in this view.

The operation of this automatic stop coincides with that of the home signal in the block next preceding it. When that home signal indicates danger, the trip is in its elevated position, so as to make an emergency application of the brakes. This trip is normally held in its elevated position by a heavy counterweight located within the controlling box in the middle of the track, as shown in the sectional view of the device. When the home signal is cleared, compressed air is admitted also to the pneumatic cylinder of this automatic stop, which acts to raise the counterweight and thus lower the trip, holding it depressed until the home signal is again changed to danger indication.

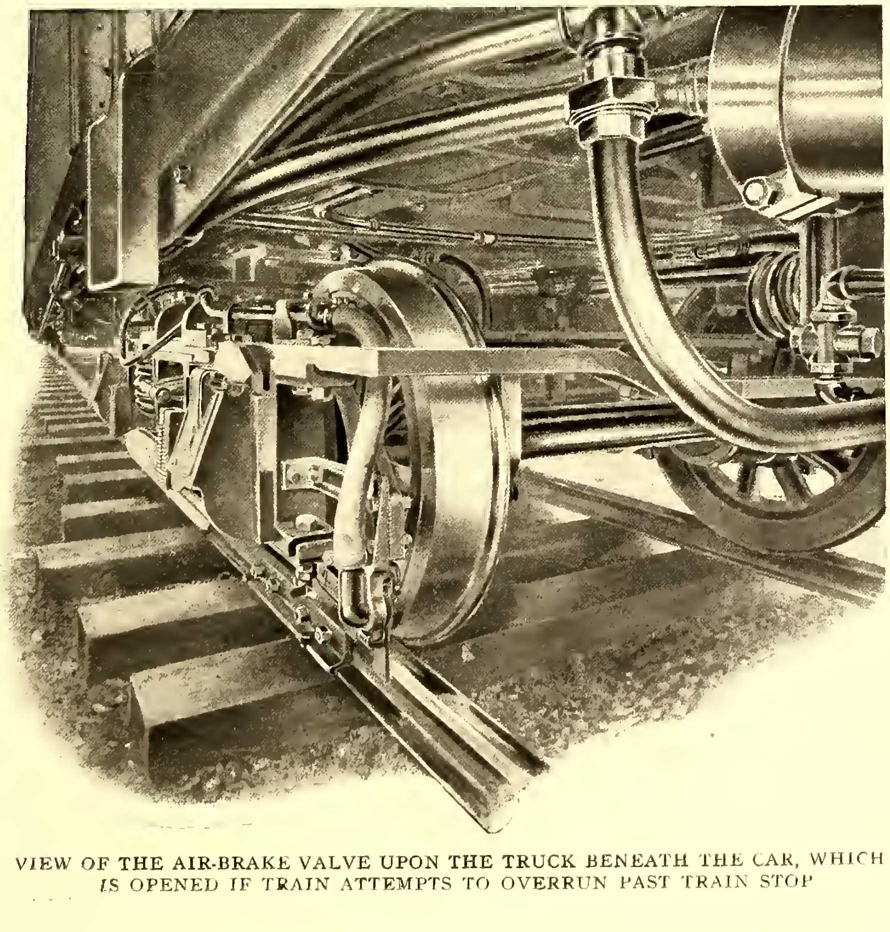
The controlling mechanism for the automatic stop is located in a neat cast-iron box upon the pillar below the track-instrument case illustrated on pages 652 and 653. The mechanism consists of a magnetically operated air valve of the same type as used in the signals, which is so connected as to be operated in conjunction with the home signal, as above mentioned. Thus, when the home signal is set to "clear" the automatic stop valve is also operated to admit compressed air to the pneumatic cylinder, which depresses the trip. An additional feature of interest involved in this controlling box is to be seen in the form of an automatic stop release, by which, in case of failure of any portion of the signal control, the automatic stop can easily be depressed to "clear," so that a train may proceed without danger of an emergency application of the brakes. This is accomplished by a special key, which the guard or conductor may insert in the controlling box and turn to admit air to the pneumatic cylinder; as long as he holds the key turned the trip remains depressed, and as soon as the key is removed the trip will normally rise again. This ingenious mechanism adds an important factor of safety to train operation in the subway.



THE MECHANISM FOR OPERATION OF THE PNEUMATIC TRACK TRAIN STOP, SHOWING TRIGGER ELEVATED TO "STOP" POSITION

SPECIAL SAFETY DEVICES

Two novel safety devices closely allied with the signaling system may be here described. The first is an emergency train stop for the use of those at stations. It is designed to place in the hands of station attendants, or others, the emergency control of signals upon all adjacent approaching tracks. The protection afforded is similar in principle to the emergency brake handle found in all passenger cars, but operates to warn all trains of an extraneous danger condition. It has been shown in electric railroading that an accident to apparatus, perhaps of slight moment, may cause an unreasoning panic, on account of which passengers may wander on adjoining tracks in face of approaching trains; on a four-track railway, with express trains approaching at high rates of speed so as not to receive visual warning in time to stop, this is especially hazardous. Other conditions also may develop, such as a passenger being forced off a station platform, injury to a workman, etc., thus rendering an emergency control of trains very desirable. To provide as perfectly as practicable for such conditions, it has been arranged to loop the control of signals into an emergency box set in a conspicuous position in each station platform. The pushing of a button on this box, similar to that of the fire alarm signal, will set all signals immediately adjacent to stations in the face of trains approaching, so that all traffic may be stopped until the danger condition is removed.

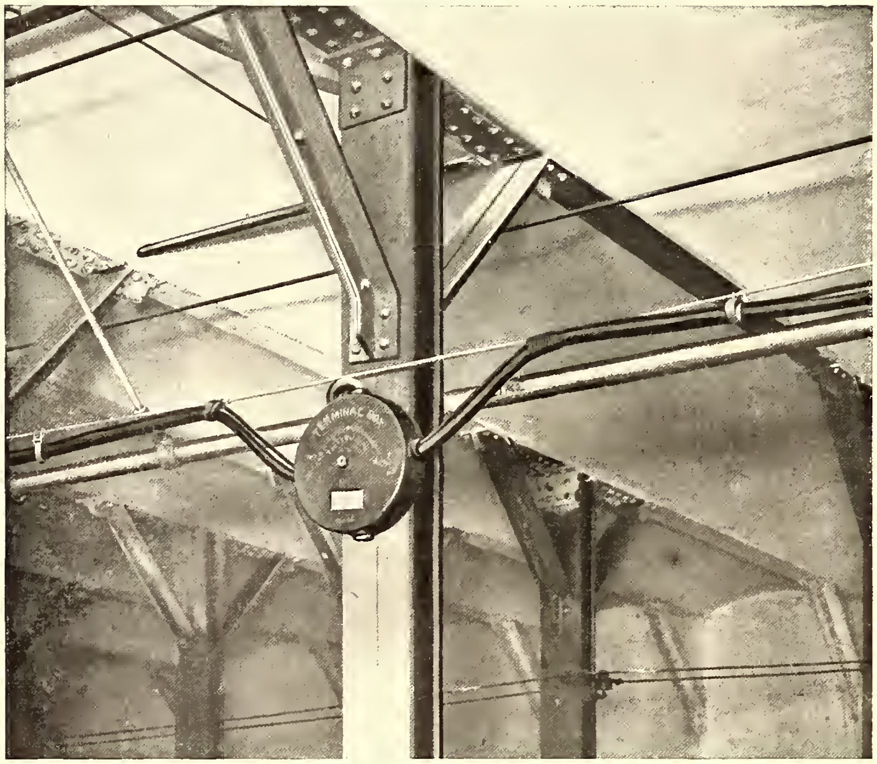


VIEW OF THE AIR-BRAKE VALVE UPON THE TRUCK BENEATH THE CAR, WHICH IS OPENED IF TRAIN ATTEMPTS TO OVERRUN PAST TRAIN STOP

The second safety appliance is the "section break" and cross-over protection. This consists of a special emergency signal placed in advance of each separate section of the third rail; that is, at points where trains move from a section fed by one sub-station to that fed by another. Under such conditions the contact shoes of the train temporarily span the break in the third rail. In case of a serious overload or ground on one section, the train wiring would momentarily act as a feeder for the section, and thus possibly blow the train fuses and cause serious delay until they could be replaced.

In order, therefore, to prevent trains passing from a section charged with the full normal potential into a dangerously overloaded or grounded section, an overload relay has been installed at each section break to set a "stop" signal in the face of an approaching train, which holds the train until the abnormal condition is removed. The apparatus is applied at all section breaks in the third rail and at all cross-overs where the train might pass from a third-rail section in one track to a different one on another track. In any of these cases serious trouble might occur from one third-rail section being grounded while an adjacent one is at its full voltage.

On express-line tracks an effect of this signaling mechanism will be to throw the home signal to danger at the nearest block in advance of the third-rail section break. The method of operation of this signal control mechanism is interesting; it consists of a differential magnetic mechanism with rotating armature, one of the magnetic coils being connected between the third rail and the ground on one side of the section break, and the other magnetic coil similarly between the third rail and the ground on the other side of the break. When both sections of the third rail are fully charged, these magnets operate so as to annul each other, so that the rotating armature is not attracted; if, however, the current supply is removed from either section of the third rail, one of these magnetic coils becomes inoperative, while the other is still magnetized, and the result is that the differential action is removed and the armature is strongly attracted and, by lifting a counterweight, breaks the contact in the control circuit of the nearest home signal in advance of this point. This sets the home signal to danger, and in turn the distant signal at the further block in advance, to prevent trains from approaching the section under these circumstances.



ARRANGEMENT OF AIR-SUPPLY PIPING AND CONDUIT SYSTEM, IN THE SUBWAY, TO CARRY THE SIGNAL CIRCUIT WIRES

Upon the local tracks, where a block signal is not used, a special type of section-break signal will be used for a similar purpose and prevent trains from approaching a section break when voltages are unequal on either side. This type of signal is operated by a differential relay of special construction and gives a color indication. In this case a warning of approaching trains is furnished by a special box plainly marked "S. B.," which indicates by a red light for danger or stop.

At cross-overs and sidings, where it is similarly desired to prevent trains from crossing over from one third-rail section to another in case of unequal voltages upon the third-rail sections, a different procedure is necessary. In these cases a special form of indication is to be used, which will show the tower man, or those in charge of the interlocking switches, whether it is safe for trains to be passed over from one section to another or not. This will be accomplished by means of vertical scale voltmeters arranged side by side and connected to the third-rail sections on either side of the cross-over; by a mere glance at the voltmeters, the switchman can easily see whether the voltages on both sides are sufficiently near together to permit trains to cross over safely.

There has also been installed a special emergency signal system, embodying provision for cutting off power from the contact rail, in case of imminent danger. In the booth of each ticket seller and at every manhole along the west side of the subway and its branches is placed a glass-covered box of the kind generally used in large American cities for fire alarm purposes. In case of accident in the subway which may render it desirable to cut off power from the contact rails, this result can be accomplished by breaking the glass front of the emergency box and pulling the hook provided. Special emergency circuits are so arranged that pulling the hook will instantly open all the circuit breakers at adjacent sub-stations through which the contact rails in the section affected receive their supply of power. It will also instantly report the location of the trouble, annunciator gongs being located in the sub-stations from which power is supplied to the section, in the train despatchers' offices and in the office of the general superintendent, instantly intimating the number of the box which has been pulled. Automatic recording devices in train despatchers' offices and in the office of the general superintendent also note the number of the box pulled.

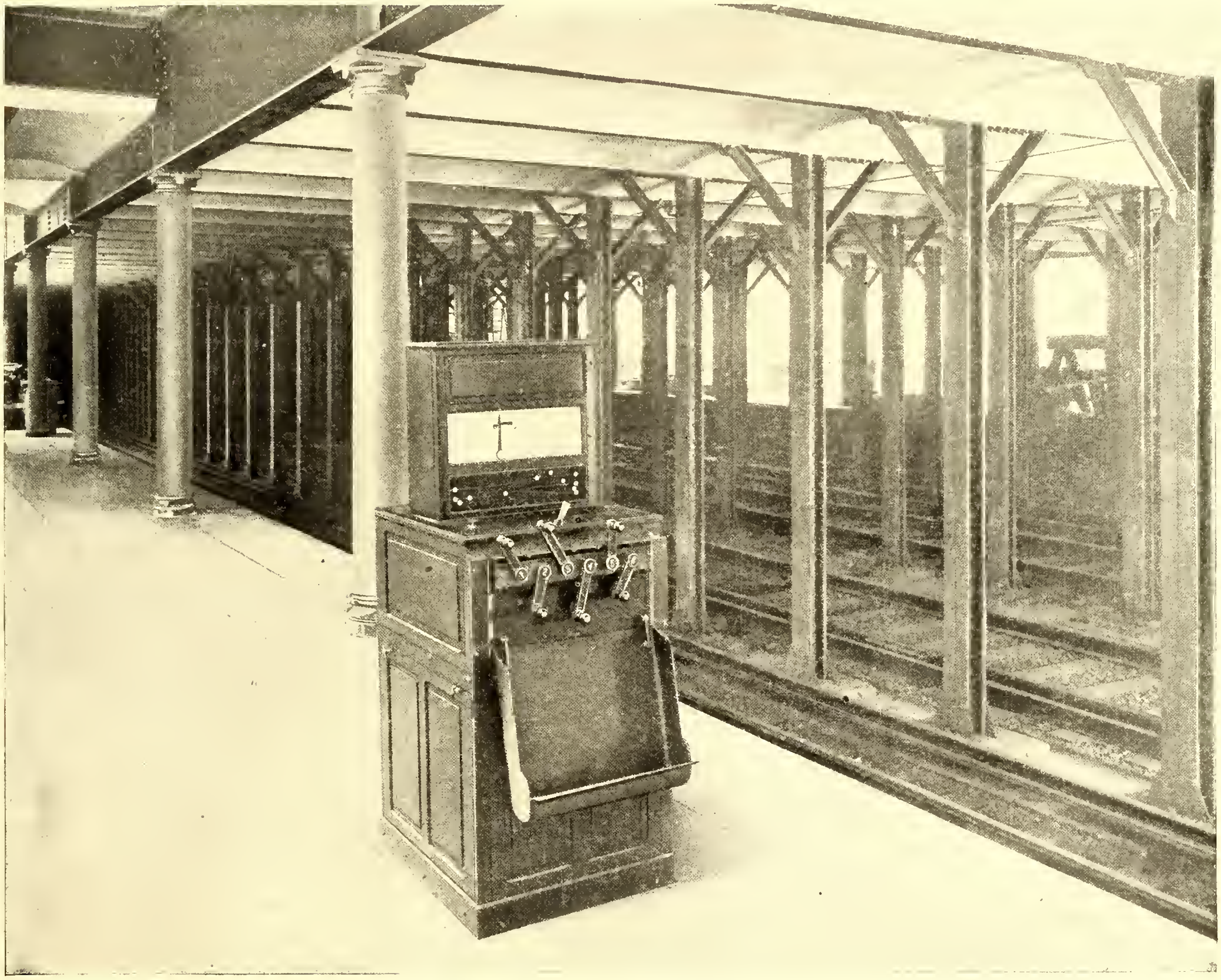
The provision of such elaborate means for protecting trains and insuring safety to workmen in the tunnel is a remarkable testimony of the completeness of the work of installation, and will insure the confidence of the traveling public.

THE ELECTRIC CURRENT AND COMPRESSED AIR SUPPLIES

An important feature of the signal and interlocking work is the provision of supply for the 500-volt alternating-current distribution mains throughout the subway system and for the low-voltage direct-current storage-battery supply mains, extending to all signals throughout the system for operating the valve-controlling magnets, and also for the compressed-air supply system. The alternating-current main is fed by seven motor generators, arranged to operate in multiple, each of which is of 30-kw capacity, generating single-phase, alternating current at 60 cycles and 500 volts. They are located separately in seven of the more important sub-stations of the line, so that it will be practically impossible that all should be disabled at the same time, thus affording an important factor of safety to the system, inasmuch as any four of these machines will deliver the current required for operating the entire system. The various machines operated will feed into the main in multiple from its point of location upon the system.

The direct-current main, supplying current for the signal operating magnets, is supplied by eight groups of storage-battery sets in duplicate, each set designed to deliver 16 volts, located at convenient points in the subway, usually in signal towers. Each battery has a capacity of 450-amp.-hours, and the two sets at each battery station are operated alternately, one being charged while the other is discharging. The batteries are charged by small motor generators, driven by current from the 600-volt direct-current propulsion system, one being located at each storage-battery point. They deliver to the storage batteries at 25 volts potential.

The compressed-air supply for the various signal mechanisms and switches, the automatic car stop, etc., is supplied by a 2-in. main extending the length of the system. This main is fed by six 35-hp electrically-driven compound air-compressors, one of which is located in each of the following sub-stations: Nos. 11, 12, 13, 14, 16 and 17; three of these are reserve units. They are driven by Westinghouse direct-current motors, taking current from the direct-current bus-bars at the sub-stations at from 400 volts to 700 volts. These compressors have each a capacity of 230 cu. ft. of free air per minute, delivered into the supply system at a pressure of from 60 lbs. to 75 lbs. per square inch. These compressors are each automatically controlled, in an interesting manner, by the rise or fall of air pressure in the system. The details of this controlling apparatus are interestingly worked out. A pressure gage operating upon the Bourdon steam gage principle is arranged to make different contacts for certain maximum and minimum pressures, as shown upon the switchboard. When the pressure falls so as to close the upper contact, current is delivered to an automatic switch, which operates a mechanism in such a way as to move the starting resistance switch for the air-compressor driving motor. This mechanism is so arranged that when the starting resistance is cut entirely out and the motor is up to speed, the starting switch is held magnetically in place, and the solenoid is actuated so as to throw the load on to the compressor to cause it to deliver air to the system. This same action starts the flow of cooling water through the cylinder jackets of the compressor cylinder, and automatically admits oil to the cylinders and bearings. When the air pressure in the system rises to the predetermined maximum the opposite contact is made, which causes the load to be removed from the compressor by closing the delivery of the system, and also shuts down the motor, the jacket water supply for the compressor and the oiling system being also incidentally shut off. In this way the compressor is always started unloaded and stopped unloaded, the action being entirely automatic, so that no attention is required; it is designed to respond to variations of air pressure of 5 lbs. or less, and operates very satisfactorily.

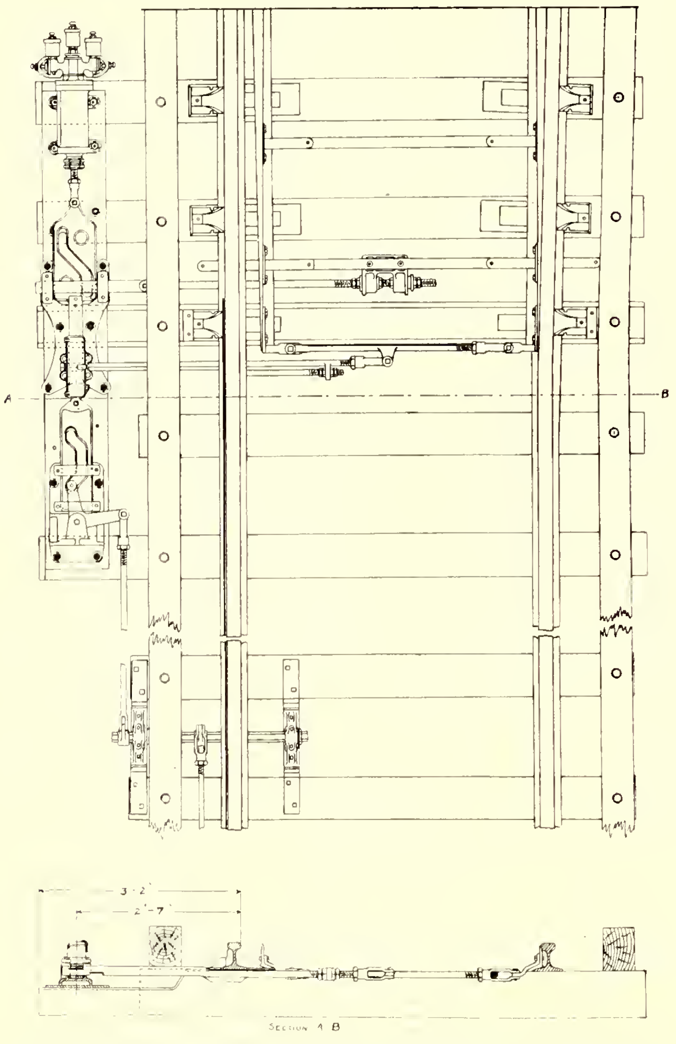


A TYPICAL ELECTROPNEUMATIC INTERLOCKING MACHINE, LOCATED UPON A STATION PLATFORM, FOR THE OPERATION CROSS-OVER SWITCHES

THE INTERLOCKING SYSTEM

The to-and-fro movement of a dense traffic on a four-track railway requires a large amount of switching, especially when each movement is complicated by junctions of two or more lines. Practically every problem of trunk-line train movement, including two, three and four-track operation, had to be provided for in the switching plants of the subway. Further, the problem was complicated by the restricted clearances and vision attendant upon tunnel construction. It was essential that the utmost flexibility of operation should be provided for, and also that every movement be certain, quick and safe.

All of the above, which are referred to in the briefest terms only, demanded that all switching movements should be made through the medium of power-operation interlocking plants.



DETAILS OF THE SPECIAL TYPE OF SWITCH AND INTERLOCKING MOVEMENT USED IN THE SUBWAY FOR ECONOMY OF SPACE, SHOWING ARRANGEMENT OF CYLINDERS, ETC., AT THE SIDE OF AND BELOW TOP OF RAIL

These plants in the subway portions of the line are in all cases the Westinghouse electro-pneumatic, while in the elevated portions of the line mechanical interlocking has been, in some cases, provided.

Special equipments of both interlocking signals and switches were designed with particular reference to the subway installation requirements, and in it is involved a most interesting study of modern interlocking. Provisions have been made for handling the maximum of traffic conditions without congestion at yards and switching terminals.

A list of the separate and distinct interlocking plants which have been installed in the subway will be interesting, and are accordingly given herewith:

MAIN LINE

Location	Interlocking Machines	Working Levers
City Hall	3	32
Spring Street	2	10
Fourteenth Street	2	16
Eighteenth Street	1	4
Forty-Second Street	2	15
Seventy-Second Street	2	15
Ninety-Sixth Street	2	19
WEST SIDE BRANCH		
100th Street	1	6
103d Street	1	6
110th Street	2	12
116th Street	2	12
Manhattan Viaduct	1	12
137th Street	2	17
145th Street	2	19
Dyckman Street	1	12
216th Street	1	14
EAST SIDE BRANCH		
135th Street	2	6
Lenox Junction	1	7
145th Street	1	9
Lenox Avenue Yard	1	35
Third and Westchester Avenue Junction	1	13
St. Ann's Avenue	1	24
Freeman Street	1	12
176th Street	2	66
Total	37	393
Total number of switches		224

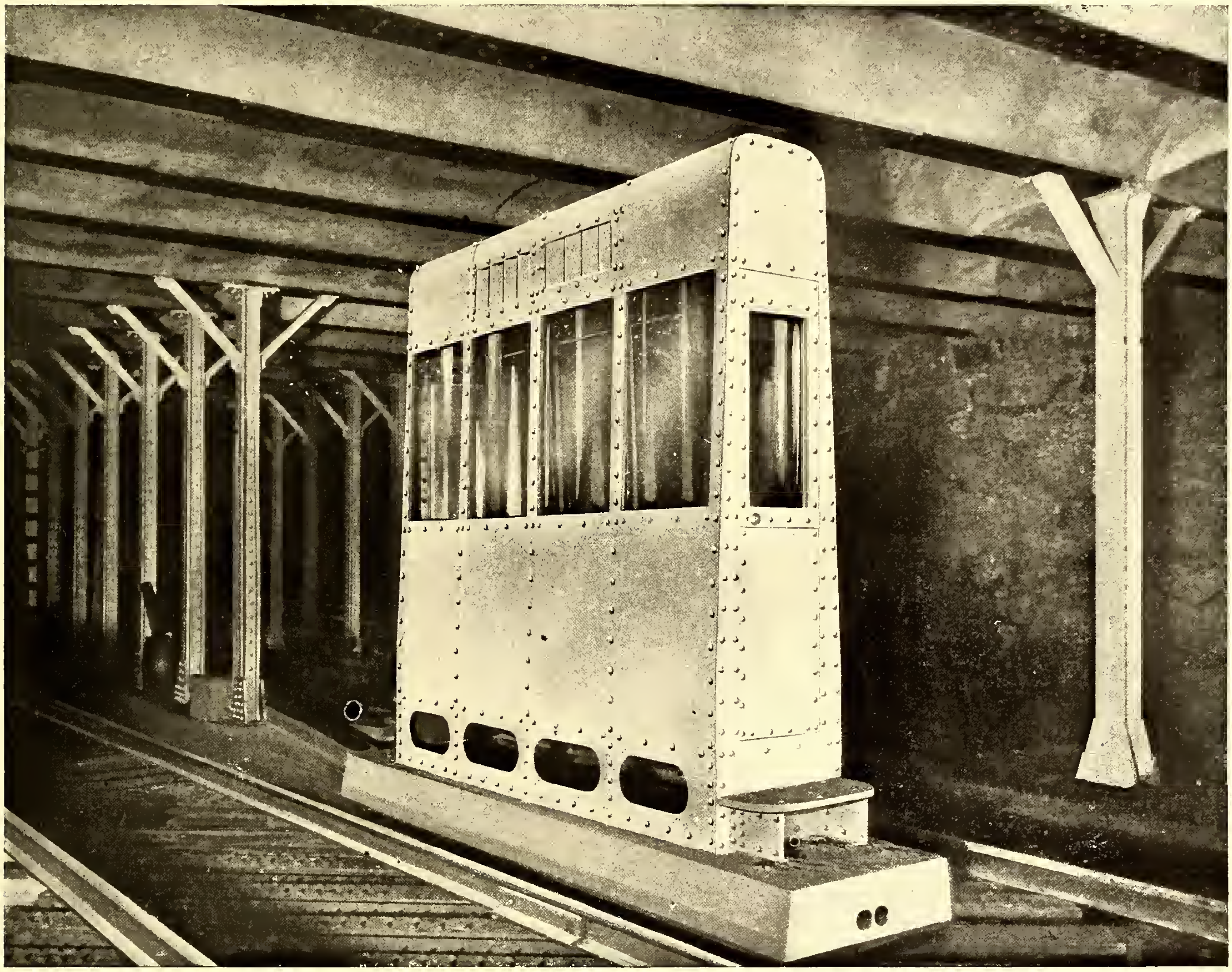
The total number of signals, both block and interlocking, is as follows:

Home signals	366
Dwarf signals	150
Distant signals	193
Total	709

It will be noted that in the case of the City Hall station, three separate plants are required, all of considerable size, and intended for constant use for a multiplicity of train movements. It is, perhaps, unnecessary to state that all the mechanism of these important interlocking plants is of the most substantial character and provided with all the necessary safety appliances and means for rapidly setting up the various combinations. The interlocking machines are housed in steel concrete "towers," so that the operators may be properly protected and isolated in the performance of their duties.

An unusual type of switch movements and interlocking mechanism is required in the subway installation on account of the confined space and cramped conditions. The apparatus installed is the well-known electro-pneumatic interlocking system of the Union Switch & Signal Company, but the form of apparatus used is of an entirely new and radical design. The pneumatic switch operating movements are arranged with the pneumatic cylinders and the movements at the side of and below the top of the rails. A general idea of the arrangement of this new type of switch movement may be gained from the drawing on this page.

Innovations are to be found in this mechanism in the application of the cam plate for the shifting of the switch and of the arrangement of the switch indication box. The magnetically controlled valves for operating the pneumatic cylinders, as well as also the switch tower apparatus used in connection with these apparatus, involves nothing new in design. The cylinder has a stroke of 8 ins. in operating the cam plate which moves the switch points. Suitable magnetical connections are provided for adjusting the connections to the switch points, and also to the locking mechanism in the signal indication box. The detector bars are similarly operated by a rocking shaft connection which is traversed by a separate cam plate, as is clearly shown in the drawing.



THE SPECIAL TYPE OF INTERLOCKING SIGNAL CABIN, LOCATED AT AN IMPORTANT SWITCHING POINT SOUTH OF THE BROOKLYN BRIDGE STATION

In the Lenox Avenue yard, space at the side of the track is so narrow and the arrangement of switch leads to the car house are so complicated as to prevent the location of the switch operating cylinders at the sides of the track, so that a new design of centrally-located cylinder was prepared for this particular location. In this case the cylinder has a through piston rod, with stuffing boxes in each head, and operates the switch by acting against the two bent plates, as shown. Adjusting knobs are located at each end of the piston rod, so that the stroke of the switch cylinder may be easily adjusted to the movement of the switch.

The magnetically controlled air valves are in this case located in the narrow space between the third rail and the retaining wall at one side, as shown. In all features of the switch construction, however, careful provision has been made for ease of inspection and repairs, so that the expense of maintenance will be reduced to a minimum while reliability of operation will be insured.

This entire system of signals and interlocking was designed and installed under the direction of George Gibbs, consulting engineer of the Interborough Company, who was assisted by J. M. Waldron, signal engineer of the company. The contract for the installation of the system was undertaken by the Union Switch & Signal Company, Swissvale, Pa., who have incorporated many innovations and radical departures in design of apparatus as especially adapted to the conditions of operation in the subway.

RECENT TRACTION APPARATUS

FINE STREET CAR HEATERS FOR THE PUBLIC SERVICE CORPORATION OF NEW JERSEY

The Public Service Corporation of New Jersey, which controls one of the largest electric railway systems in the world, recently made a careful investigation into the question of car heating, and after comparing the relative costs and efficiencies of various types of heaters, it decided to adopt the "Jewel" street car heater manufactured by the Detroit Stove Works, of Detroit, Mich.

This heater is made of cast iron, containing no sheet iron to burn out when the stove is in use or to rust when it is not in use. The fire pot has no brick linings to be replaced at intervals. It is cast separate from the rest of the stove, so that it may be easily removed if it should burn out—a circumstance not likely to occur for many years. In the construction of this heater provision is made for unequal expansion, and thus the durability of the stove is indefinitely prolonged.

Practical experience as stove makers has also demonstrated to the manufacturers that a small stove with a self-feeding attachment cannot be made a success, and that a street car stove so built is certain to prove a disappointment. A stove provided with a deep fire-pot, such as is employed in the construction of this heater, insures a good bed of smouldering coals, and requires less attention, consumes less fuel and gives off more heat than one that is built with a self-feeding attachment.

CAST-IRON STREET CAR HEATER USED BY THE PUBLIC SERVICE CORPORATION OF NEW JERSEY

The draw-center shaking grate, when shaken, relieves the fire-pot of ashes; and when the center is drawn out, the fire-pot may be cleared in an instant. With this contrivance there is no possibility that the fire will be accidentally dumped, and the construction is both simple and durable. There is but one opening for both the shaking grate and the draft, and the draft slides fit tightly, giving positive control of the fire. The ash pit is capacious and contains a large, bailed ash pan. The feed door is large enough to admit the ordinary coal shovel and has a draft register for checking the fire, while the mica frame is made to thoroughly protect the mica, thus saving another item of expense.

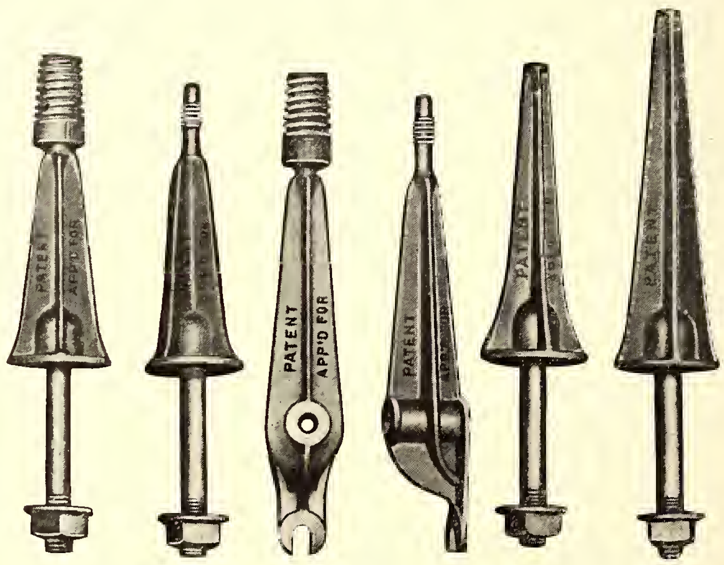
The doors are provided with a double catch, so that the most severe jarring will not open them. The nickeled plates for the box have a double coat of nickel, and both these plates and the stove itself are carved in very artistic designs. All the heaters are made with interchangeable parts. The outfit, as a whole, is very handsome and harmonizes well with the interior furnishings of the finest modern cars.

The case is made of cast iron, handsomely ornamented and finished in aluminum, and so protected and ventilated that too much heat will not annoy those sitting next to the stove. The upper casting on the box is made on a curve, to insure it against cracking.

HIGH TENSION INSULATOR PINS

The use of iron and steel insulator pins for high-tension work is becoming very common practice on some of the larger transmission installations. The use of wooden or porcelain pins on account of their insulating properties is not considered good practice by many, because, if the line insulator which is supported by the pin cannot be depended upon for proper insulation, it is poor practice to depend upon the pin. A line of malleable iron pins for this class of work is manufactured by the Creaghead Engineering Company, of Cincinnati, Ohio. These pins have been made for the most exacting conditions.

Pin No. 1310 illustrates a malleable pin with ¾-in. steel stud for cross-arm, designed for use with porcelain insulators. This pin is attached to the porcelain insulator by cement or lead alloy. The pin is 8½ ins. above the cross-arm. Pin No. 1311 is a similar pin, made 10½ ins. high above the cross-arm.



No. 1307 Malleable Iron Pin — No. 1312 Pole Top Bracket Pin — Nos. 1310 and 1311 Malleable Pin for Cement

THREE TYPES OF HIGH-TENSION INSULATOR PINS

Pin No. 1307 is shown with wooden thimble 1½-in. thread, and also with the thimble removed. The wooden thimble protects the glass or porcelain insulator from breakage due to expansion and contraction, and is firmly secured to the top of the malleable pin by special raised thread. The strength of this pin is very great, and when bolted into the cross-arm and the side strain applied to the insulator, the pin will stand a side strain of about 1000 lbs. at right angles to the pin before breaking.

The pole top bracket pin, No. 1312, illustrated, is a new device to meet the demands for a top pin for the top wire of a three-phase equilateral circuit. The use of a pin set into a hole in the top of pole is not good practice, and ridge irons that are very frequently used are the source of trouble on account of the numerous parts and on account of the shaking loose of the bolts from the center of the pin. The pole top bracket pin, No. 1312, is bolted through the gable of the "housing" at the top of the pole, and the bottom part of the pole top bracket pin is attached to the side of the pole by a lag screw set in the bottom U slots. The bolt securely fastens this bracket pin to the pole and the part of the bracket pin above the bolt also extends above the pole. This bracket pin is attached to the face of the pole on which the cross-arm is attached, or on the face immediately opposite.

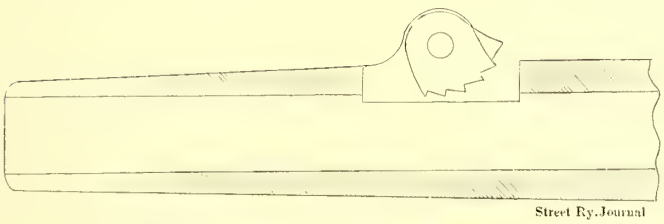
The principal advantages of a malleable pin with a steel stud fastened to the cross-arm, lie in the great strength of the material and its distribution to stand the strains, and in the fact that the strength of the cross-arm is very greatly preserved by boring a small hole through the arm for the steel stud instead of using a hole 1½ ins. to 2 ins., as is the case with wooden pins. A hole 2 ins. in diameter in a cross-arm 4 ins. x 5 ins. very materially reduces its strength.

These pins are preferably painted with black asphaltum paint. While there is some demand for galvanized pins, the manufacturer discourages this, as the best galvanizing process is such that the quality of the malleable iron is affected and the strength of the pin reduced in such a way as to give a very uncertain result. Many of these types of pins have been recently furnished for high-tension transmission work to the Pennsylvania Steel Company, of Philadelphia; Cauvery power transmission plant of India; the Pueblo Lighting & Traction Company, of Victor, Col.; the Aurora, Elgin & Chicago Railway, Wheaton, Ill.; the Hudson River Power Company, Glens Falls, N. Y.; the General Electric Company, Schenectady, N. Y., and others.

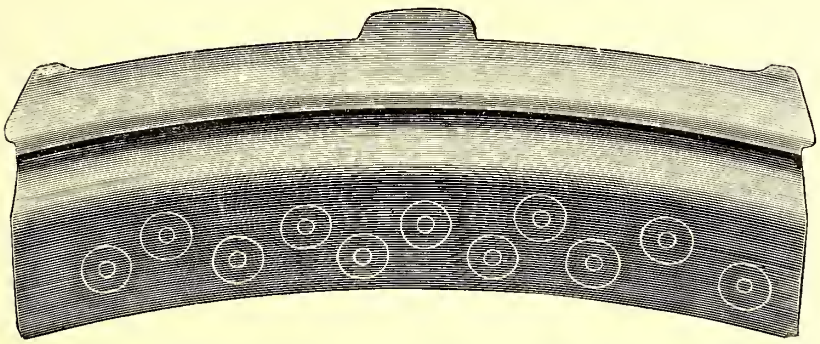
SOME PRODUCTS OF THE CENTRAL UNION BRASS COMPANY

A new trolley splice for which several advantages are claimed, has just been put on the market by the Central Union Brass Company, of St. Louis.

The general principle of this device is shown by the accompanying sketch. It consists of a heavy drawn brass tubing with a ratchet dog suspended on a pin near each end. The two ends of the wire to be spliced are pushed into the tube and are engaged by the dogs. Increased tension on the trolley wire causes the dogs to be pulled down tighter, and the wire is gripped with increased firmness. When it is desired to remove the splice all that is necessary is to release the tension on the trolley wire. This disengages the dogs and the ends of the wire can be readily removed. The facility with which a broken trolley may be temporarily repaired by means of one of these new splices will no doubt bring them into general favor.



A SIMPLE SPLICE FOR TROLLEY WIRE


BRAKE-SHOE WITH INSERTS CONSISTING OF ROUND STEEL PUNCHINGS

An insert brake-shoe of novel design is also being introduced into the electric railway field by this company. The inserts consist of round steel punchings ¾ in. in diameter, and of the same depth. The inserts, as is shown by the cut, are scattered uniformly over the wearing surface of the shoe, so that the surface is composed of about equal proportions of soft steel and gray cast iron. One advantage of distributing the inserts in this manner, it is claimed, is that the short distance between adjacent inserts does not allow them to project beyond the surface of the shoe and have a cutting or scraping action on the tread of the wheel. The increased mileage claimed for this shoe, the firm states, is substantiated by the many favorable reports from railway men who have adopted it.

WOOL FELT FRICTION-PLATE FOR EMERGENCY CAR BRAKE

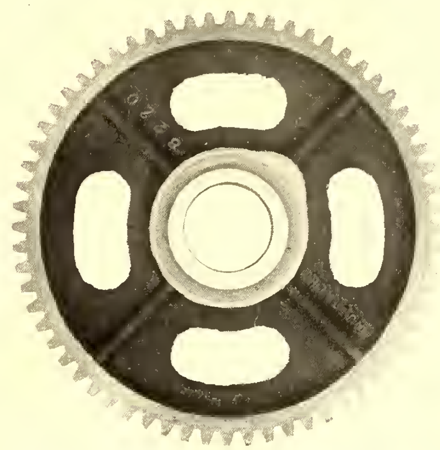
The accompanying illustration shows the wool felt friction plate employed under the Fresh emergency car brake, made by the Emergency Car Brake Company, of Cumberland, Md. The use of wool felt for brake friction was decided upon after the company had made many trials and had found it superior to emery, carborundum, wood, rubber, corrugated iron or steel and other material. It was found that neither expansion or contraction injured the frictional qualities of the felt. In fact, when the felt comes in contact with water or ice, it absorbs the moisture, thereby expanding and offering greater resistance between the wheels and the rail.


WOOL FELT FRICTION-PLATE FOR EMERGENCY CAR BRAKE

The elasticity of the wool felt obviates the jarring caused by using harder materials, and its adhesive quality enables it to retain its grip on the rail until the car is stopped. This material has proved fully equal to the hardest braking requirements, is very durable and can be quickly replaced at small cost.

SOLID MOTOR GEAR FOR ELECTRIC RAILWAYS

The R. D. Nuttall Company, of Pittsburg, Pa., manufacturer of gears and pinions, has recently added to its many improvements in this line the solid motor gear, of which a general design is presented in the accompanying illustration. The company's experience has convinced it that solid gears are more reliable than split gears, particularly on high-speed electric railways using heavy equipments where an accident to the gearing would lead to serious consequences.


GENERAL DESIGN OF SOLID MOTOR GEAR

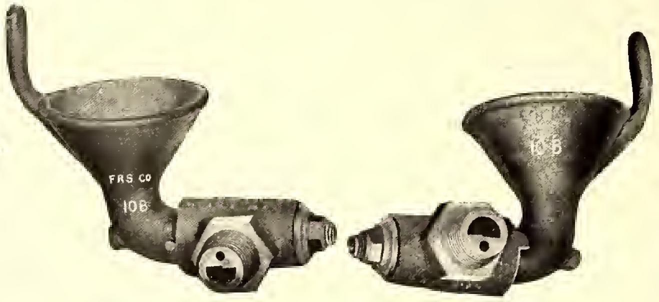
One of the admitted advantages of solid gears is the avoidance of accidents such as are caused by the breaking of the bolts used with split gears. When a bolt becomes loose or broken, it invariably causes a bent armature shaft and injures the gear case and other parts that are directly connected. As the solid gear is pressed on the axle under a pressure of from 10 tons to 25 tons, there is no danger of the gear case becoming loose on the shaft, as is the case when split gears are used.

The design of the solid gear allows a perfect distribution of the metal, insuring an exceptionally strong gear without the disadvantage of excessive weight. While the gear is recommended especially for heavy work, it has met with success on systems where light equipments are in vogue. The design illustrated represents a general type which can be adapted to meet special conditions.

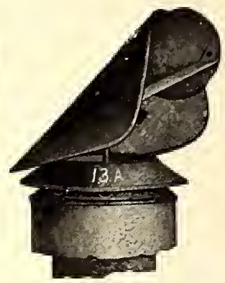
AN IMPROVED HOT WATER CAR HEATER

The Franklin Railway Supply Company, of Franklin, Pa., is manufacturing a new type of hot-water car heater, which appears to be meeting with considerable favor. Last winter it was given a trial upon one of the Chicago & Milwaukee Railway Company's cars, at Highwood, Ill., and after a number of competitive tests, was adopted as the standard for all of the company's new Jewett cars. Since then it has been placed on new cars of the Milwaukee Electric Railway & Light Company; the Metropolitan West Side Elevated Railway, of Chicago; the South Chicago City Railway; the Central Illinois Construction Company; the Green Bay Traction Company, and contracts have been made for its installation on all the closed cars of the Syracuse Rapid Transit Company and sixty large cars of the Rochester Railway Company.

HOT-WATER CAR HEATER COMPLETE



(Open) (Closed)
FILLER COCKS, OPEN AND CLOSED



REVOLVING SMOKE JACKET

(Open)

(Closed)

SAFETY VALVE

This heater, which is known as the "Western," possesses the advantage of taking up very little space in the car, as its outside diameter is only 16 ins., and if placed on the platform it does not in any way interfere with the motorman in the performance of his duties. The entire fire space of the heater is surrounded by a water jacket, the outer shell of which consists of ¼-in. flange steel extending from the cast iron base plate to the ornamental hood. Within this, from the grate to the top ring, is another flange steel shell riveted to the outer shell. The two nickel rings hide the rivets from view. Between these two shells is the 1¼-in. water jacket, the outer shell of which is tapped at the top and bottom and connected with the radiating pipes. These pipes are so arranged that the water circulates freely around the entire stove. This construction prevents the overheating of the air or woodwork in the immediate vicinity of the heater, and the heat ordinarily radiated to the air is imparted to the water, thus increasing the efficiency of the equipment. As the outer shell is of heavy steel, it cannot be marred or dented, and since the water jacket prevents it from becoming hot enough to burn off the enamel, the heater presents a neat appearance at all times. The heater is furnished with a heavy cast iron base-plate which has a large lip in front of the bottom door to prevent the scattering of ashes.

The top of the heater consists of two cast iron hoods resting on a cast iron top-plate. The outer ornamental hood is of open nickel scroll work. The inner hood is a single heavy casting, the only opening being the stove door and the flue for the stovepipe. This construction, in connection with the gas chamber, which rests upon the top ring, extending over the magazine hole made in front of the coal door, prevents the escape of smoke and gas into the car. The coal magazine hangs from the center of the top ring and has around it a coil of ¼-in. pipe, whose length depends upon the heating surface desired in the equipment. A cast iron door swings over the top of the magazine to prevent a draft from passing through the coal within. This magazine construction, besides acting as a feed to the fire prevents the coal from obstructing the heating surface and acts as a flue to guide the gas freely around the entire surface of the coal.

The filler cock used in this system is composed of but two pieces of brass, requires no wrench and has an automatic outlet for the air when water is poured into the expansion drum. The safety valve is so constructed that cinders and dust cannot block or aid in the corrosion of the valve seat. The revolving smoke jacket acts as a ventilator for preventing smoke and gas from being blown down the stove pipe and into the car.

The car heating department of the Franklin Railway Supply Company is represented in the Central West by Porter & Berg, of Chicago, and for Missouri and west of the Missouri River, by W. H. Schofield, of Kansas City, Mo.

ADVERTISING FOR PASSENGER TRAFFIC

Electric railway officials who have to do with the passenger-attracting end of the business will be interested in recent developments in attractive promotive printed matter for trolley lines and resorts. Recently a number of noteworthy pieces of advertising matter have been designed for sounding the praises of pleasure grounds reached by electric cars.

The first of these is a neat folder, size 3½ ins. x 6¾ ins., issued by the International Railway Company in the interest of its Lake Ontario resort, Olcott Beach. A beautiful two-tint representation of the hotel, seen through the stately pines, with the bluff and beach fronting it, adorns both front and back covers.

The Great Blue Hill and Reservation are graphically represented on the front cover of a 4-in. x 7-in. booklet printed in darkest blue and brown. This picture readily convinces the recipient of a copy of the booklet that there is something impressive and awe-inspiring to be seen "on and up, where Nature's heart beats strong amid the hills." The views and type both are printed in dark brown. A running head band in blue adds greatly to the typographical charm of the pages.

Number three of this trio of business winners is a four-page leaflet in a three-ply cover; Norumbega Park, at Auburndale, Mass., is the resort advertised, and the plan is well carried out—a boy and a boat in the foreground—or "water"—of a park view, are on the long flap of the cover, while an old buck elk proudly

THE BROCKTON & PLYMOUTH STREET RAILWAY COMPANY'S MAYFLOWER GROVE PAMPHLET

poses on the shorter flap. The inside contains several views, and a number of well-chosen, succinct statements regarding the attractions here to be found.

Something entirely new in resort advertising is a one-sheet poster printed from half-tone plates, on heavy paper. A glance at

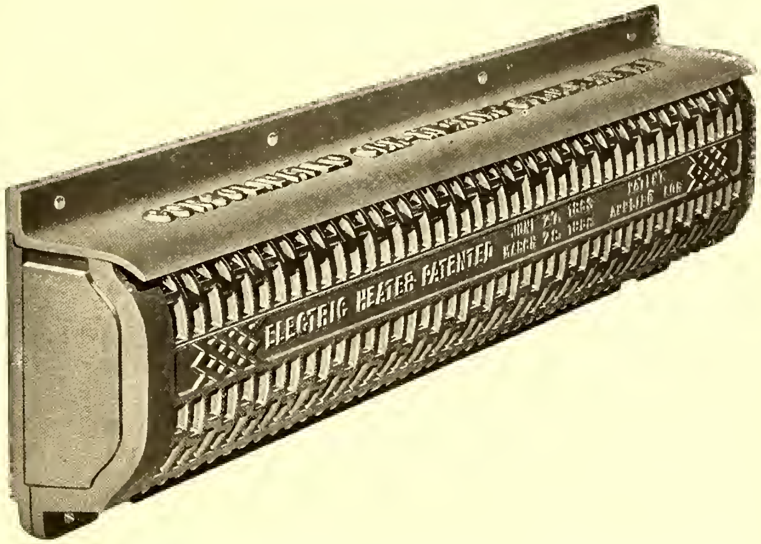
SOME ATTRACTIVE STREET RAILWAY BOOKLETS

the photo-reduction of this sheet, printed on this page, will show that it is doubly striking and noteworthy for being artistically arranged and beautifully printed. The Brockton & Plymouth Street Railway issued this poster.

All of these things were done, from inception to delivery, by the Matthews-Northrup Works of Buffalo, N. Y., under the direct charge and supervision of their "Routes and Resorts" department. This concern is well equipped for the manufacture of advertising literature for railways and resorts, having been engaged in map engraving and railroad printing for the past half century.

ELECTRIC CAR HEATER AND REGULATING SWITCH

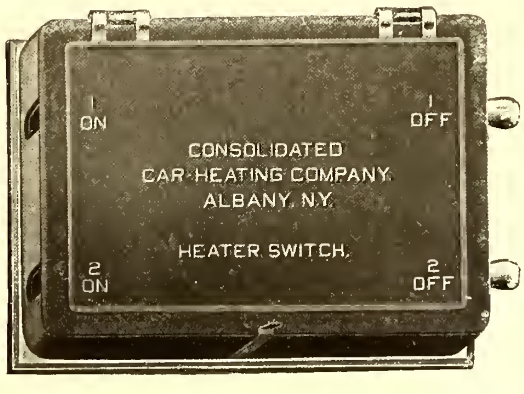
The accompanying cut illustrates one of the Consolidated Car-Heating Company's new electric heaters for cross-seat and parlor cars. The heater is intended for use along the truss plank and projects but 2⅝ ins. It is 5¾ ins. in width, and made in 24-in. lengths. The heating element consists of the Consolidated standard spiral coil, but in this heater it is wound on an elliptical spindle. The heater has a cast-iron back to which the spindle is attached. The heater top and front are also of cast iron. The



ELECTRIC HEATER FOR USE ALONG THE TRUSS PLANK OF CROSS-SEAT AND PARLOR CARS

lead wires are carried from the bottom of the heater to a grooved moulding, and there are, therefore, no exposed wires. The heater front can be easily removed and connecting wires attached to the binding posts inside the heater case if desired. With this type of heater it is impossible to overheat the seats, the heater being placed along the truss plank near the floor, and the maximum consumption of a 24-in. heater being only 400 watts. For interurban cars a continuous row of heaters on either side of the car is recommended.

The switch shown herewith is the Consolidated Car-Heating Company's new regulating switch for heater circuits. There are two quick-break knife switches, and two fuses mounted on a slate base. The frame and cover are of malleable iron, finished in



HEATER REGULATING SWITCH

copper bronze. The cover is hinged to the frame at the top and locked by a spring at the bottom. This cover is raised when it is desired to change the position of the switch.

The Hartford & Springfield Street Railway Company is now charging 5 cents fare for the trip between East Windsor Hill and the Massachusetts line, making the total fare from Springfield to Hartford 35 cents instead of 30 cents.

SOME SPECIAL DESIGNS OF THE No. 27-E BRILL TRUCK

Among the recently built trucks of the J. G. Brill Company's No. 27-E high-speed type are a number which include some unusual features. Not infrequently the ingenuity of builders is taxed to the utmost to adapt trucks to requirements of unusual conditions. The simple form of the solid-forged frames of the trucks built by this company, it is claimed, frequently assists considerably in conforming in a highly satisfactory manner to special requirements. The four trucks in the accompanying illustrations have some very interesting features, and the dimensions given, particularly those of the solid-forged side frames, speak eloquently of the marvelous strides made in electric truck building.

Before describing these trucks individually, it may be briefly stated that the system of equalization of the No. 27-E type combines a swing bolster and a cushioned connection with the frame by means of spring-link suspended equalizing bars. These spring links are supported by the frame near the yokes, relieving the strain upon the frame and giving a wide suspension to the centrally borne load, theoretically and practically the correct method of equalization. Not only is the load distributed equally upon each wheel, but a leverage is obtained in favor of the frame against the wheels and brakes, preventing tilting or kicking up, no matter how violent the brakes are set. Another advantage of the cushioned side swing is the softness of contact of the wheel flanges with the rail heads. The equalizers and journal springs are heavy double coils and the equalizing bars are 2½ ins. thick.

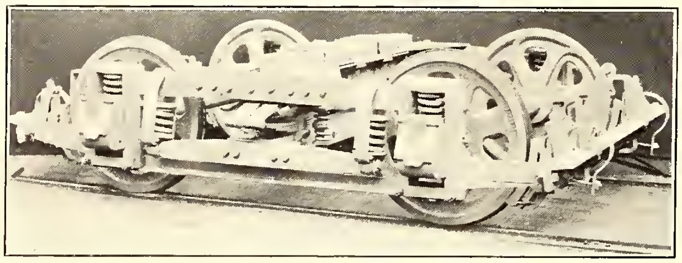


FIG. 1.—TRUCK BUILT FOR THE TWIN CITY RAPID TRANSIT COMPANY

Fig. 1 shows a truck built for the Twin City Rapid Transit Company, of Minneapolis, Minn. The brake hangers are of a special design of the railway company, having a ball and socket arrangement at both ends of the single bolts to which the brake-shoe holders are attached. The upright lever is attached directly to the brake beam, which is unusual in electric practice. The motor support springs are upon spring posts, the heads of which bear upon gusset plates secured to the transoms and side frames. Double- and single-corner brackets are also used to connect transoms with side frames. The total length of a side frame of this truck is 10 ft. 7 ins.; width at the center of bar between yokes, 5½ ins.; thickness of bar, 1¾ ins.; thickness of the yoke extensions, 1½ ins.; thickness of the pedestals, 4 ins.; length of the axles, 6 ft. 8⅞ ins.; diameter of the axles, 5 ins. and at the gear seat, 5½ ins.; journals, 4¼ ins. x 8 ins. The wheels are 33 ins. diameter and steel-tired; the wheel base is 6 ft. 6 ins.

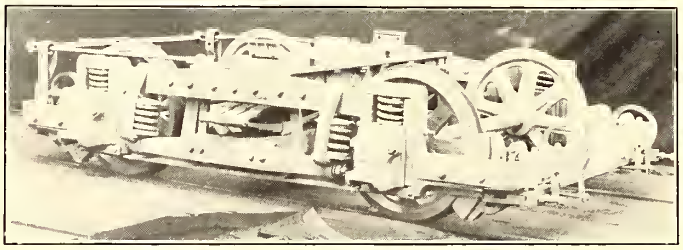


FIG. 3.—THE WILKESBARRE & HAZELTON RAILWAY COMPANY'S TRUCK

Fig. 2 shows a truck of the Schenectady Railway. This truck has double horizontal brake levers with upright levers held in a vertical position when retracted. Special swivel locks are placed on the bottom brake rods. The extensions of the frames are bent around the wheels to increase the clearance of the truck. The double- and single-corner brackets which connect the transoms and side frames are plainly seen in the illustration of this truck. These brackets are 1 in. thick, forged from single billets, and are used on all trucks of the 27-E type. The length of the side frames is 9 ft. 10 ins.; width at center of the bar between yokes, 5¾ ins.; thickness of the bar, 1¾ ins.; thickness of the extensions, 1½ ins.; thickness of the pedestals, 4 ins.; length of axles, 7 ft. 4½ ins.; diameter, 6 ins. and at gear seat, 6½ ins.; journals, 5 ins. x 9 ins. The wheels are 34 ins. in diameter and are steel-tired. They have a 2-in. tread and a 15-16-in. flange. The wheel base of the truck is 6 ft.

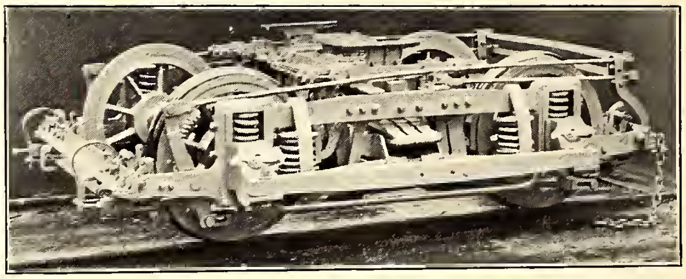


FIG. 2.—SCHENECTADY RAILWAY COMPANY'S TRUCK, WITH DOUBLE HORIZONTAL BRAKE LEVER

Fig. 3 illustrates the truck as used on the Wilkesbarre & Hazelton Railway, Pennsylvania. The special features of this truck are four braking appliances. The outside brakes are operated by two methods, automatic air and hand, and the inside brakes also have two systems of control, magnetic and hand. It is said that this is the most complete brake system ever furnished to any form of rolling stock. The spring plank is composed of angle irons with the ends brought over the equalizing bars. The length of the side frames is 11 ft. 3 ins.; width at center of the bar between the yokes, 5½ ins.; thickness of the bar, 1¾ ins.; thickness of the extensions, 1½ ins.; thickness of the pedestals, 4 ins.; length of the axles, 7 ft. ¼-in.; diameter of the axles, 7 ins. and at the gear seats, 7½ ins.; journals, 4¼ ins. x 8 ins. The wheels are 36 ins. in diameter, are steel-tired and have the M. C. B. type tread and flange. The wheel base is 6 ft. 6 ins.

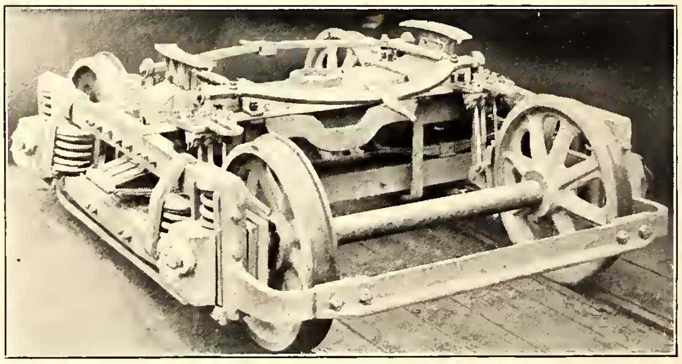


FIG. 4.—SOLID FORGED TRUCK FOR THE MILAN-GALLARATE RAILWAY

Fig. 4 shows the truck as built for the Gallarate-Milan Railway, Italy. This is said to be the largest electric truck ever built, and is considerably larger than the standard four-wheeled steam railroad trucks. The solid-forged frames and the strength and disposition of the springs give it a carrying capacity equal to the large six-wheelers used under the heavy steam coaches. It is interesting to note that this enormous strength is obtained without bulk. Unfortunately, the truck does not show to good advantage in the engraving, as the wheels do not belong to the truck and are but 33 ins. in diameter. The angle-iron end-pieces of the frame are bent around the extensions of the side frames and heavily bolted thereto. The length of the side frames is 12 ft. ½ in.; width at center of the bar between the yokes, 7 ins.; thickness of the bar, 1¾ ins.; thickness of the extensions, 1½ ins.; thickness of the pedestals, 2 ins.; length of the axles, 7 ft. 3¾ ins.; diameter of the axles, 6¾ ins. and at the gear seat, 7¼ ins.; journals, 5⅛ ins. x 9 1-16 ins. The wheels are 41 ins. in diameter and have the M. C. B. type tread and flange. The wheel base is 7 ft.

THE HAMILTON-HOLZWARTH STEAM TURBINE

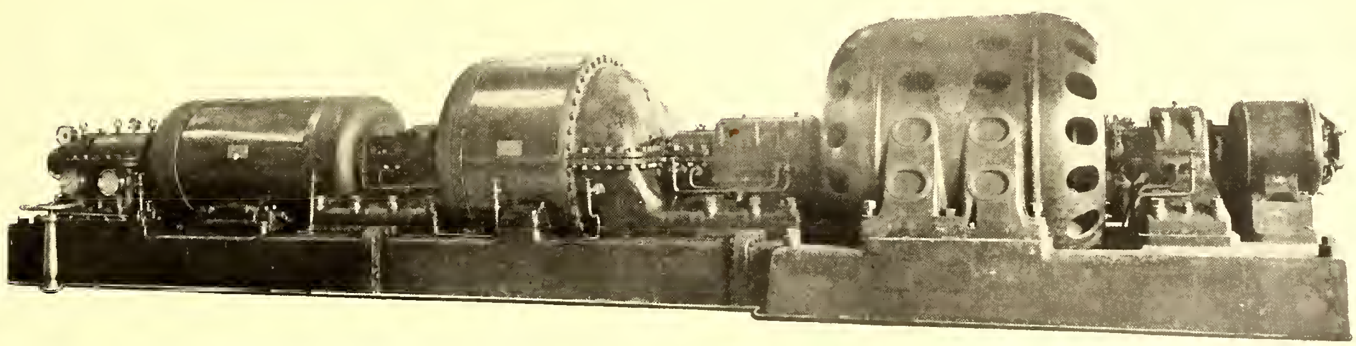
It has been well known that the Hooven, Owens, Rentschler Company, of Hamilton, Ohio, has been engaged for some time on the design of a steam turbine, but no particulars have been available until this issue. The turbine is illustrated herewith and differs in a number of particulars from other turbines which have been described in these columns. In units of 750-kw upward, the turbine is built with separate high and low-pressure casings; smaller units have one casing only. Owing to the design of the turbine, there is no back pressure to the steam in the running wheels and any slight end thrust is taken up by a thrust ball bearing. The turbine is built only with horizontal shafts.

Like the Parsons, this turbine has a large number of stationary disks and running wheels, but while the Parsons expands in both stationary blades and running wheels, the Hamilton-Holzwarth steam turbine expands only in the stationary blades. The number of blades and wheels is also less than in the Parsons type. The radial height of the vanes in these blades is gradually increased from high to low pressure, corresponding to the volume to which the steam expands in its course. In the bore of the stationary disks runs, with as small clearance as practical, the hub of the running wheel. This restricts the leakage losses to a minimum. The stationary disks are located in grooves in the turbine casings and the stationary disk vanes are of drop forged steel, milled and ground to the proper shape. A tough steel ring is then shrunk on the outside periphery.

The running wheels are made as light as possible in order to keep the diameter of the shaft, and hence the bore of the stationary disks as small as possible, also so as to reduce the strains due to centrifugal stresses. The running wheels are built with cast-steel hubs; steel disks are riveted to both sides of the hub and the vanes are then riveted in place. On the outer edge of the vanes is a thin steel band which give an outside wall to the steam channel. Tests made with these vanes have shown that it takes over 1000 lbs. to pull them out of the clips. Every wheel is balanced to within 1-16 of an ounce. The bearings for the turbine shaft, having much less weight to support than those of the generator shaft, are made short, with straight, cylindrical shells. A thrust bearing is used on the exhaust side of the bearing, arranged so that the whole shaft can be moved axially and the position of the running wheels changed. Flexible couplings of an ingenious type are used between the high and low-pressure shafts so that either shaft can be fixed and located without affecting the location of the other shafts.

The expansion of the turbine shaft and casing is provided for by holding each rigidly only at the cool or exhaust end by the high-pressure and low-pressure pedestals. The casings are not fastened to the bed-plate, and they as well as the shaft can slide or expand against the direction in which the steam flows.

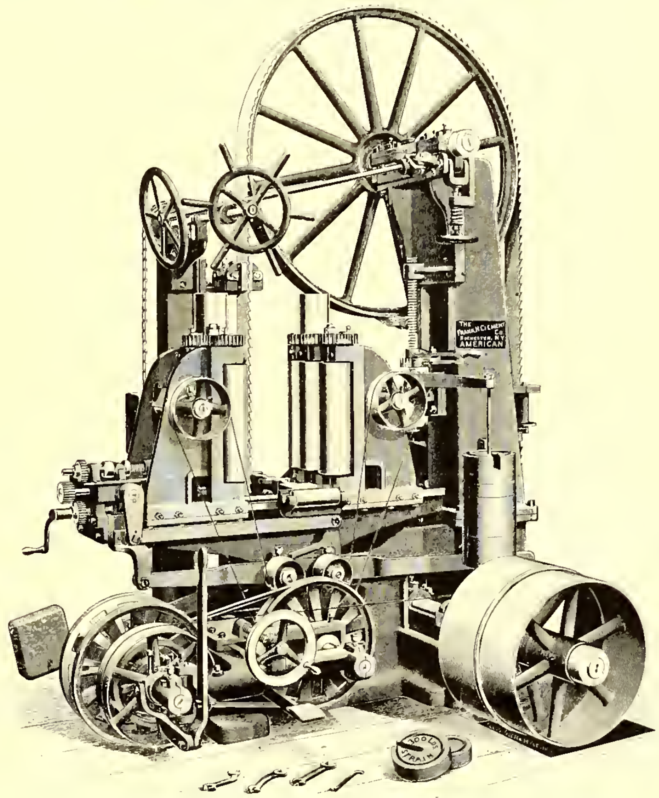
The governor operates by throttling, a method which does not present the same disadvantages as in the reciprocating engine. In the latter the static pressure of the steam is reduced by a throttling valve, but in steam turbines static pressure is not used owing to the fact that all the energy is converted into kinetic energy. The regulating valve is located below the bed-plate, and is of the double-seated poppet-valve type, which insures a perfect balance.



1000-KW HAMILTON-HOLZWARTH STEAM TURBINE, DIRECT CONNECTED TO 1000-KW ALTERNATOR, IN OPERATION AT THE LOUISIANA PURCHASE EXPOSITION

A 54-INCH BAND RE-SAW

The accompanying cut illustrates a late improved machine built by the American Wood Working Machinery Company, of New York, Chicago and New Orleans, which is said to embody all the conveniences and attachments that are necessary or desirable for any kind of resawing on hard or soft wood. The frame is strong, heavy, has a broad base, and if properly set will not vibrate, even when running on a light floor. The shafts are large in diameter and have bearings from 9 ins. to 14 ins. long, running in self-oiling boxes. The lower wheel is a solid web and very heavy. The upper one is as light as is consistent with strength.



BAND RE-SAWING MACHINE FOR RAILWAY SHOPS

The feed works are very powerful, there being six feed rolls, and the feed varies from 12 ft. to 120 ft. per minute, by adjusting the expansion cones according to the work required. The right-hand rolls are rigid in the boxes, but the left-hand set are elastic so as to grasp uneven stock and hold it firmly against the rigid roll, thus making a powerful feed even on very unequal sawed lumber. All rolls are adjustable to the blade and wheels in case of wear. With a special self-centering attachment both sets of rolls are held rigid and the adjustment for thickness is made by a lower screw and hand crank. The capacity of the machine is 30 ins. vertically and from ⅛ in. to 20 ins. horizontally. It will do slabbing from 12 ins. wide, will split a 16-in. timber in the center and cut a veneer from 12-in. timber.

IMPROVEMENTS IN BLOCK SIGNAL SYSTEM FOR SINGLE TRACK RAILWAYS

In the Street Railway Journal of Aug. 29, 1903, a description was presented of the block signal system which had then been in use on the line of the Tamaqua & Lansford Street Railway Company for over a year. The electrical details of this system, which was installed by the Eureka Electric Signal Company, of Lansford, Pa., proved thoroughly satisfactory from the start, but certain mechanical changes in the controlling apparatus were found desirable, the principal one being a new controller of simplified construction and affording a wider range of protection. It will be apparent from the following that this system possesses a number of valuable mechanical and electrical features which make it worthy of the careful attention of railway companies operating single track lines not now furnished with an efficient block signal system.

The simplicity of operation is well shown in the wiring diagram,

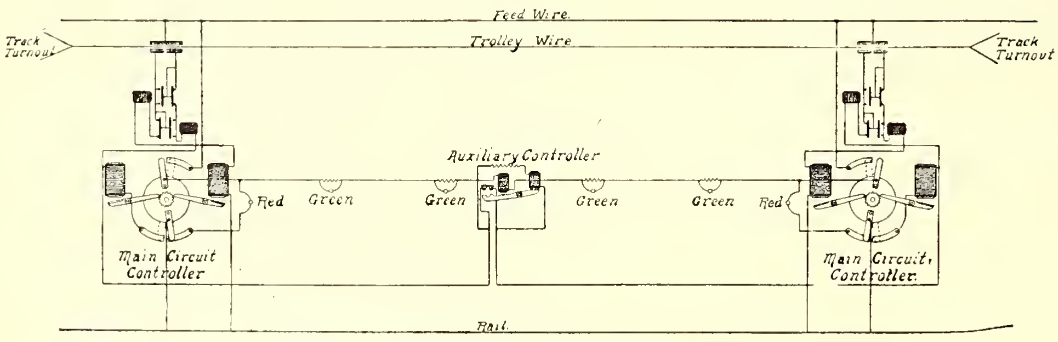


FIG. 1.—WIRING ARRANGEMENT FOR THE TWO-WIRE SYSTEM

Fig. 1. Normally, the signal circuit of an empty block is grounded at both ends. This circuit includes a series of green lamps distributed along the block in any desired position, and red lamps at the extreme ends of the block. The feed-wire connections to the signal circuit are normally open. The practical advantage claimed for this arrangement is that the signal circuit being normally dead, no accidental grounding through bad insulation, falling wires, etc., can energize the circuit and cause false signals. Should such a "ground" occur the system will still work on the entrance of a car into the block affected, but the dulling of the lamps in the portion shunted by the accidental ground will show the existence of trouble in that part of the circuit.

Upon entering a block, the trolley wheel automatically takes the right-hand branch of the divided trolley wire and engages the contact device thereon. The current supplied from the contactor operates the circuit controller at that end of the block, thereby cutting out the ground at that end of the signal circuit and cutting in the feed connection. This causes all the green lights to glow and also the red light at the far end of the block. The green lights show the motorman that the block ahead is clear, and the far red light shows the motorman of a car approaching the other end of the block that the block is occupied by a car coming toward him.

If another car follows the first, the glowing green light and the absence of any red light show the motorman that a car is ahead of him going in the same direction, and if his instructions are to trail that car he goes into the block under control. This does not change the signals, but moves the circuit controller a notch farther.

When a car goes out of the block at the distant end, it co-operates with the contact-maker and sets back the controller at the end where the car entered. If this was the only car in the block it cuts out the lamps and leaves the block clear. If there are one or more cars following in the block, it sets the controller back one notch, but does not put the lights out. The red lamp glowing at the end of the block as he leaves it tells the motorman that another car is trailing him.

The last car out of the block extinguishes all the lamps. If a motorman overruns a red lamp danger signal and enters a block while a car is in it running in the opposite direction, it cuts out both grounds and extinguishes all the lamps. This notifies the motorman in the block that a car has entered it from the other end in defiance of the signals, or that the system is out of commission, and he must stop or feel his way out of the block. If a car enters a block wrongfully through failure of brakes, or for any other reason, backing out will reset the system in its proper condition. If the signal system, or any part of it is out of order, every motorman within the district affected is notified by the lamps going out.

The fundamental idea of this signal system is the operation of only one controller; to set the system to danger when cars enter the block, and to safety when they leave it. To protect a block, two controllers are used, one at each end, but as they are not wired in series their operation is independent and opposite to each other. The No. 2 controller shown in Fig. 2 is the latest development in Eureka appliances, and is the standard machine now used with the two-wire system, combining in itself the functions of both the original No. 1 controller, and the automatic current directing relay which switches a path for current from both short plates of the contact maker through the coils of the magnets operating the signals. In addition, the new controller includes an alternating device, placed in the signal circuit, by which two green lamps at the entrance to the block are alternately cut in and out of circuit. When a car enters the block one of these lamps goes into service. Should another car follow the first, it will put out that lamp and light the other. This alternating continues with each successive car that enters the block. This device, however, may be omitted.

The magnets of this controller are wound to stand the working current continuously without burning out. All working parts are massive; all levers operate on trunions, adjustable to take up wear; all switches fall by gravity, eliminating spring operation; all bridging contacts work on pins, being held in place by cotters; and all contacts are made by crossing heavy silver wire at right angles. This controller

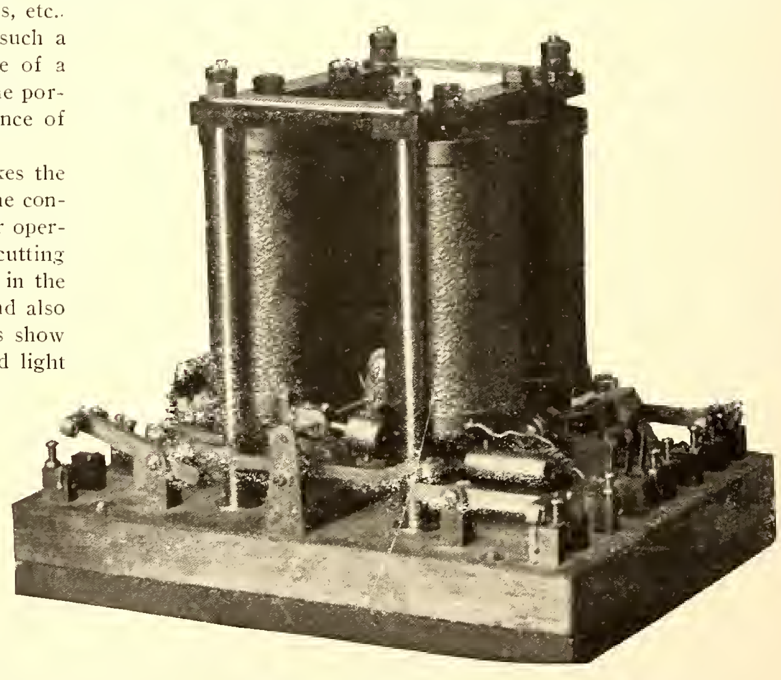


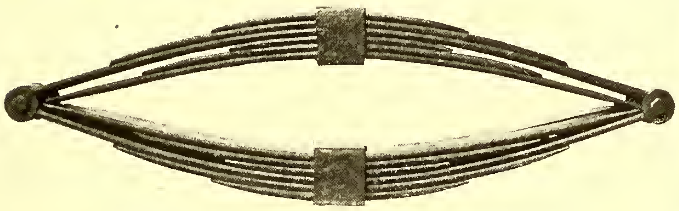
FIG. 2.—THE NO. 2 CONTROLLER

needs but one contact-maker for its operation, setting the signals to danger when cars enter the block, and to safety when they leave it. It embodies the accumulated experience of many years of signal work, and has been designed and is guaranteed to handle heavy work successfully, with little danger of breaking down in service.

The Springfield, Troy & Piqua Railway Company has made arrangements with the Southern Ohio Express Company to handle the express business on this line.

NEW ELLIPTIC SPRING FOR ELECTRIC MOTOR TRUCKS

The Union Spring & Manufacturing Company, of New Kensington, Pa., has brought out recently an improved type of elliptic spring, which is now used in the electric motor trucks built by the Standard Steel Car Company, of Pittsburg, Pa. In motor trucks, owing to the limited wheel base between plates and the space necessarily occupied by the motor, the bolsters have to be very narrow, and hence the bolster springs are limited to double elliptics with leaves about 3½ ins. or 4 ins. wide. To carry the load and at the same time provide for sufficient deflection to insure easy riding, it is necessary to make these springs not less than 36 ins. long, and with as many as six leaves or even more; but it is a well-known fact that too many leaves in the ordinary type of elliptic spring cause it to be hard riding, owing to the excessive damping effect, due to friction. The manufacturer's experience confirms the belief that three or four-leaved springs are the easiest riding. In order to make a six-leaf spring of ample strength that will ride as easily



NEW TYPE OF SIX-LEAF ELLIPTIC SPRING

as a three-leaf spring, the six leaves have been divided into two sets of three leaves each, both sets being secured by one band, but beyond the band the sets are separated so that no friction is produced between them. The outside set carries a plate which connects the upper and lower sets of the spring and the inside set has the long leaves merely resting together at their ends, as is shown in the illustration. The action of this spring is precisely the same as a quadruple elliptic three-leaved spring of the same length and width of leaves, which is equal in good riding qualities to the best springs used on steam railroad passenger cars.

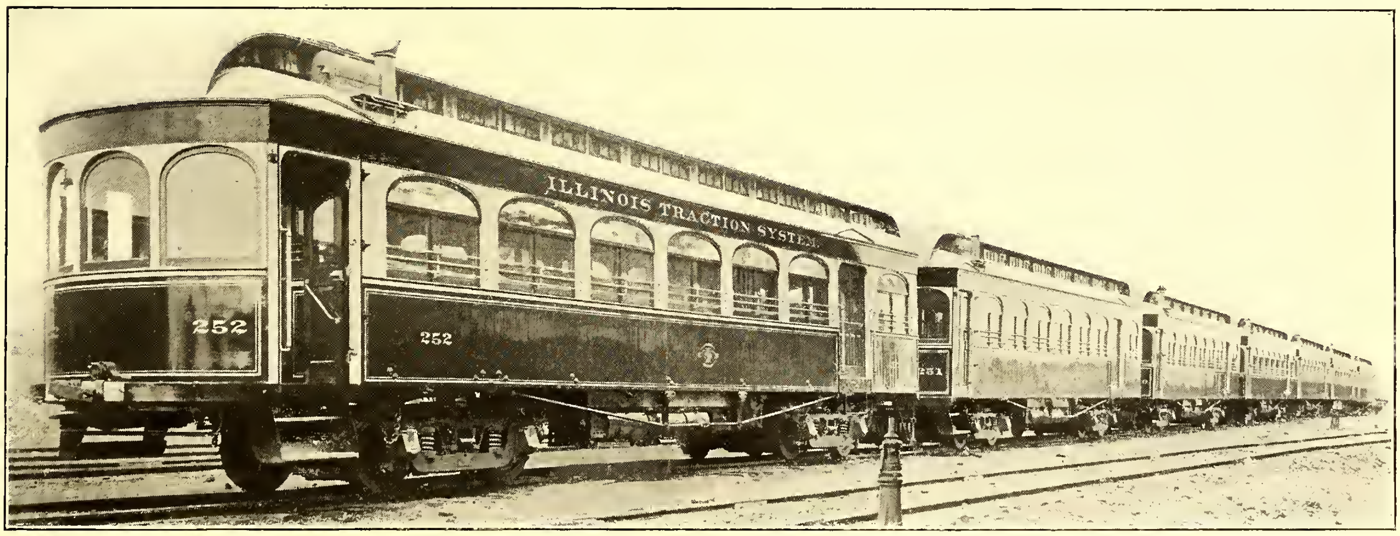
The Union Spring & Manufacturing Company was one of the first independent spring manufacturers to go into business after the formation of the Railway Steel Spring Company. It manufactures helical and elliptical springs for all types of rolling stock, as well as pressed steel spring plates and pressed steel journal-box lids, and has furnished its products to most of the large steam railroads, electric railways, and car and locomotive builders throughout the country. Its general offices and works are located at New Kensington, Pa., eighteen miles from Pittsburg, on the Allegheny Valley Railroad and the Allegheny River. The capacity of the plant in all lines of the company's manufactures is 1200 tons per month. The officers of this company are: Archibald M. McCrea, president; Leonard G. Woods, vice-president; Albert Pancoast, secretary and treasurer.

LARGE CARS FOR THE ILLINOIS TRACTION SYSTEM

The accompanying illustration shows a train of seven cars built for the Illinois Traction System, which left the works of the American Car Company a few weeks ago for Springfield, Ill. The train was drawn by a special locomotive and the cars were carried on their own wheels. The order called for eight cars, but one was shipped a week or two previous to the others and placed

INTERIOR OF INTERURBAN CAR FOR THE ILLINOIS TRACTION SYSTEM

at once on the lines between Danville and Champaign which pass through Urbana, where the University of Illinois is located. The cars which had been running on that division required two hours to make the trip of 35 miles. The new car is run as a limited, upon which an extra fare is charged, and the trip from Danville to Champaign is made in 1 hour and 15 minutes. The Illinois Traction Company, also known as the McKinley syndicate, has about 300 miles of lines in operation at and between Springfield, Decatur, Champaign, Urbana and Danville. The company is connecting the sections of this system, intending to run through cars from Danville to St. Louis, a distance of 200 miles, and a large part of the new construction has been completed.



SEVEN NEW CARS FOR THE ILLINOIS TRACTION SYSTEM LEAVING SPRINGFIELD, ILL., ON THEIR OWN TRUCKS

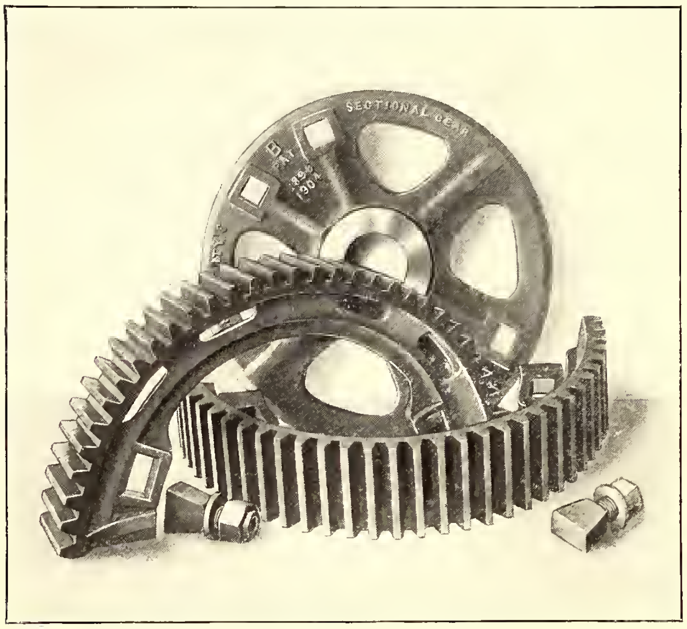
The new cars measure 51 ft. 6 ins. over all, 49 ft. 10 ins. over crown pieces, and from the outside of the vestibule at the front end over the end panels at the rear, 45 ft. 1½ ins. The width over the sills, including the sheathing, is 8 ft. 10 ins.; over the centers of the posts, 2 ft. 6⅛ ins. The side sills are 5 ins. x 7¾ ins. and 2 ins. x 6 ins., with 7-in. x ⅝-in. sill plates on the inside. The end sills are 5 ins. x 7¾ ins., with 7-in. x ½-in. plates. The thickness of the corner posts is 3¾ ins., and of the corner sub-posts,

$2\frac{1}{4}$ ins. The thickness of the side posts is $2\frac{1}{4}$ ins. Four 6-in. I-beams with yellow pine fillers constitute the center sills.

The passenger compartment is seated for forty-six persons, and the baggage compartment has folding seats for the accommodation of smokers. The motorman's cab is located on the left side of the latter compartment. Incandescent lights are placed singly on the arched rafters of the deck, four to each rafter. The seats in the passenger compartment have stationary backs, are upholstered in green leather and are 36 ins. long. The toilet room of standard steam car character is located at the rear end. The bronze trim throughout is of a substantial character and includes continuous parcel racks.

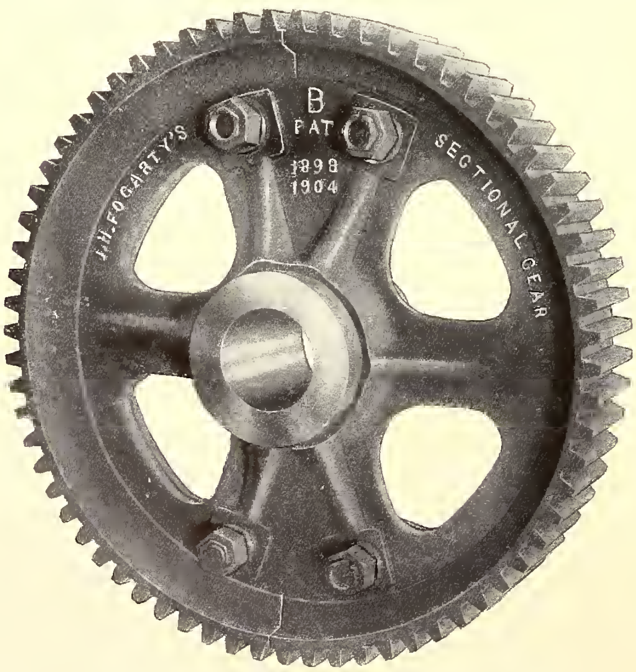
THE PEERLESS SECTIONAL GEAR

The Peerless Sectional Gear Company, of New York, has recently perfected and is now placing on the market a gear which, as illustrated herewith, embodies a number of radical features



THE SECTIONAL GEAR TAKEN APART

not found in the gears now in universal use. It consists of a cast-iron hub, or center piece, to which are attached removable sections of the gear. The sections, which are two in number, are interchangeable on any hub. When the hub is once pressed into



THE SECTIONAL GEAR ASSEMBLED COMPLETE

place on the axle it requires no further attention as long as the car is in use. The rims or sections of the gear are attached to the hub independently. When the teeth are worn out and no longer serviceable the rims are removed and new ones substituted, thus making practically a new gear. The ease with which this can be done can be readily appreciated by examining the accompanying illustrations. Where the hub piece and the rim come in contact they are beveled in such a way as to make a perfect fit, thus preventing all lateral motion. To escape the possibility of the rim revolving or slipping on the center piece, a steel safety key is placed through the hub and rim section, locking them absolutely. The weight and amount of metal in the entire gear is about the same as in the ordinary type. There is, however, a considerable saving to users of this gear, because when the rims are worn out they can be replaced without buying a new hub. The great advantage of this type, however, is in the saving of time and labor in replacing the gears. The car is simply run over the pit, and one man with one wrench can remove the old rims and replace them with new ones in less than an hour, as the nuts and bolts are all of the same size.

This gear is the result of a long series of experiments under regular operating conditions. At the present time it is in service on the lines of the Public Service Corporation of New Jersey, whose engineers have watched its successful development with considerable interest.

MORE SEMI-CONVERTIBLE CARS FOR CHICAGO

The Calumet Electric Street Railway Company, of Chicago, has lately added to its equipment fifteen combination passenger and smoking cars of the Brill semi-convertible type built by the

SEMI-CONVERTIBLE COMBINATION PASSENGER AND SMOKING CAR FOR THE CALUMET ELECTRIC STREET RAILWAY COMPANY

G. C. Kuhlman Car Company, of Cleveland. These cars are similar to a lot of fifteen built by the J. G. Brill Company two years ago. The railway company operates 90 miles of lines, giving direct rapid transit from the center of the city to various parts of South Chicago, outlying districts of that section and the suburban towns beyond. Fast schedules are maintained and a large business is done from the farthest points.

The new cars are 31 ft. 8 ins. long over the end panels and 44 ft.

INTERIOR OF COMBINATION SEMI-CONVERTIBLE CAR FOR THE CALUMET ELECTRIC STREET RAILWAY COMPANY

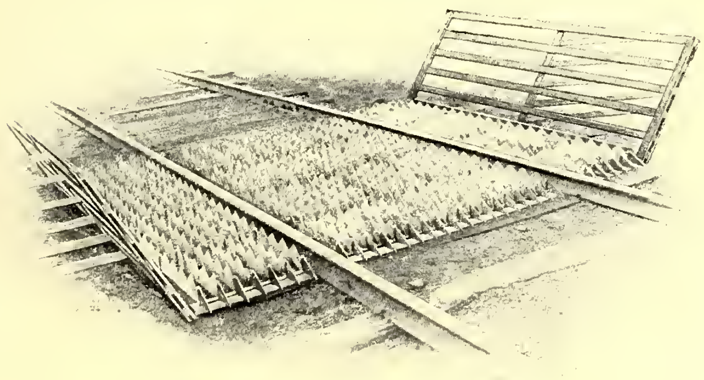
8 ins. over the crown pieces. Their width over the sills is 8 ft. $3\frac{1}{2}$ ins., and over the posts at the belt, 8 ft. 6 ins. The seats are

37 ins. long and the aisle 24 ins. wide. The centers of the posts are 2 ft. 8 ins., and sweep of posts 1¾ ins. The thickness of the corner posts is 3¾ ins. and of the side posts 3¼ ins. The side sills are 4 ins. x 7¾ ins., with 12-in. x ⅜-in. sill plates. The end sills are 5¼ ins. x 6⅞ ins. The cars are seated for forty-four passengers, the smoking compartment having accommodation for twelve. The cars have a large amount of standing space, because of the wide aisle and long platforms. The interiors are finished in cherry, stained to a mahogany tint, and the ceilings are of bird's-eye maple. Between the compartments is a hard wood partition with a single sliding door. The interior view shows two windows entirely open on the right-hand side, the sashes being raised into pockets in the side roof. The simple character of the single runway in each post is clearly shown, and the five window lock stops in the runways may also be seen. These runways are entirely of metal from the window sills to the upper ends in the roof pockets. The top of the window sills is but 24⅝ ins. from the floor and has arm rests bracketed thereto which are arranged not to interfere with the window locks. The sashes in the vestibules drop into pockets in the wainscoting. The vestibule doors fold against the vestibule posts. The cars are mounted on Brill No. 27-G trucks having 4-ft. wheel base, 33-in. wheels and 4-in. axles.

ALL-STEEL AND WOOD-STEEL CATTLE GUARDS

Cattle guards have long been recognized as a necessity on railways operating in stock raising districts, particularly as the traction company is usually the sufferer financially when accidents occur. The Merrill-Stevens Manufacturing Company, of Kalamazoo, Mich., has given considerable attention to the manufacturing of such guards, and has brought out a number of designs to meet special conditions.

In laying the Cook all-steel cattle guard made by this company no track preparation is needed, except to space the ties at the ends of the guard so that the guard will rest on the end ties only, hanging clear of the intermediate ties underneath. Each section is spiked down to the ties at the ends of the guard only. It will be seen that the guard vibrates under weight, and this feature, combined with the sharp teeth alternating in height, offers such unstable footing as to stop the most unruly animal. The guard is made of annealed steel, and can be easily repaired or straightened by an ordinary section hand. The parts are riveted with pneumatic riveters, the whole forming practically a solid structure. If desired, hog attachments are furnished to prevent the passage of animals with feet small enough to pass between the main guard rails.

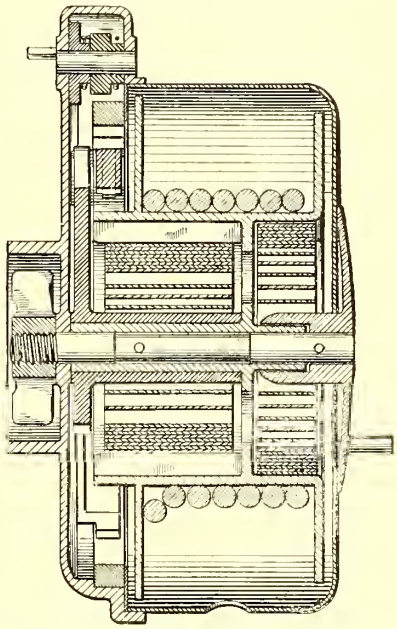


ALL-STEEL CATTLE-GUARD IN POSITION

The company also builds a wood-steel guard, which is in extensive use on many railroads. The metal transverse clamping fixtures are of soft Bessemer steel, pressed into shape with powerful presses. The wooden parts are white oak, creosoted, if desired. All pieces are brought to exact size and shape, thus making them interchangeable. Broken wooden slats may be removed and new ones inserted in a few minutes time. All that is required is to unscrew the nuts which hold the span pieces in position, put in the new ones and fasten as before. This guard is open from one end to the other; that is, there are no spacing blocks between the slats so that drifting snow and dirt will not lodge and fill up the guard. This guard, like the metal one, requires no preparation of track, but is spiked down upon the ties as they lie in the roadbed. The same hog attachments may be used as with the regular Cook guard.

IMPROVED TROLLEY RETRIEVER

The term trolley retriever, as distinguished from trolley catcher, has now acquired a definite significance and refers to a device which not only checks the upward movement of the trolley when it jumps the wire but also pulls it down far enough to safely clear the overhead structure. To those interested in the operation of the cars by the overhead system, the trolley retriever is becoming of steadily increasing importance. For high-speed railways it is now recognized as a necessity, and roads operating at comparatively low speeds are learning that it pays to provide a retriever so that the conductor may devote all of his time to collecting fares and attending to his many other duties.



CROSS SECTION OF RETRIEVER

A sectional cut is presented herewith of the Earll trolley retriever, manufactured by C. I. Earll, of New York. This device has been on the market for nearly three years, but has recently been considerably modified and improved. It is both compact and light, and has a very large rope space. The heavy retriever spring and the light spring which takes up the trolley rope slack are wholly inside the drum. The enclosing case is made up of a malleable iron back and a drawn steel shell which fits into a recess in the back, where it is held by the central shaft on which the sheave rotates, being secured by a thumb-nut at the rear, as shown in the sectional illustration. This thumb-nut is the only screw in the entire machine. When it is taken off the shaft may be withdrawn and the steel case removed from the back, thus giving access to every part. The drum has a bearing on the shaft 3½ ins. long; the diameter of the case is 7¾ ins., and the weight of the retriever 14 lbs. All of the parts are made of steel except the drum and back, which are of malleable iron.

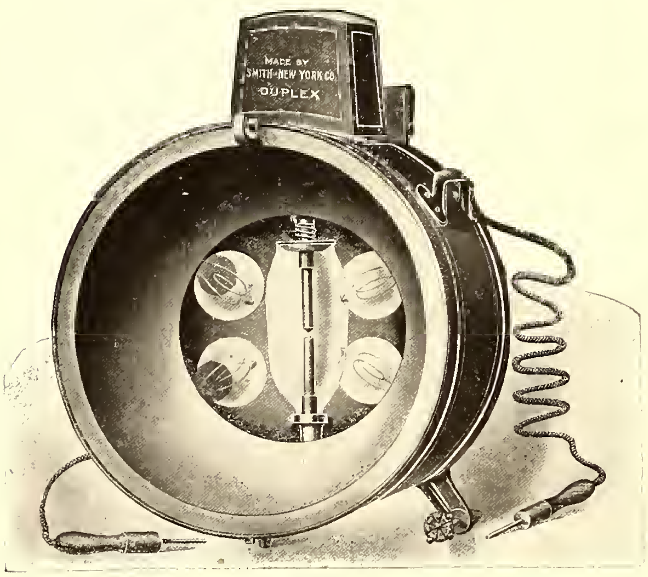
TROLLEY RETRIEVER READY FOR OPERATION

All retrievers require to be reset after the pole has jumped the wire and been pulled down, but there is some diversity of opinion among railway managers whether the conductor shall be compelled to set the retriever before replacing the trolley on the wire, whether he shall always set it to the same extent, or be permitted to replace the trolley and start the car before setting the retriever. One of the features of this retriever is that by merely removing certain parts and substituting others which are interchangeable with them, the retriever may be set in any of these three ways. Where the first method is used it is not necessary to touch any part of the retriever to accomplish the setting, but merely to take hold of the rope. Where the second and third methods are employed, the conductor has to depress the set lever before pulling out the rope.

In all three methods of setting with this retriever the trolley pole may be pulled down close to the roof of the car before beginning to set, thus enabling the conductor to use the up-pull of the trolley pole to assist in setting without danger of carrying the pole high enough to strike the span wires should the car be in motion.

COMBINATION ARC HEADLIGHT

The detachable duplex combination arc headlight shown in the accompanying cut is a product of the Smith of New York Company,

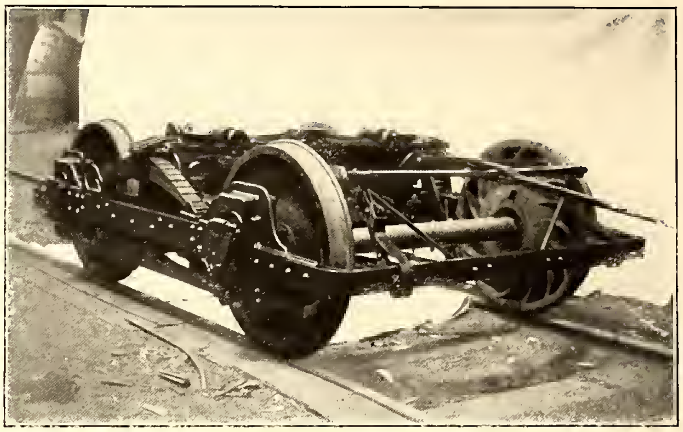


DUPLEX COMBINATION ARC HEADLIGHT

New York City. It is 18 ins. high and 14 ins. in diameter, weighing 23 lbs., and is light and convenient to handle. The arc is said to throw a light 1500 ft. without a shadow, while the incandescent equals in efficiency three of the ordinary type. Each headlight is furnished with two positive plugs (arc and incandescent), with four receptacles, the hook on headlight case being negative contact for both circuits. Change of light is made by inserting the proper plugs in the receptacles, or by operating a two-throw switch placed in the vestibule of the car. The back of the case is made of cast iron, the case itself being of extra heavy sheet steel. The reflectors are made of extra heavy gage aluminium, brass or copper, heavily plated. The ring for the glass is made of brass, and can be easily taken out and glass relaced by adjusting one screw. The headlight is easily adjusted on the dash by its bumpers. The lamps can be replaced without removing either the case or the reflector.

INTERURBAN CARS FOR THE ATLANTIC SHORE LINE RAILWAY

The Laconia Car Company Works, of Boston, Mass., have recently built for the Atlantic Shore Line Railway, of Kennebunk-



HIGH-SPEED INTERURBAN TRUCK FOR INSIDE-HUNG MOTORS

INTERIOR OF CAR FOR ATLANTIC SHORE LINE RAILWAY

port, Maine, the type of car shown in accompanying illustrations.

The car body is of the semi-convertible type, 35 ft. long over

SEMI-CONVERTIBLE INTERURBAN CAR FOR KENNEBUNKPORT, MAINE

body and about 45 ft. over all. It is built on steam car lines, with straight sides sheathed, and has an extended monitor. The windows are arranged in groups with double sash, and both sashes are arranged to drop flush with the window sill, making a very comfortable summer car when the windows are lowered. The inside finish is red birch. The ceilings are of three-ply quartered oak, decorated. Chase leather curtains are used. The seats, which were made by Heywood Brothers & Wakefield Company, are upholstered in special figured plush.

All cars are wired for electric push buttons at each post; are equipped with International registers operated by rods; Consolidated heaters; Root scrapers; Wilson trolley retrievers; Cleveland combination headlights; Westinghouse motor-driven air brakes; Westinghouse 40-hp motors No. 101 and type M control. The motors are geared for a speed of 35 miles an hour. The trucks are the Laconia Car Company Works new type, with 5-ft. 7-in. wheel base, and are adapted for inside-hung motors.

THE "NEW HAVEN" TROLLEY WHEEL

The accompanying illustration is a view of the "New Haven" trolley wheel known as the No. 53. This wheel, which is made by the Recording Fare Register Company, of New Haven, Conn., is

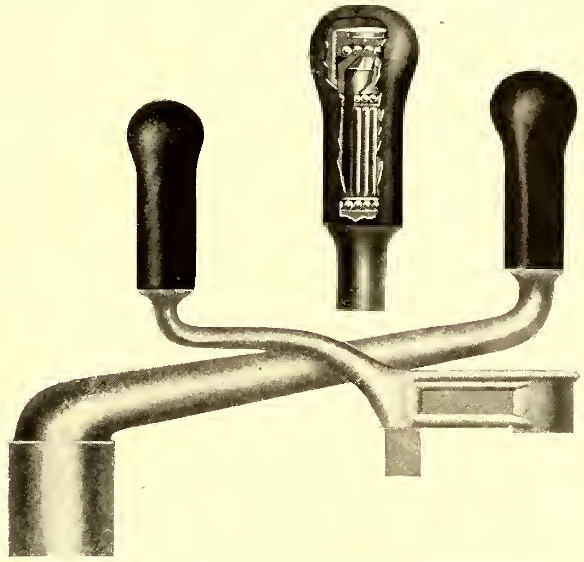
TROLLEY WHEEL WITH NON-OILING BEARINGS

especially adapted for high speed interurban work. It is used exclusively by the Schenectady Railway Company on all of its high speed lines. This type is 5¾ ins. in diameter, and is furnished for 1¾ in. or 2 in. hub, ⅝-in. spindles.

As is well known, the special feature of all "New Haven" wheels is the fact that they are furnished with bearings that outlast the wheel, and which require no oil, thereby saving the time and expense of oiling and of renewing bushings.

THE ANTI-FRICTION BRAKE AND CONTROLLER HANDLE

After a number of practical tests the Anti-Friction Handle Company, of Amsterdam, N. Y., has placed on the market a new ball and roller-bearing handle designed for the brake and con-



ANTI-FRICTION BRAKE AND CONTROLLER HANDLE

troller handles of electric cars. The improvement is in the hand hole, the construction of which consists of a series of hardened steel rollers and balls revolving between a shaft and steel shell incased in a hard rubber grip. The rubber grips make the brake and controller handles non-conductors, and the motorman will constantly grasp the revolving hand-holds to avoid short-circuit shocks. He is therefore ready at all times to stop the car quicker and with less exertion than is afforded by any other hand brake appliance. The use of padded gloves is rendered entirely unnecessary.

The great facility with which this device can be applied tends to reduce the possibility of accidents, and makes the work easier for the men. When desired, old brake handles of any make, in use on any railway, may be fitted with anti-friction handles at a small cost.

A PRIVATE ELECTRIC MAIL CAR

One of the few, if not the only, private electric mail cars in use is shown in the accompanying illustration. This car is in the service of the Lewis Publishing Company, of St. Louis, Mo., and is operated between the company's plant, near the World's Fair grounds, and the St. Louis post office. Two trips a day are necessary to carry to the city the printed copies of the "Woman's Magazine" and the "Woman's Farm Journal." The mail sacks are

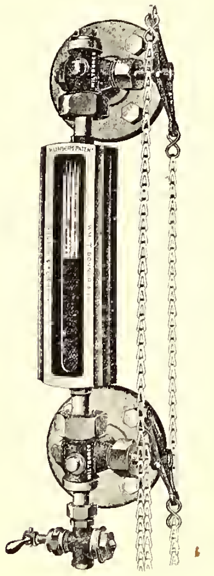
PRIVATE ELECTRIC MAIL CAR BUILT FOR AN ENTERPRISING PUBLISHER, AND NOW RUNNING AT ST. LOUIS loaded into the car from wagons. The car is run down town over the St. Louis Transit Company's tracks to a portion of unused track near the post office. Wagons convey the mail to the office.

The car was built by the St. Louis Car Company and measures over all 44 ft. Its width is 8 ft. It is equipped with the builder's arc headlight and vertical wheel brakes.

THE REFLEX WATER GAGE

The reflex water gage, which is so widely used for boilers, automobiles, tanks, separators, etc., is made in a variety of forms by Wm. T. Bonner & Company, of New York and Boston. The accompanying illustration shows a marine outfit with double hand chains and drain valve. The leading feature of this gage is the quick and reliable observation of the water level, due to the fact that the water appears black while the steam shines with a silvery lustre. When filled with water the reflex gage always appears black and when empty it instantly shows white.

The principle of the reflex glass is based upon the optical law of the total reflection of light when passing from a medium of greater refractive power to a medium of lesser refractive power. By cutting grooved facets at proper angles in the inner surface of the glass it is possible to eliminate all light from the vacant space back of the glass and at the same time permit the passage of light through that portion of the grooves covered with water or other liquid. Thus a sharp clear line marks the height of the water or other liquid, above which the air or steam space has a bright mirror-like appearance, while the liquid takes the color of the background in the chamber, and as black is usually selected for the sake of greater contrast the water shows black.



WATER GAGE WITH DOUBLE HAND CHAIN AND DRAIN VALVE

Instead of using a single glass and background, a pair of reflex glasses may be arranged, one each at the front and rear of a column of water and steam. If a gage of this kind be lighted from behind, the part containing water will show bright, the water permitting the passage of the light, while from the steam space it will be reflected.

The new waiting room on the Public Square, Cleveland, Ohio, for the interurban cars has been opened. All the interurban cars now run around the south and west sides of the Public Square and pass the station, approaching from the east and passing to the west. The station is simply part of a storeroom, but it is of great convenience to all concerned. The interurbans have been given the exclusive use of this corner of the square so that they may lay over and not interfere with the regular city cars.

PLANS FOR LARGE AMUSEMENT RESORTS

Wonderful strides in the development of the summer amusement park industry have been taken during the past year, and the plans already made indicate that the coming year will be even more remarkable. So profitable have proven the big new resorts during the season just closed that it is estimated by specialists in this unique branch of the entertainment business that within the next two years practically every one of the larger cities of this country will be supplied with at least one large resort equipped with the standard attractions which the past five years of activity have brought to the front. The subject is of particular interest to street railway companies from the fact that most of them have already gone into this work on some scale and because in any case they would have to supply the transportation to such resorts.

Perhaps the most conspicuous success in America, if not in the entire world, is that of Dreamland, the beautiful Coney Island resort, which terminated its first season Sept. 25 under auspicious circumstances. Now comes the announcement of Edward C. Boyce, vice-president of Dreamland, that he is preparing to establish in Chicago a fairyland which will eclipse the splendors even of that marvelous Atlantic Coast place of entertainment. This resort will be at Sixty-Third Street and Washington Park and will cover 13 acres. Mr. Boyce and his associates have also completed arrangements to build in Boston and two other large cities resorts to compare favorably with any enterprise in Coney Island or elsewhere.

A NIGHT VIEW OF DREAMLAND, CONEY ISLAND, SHOWING THE GREAT TOWER, LAGOON, BRIDGE AND SHOW BUILDINGS, WITH PART OF THE "CHUTES" IN THE FOREGROUND

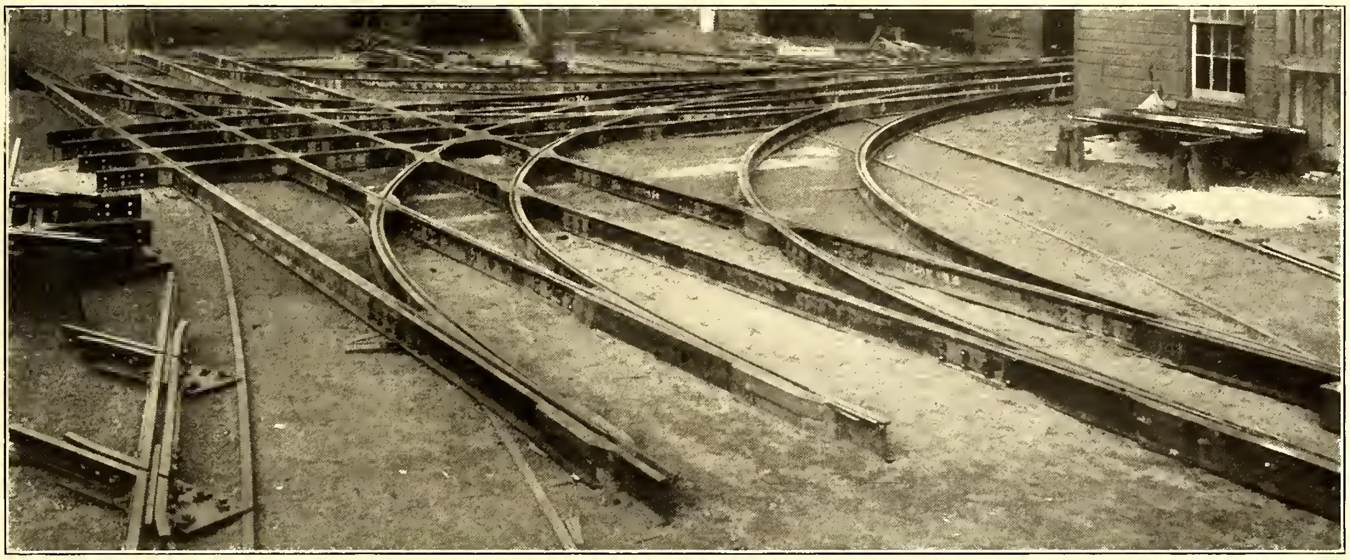
It is said that the great success which Mr. Boyce has scored in this special branch of the amusement business has been due, not only to his thorough familiarity with the construction and operation of the various devices, but to unusual judgment as to the desires of the public and how to cater to those desires. Thus it was that in selecting and arranging the various devices and attractions for Dreamland he was able to choose from the vast number of proposed schemes and plans those which would most likely prove alluring to the patrons. The same is true of the "White City," at Savin Rock Park, New Haven, which recently closed its first season with a record which attracted wide attention.

It is said that the White City in Chicago, which Mr. Boyce and his associates are now constructing, will have some absolutely novel attractions and features as well as the most profitable devices which are now in use. Mr. Boyce's chief associate in this enterprise is Joseph Beifield, owner of the Sherman House in Chicago. Work on the grounds was commenced last week and it is planned to open the resort by June 1 next. A feature of the park will be what is designed to be the largest electric tower in the United States. It will be 410 ft. in height and will be studded with no fewer than 100,000 electric lights. The longest chutes thus far constructed in this country will be established. A big spectacular feature will be a reproduction on a large scale of the great Chicago fire. The streets of Venice will be a representation on large basis of the most beautiful and historic features of the famous old Italian seat of art and romance. In this attraction Mr. Boyce plans even to surpass his charming "Canals of Venice" at Dreamland. In addition to these there will be scenic railways, toboggans, old mills, slides, etc.

Chilcoot Pass, or "Bump the Bumps," which was beyond all question the comedy feature of Dreamland and the White City, New Haven, will be given a place of prominence in the Chicago show. Bump the Bumps was the principal novelty of the season. It attracted by many thousands more spectators than any other show in Dreamland. It consists of a slide some 35 ft. wide and 50 ft. in length on an incline of about 45 per cent. Over the smooth and polished surface are distributed "bumps" of planed maple, circular in form and gradually increasing in thickness from the edge, where it neatly joins the surface of the incline, to about 6 ins. at the top. Over this surface slid many thousands of visitors to the big resorts in the past season, Gov. Benjamin Odell, of the Empire State, together with a distinguished party of United States and Supreme Court Judges and others of like prominence, being notable patrons of the game.

ANTI-STRADDLING DEVICE FOR SWITCHES

The accompanying illustration shows a double-track through Y recently built by the New York Switch & Crossing Company, of Hoboken, N. J., for the Brooklyn Heights Railroad Company. This piece of special work is to be installed at the corner of Meserole Street and Graham Avenue, and consists of 9-in. rail with hardened center special work. A special feature of the crossing, however, is the use of a method of holding the tongues of the entrance switches firmly in one position or the other to avoid all possibility of the wheels straddling the switch. The arrangement cannot be interfered with by snow or ice, but the tongue can be easily turned by a switch iron. The crossing contains eight tongue switches, four tongue mates, three standard mates and one combination mate.



DOUBLE TRACK THROUGH Y USED BY THE BROOKLYN HEIGHTS RAILROAD COMPANY AT MESEROLE STREET AND GRAHAM AVENUE, BROOKLYN

THE THOMAS SOLDERED RAIL BOND

The Lord Electric Company, of Boston, Mass., has recently acquired from Edward G. Thomas the right to manufacture and install the Thomas soldered rail bond. During the last two years the bond has been supplied to several large railway systems, notably the Chicago & Milwaukee Electric Railroad Company. The very satisfactory results given by this bond led the company to establish its rail bond department, with Mr. Thomas acting as consulting engineer. One of the largest rail bond contracts ever made has been given to the company by Westinghouse, Church, Kerr & Company for that part of the Long Island Railroad which will shortly be equipped for electric operation.

Within the last five years the soldered rail bond has become quite popular owing to the simplicity with which it can be applied and inspected. Mr. Thomas has made a number of vital changes and improvements both in the forms of the bond and in the methods of application, especially in adapting it to use a combination of riveting and soldering. Special types have been designed for the third rail and for the different styles of rail joints like the Continuous and Weber.

TESTS OF A SIMPLE ENGINE

Some interesting tests of a Reeves simple engine were recently made by Prof. R. C. Carpenter, assisted by Prof. H. Diederichs, both of Sibley College, Cornell University.

The diameter of the engine cylinder was 15 ins., the stroke 14 ins. The engine was connected through about 25 ft. of 4-in pipe to a battery of two B. & W. boilers. The machine called for a 5-in. steam pipe, but a 4-in. was the largest available, so that under the high loads some wire drawing became noticeable. The exhaust was connected through about 20 ft. of 7-in. pipe to a Wheeler surface condenser. Two series of runs were made, the one non-condensing, the other condensing. In the latter vacuum was used as high as could be obtained. This was found to be about 23.5 ins. For each series a number of runs were made, varying from friction load to approximately 25 per cent overload. The duration of these runs varied from one to two hours each, depending upon the constancy of the various observations.

The most important result, steam consumption, was computed for the ihp and the dhp per hour on the basis of dry steam. The pounds of dry steam per ihp per hour decreased steadily with the load until it reached its minimum of about 26 lbs. of dry steam at about 130 ihp for the condensing runs, and about 28 lbs. at the same load for the non-condensing series. With a higher load there was a small increase in the steam consumption, giving about 27.5 lbs. at 176.3 ihp condensing, and about 31.3 lbs. for 159.2 ihp non-condensing. The remarkable part about these results was the nearly constant steam consumption on the ihp when running condensing. At 80 ihp this was about 27.2 lbs., it dropped to about 26 lbs. at 130 ihp and rose again to 27.5 at 176.3 ihp, giving a nearly constant range from 40 per cent. underload to about 40 per cent. overload.

The dry steam consumption per developed hp followed closely the preceding figures, the best consumption being about 27.0 lbs. at 130 developed hp condensing, and about 31.9 lbs. at 130 developed hp non-condensing.

The relation between the mechanical efficiency and the developed hp was also determined. The results are excellent. The highest efficiency reached non-condensing is 92.5 per cent at 147.1 developed hp and 159.2 ihp. For the condensing series the results are still better. The best figure is 95.8 per cent. at 154.1 developed hp and 165 ihp, but the mechanical efficiency which reached 90 per cent at 78 developed hp, reaches 95 per cent at 133 developed hp and remains nearly constant from there up to 168.2 developed hp.

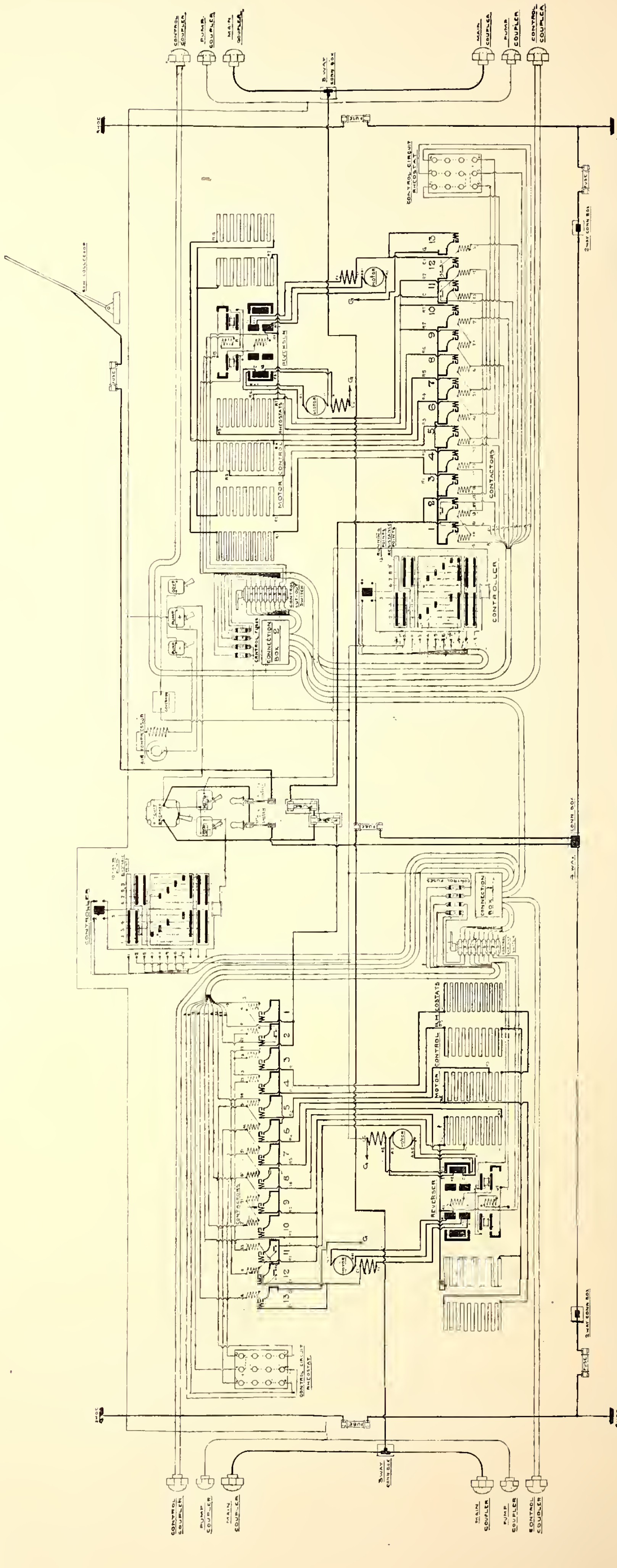
ELECTRIC FREIGHT LOCOMOTIVES FOR THE NORTH-EASTERN RAILWAY OF ENGLAND

The largest electric locomotives ever built in England are shortly to be used on the electrified section of the North-Eastern Railway, near Newcastle, displacing a large number of steam locomotives now used for hauling freight trains. The locomotives were built by the Brush Electrical Engineering Company, Limited, Loughborough, for the British Thomson-Houston Company, who recently electrified the Newcastle branch of the North-Eastern Railway, which, since its opening, has eclipsed all previous passenger traffic records on the same line. The consulting engineer for the electrification of this railway is C. H. Merz.

Each of the locomotives when operating on a 600-volt circuit is capable of handling a 300-ton (2240 lbs. per ton) train on a level at 14 miles an hour, and of starting with a train of 150 tons on a grade of 1 in 27 under all weather conditions, running up this grade at 9 miles to 10 miles an hour. As the construction of these locomotives differs in some respects from American standard practice the following data may prove of interest:

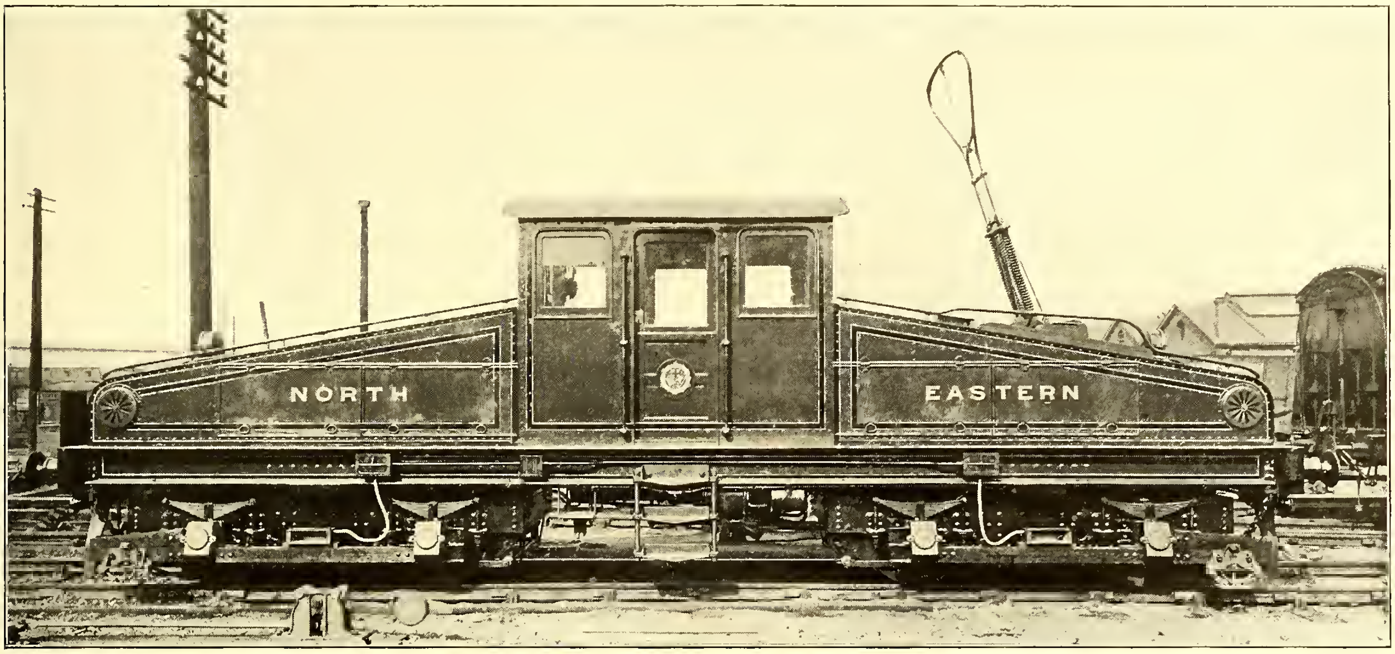
The locomotives are of the double-truck type with central cab and sloping ends, as shown in the illustrations, and weigh 50 tons when in running order. The motors are of the GE 55 type, with two turn armatures and 3.28 gear ratio, one being mounted on each of the four axles. The control adopted is the Sprague Thomson-Houston multiple unit system, and is similar to that used on the passenger trains. The leading dimensions are: Gage, 4 ft. 8½ ins.; length over central cab, 9 ft. ½-in.; length over headstocks, 35 ft.; length over buffers, 37 ft. 11 ins.; pivotal centers of trucks, 20 ft. 6 ins.; wheel base of each truck, 6 ft. 6 ins.; width over cab, 7 ft. 6¼ ins.; width over side soles, 7 ft. 10⅜ ins.; width over all, 8 ft. 8 ins.; height from rails to top of cab, 11 ft. 9 ins.; height from rails to the top of the floor, 4 ft. 3¾ ins.; diameter of wheels, 3 ft.; diameter of axles at the center, 6⅜ ins.; diameter of the axles at the journals, 6 ins., and length of journals, 10 ins.

The trucks are of the steel plate frame type and, in accordance with English railway practice, strengthened with steel angles and gussets with the swinging bolster built up with steel sections and steel castings. The bolster is supported on two nests of coil springs of circular section and is provided with cast steel wearing plates, cast steel center and side bearing plates. The side frames are supported on the axle boxes by laminated springs of heavy design. The axle boxes are of cast steel, machined to work in the horn plates, which are also of steel and machined, being riveted to the side frames which are cut out to receive them. The axle boxes are provided with babbitted wings to take the shoe beams and are fitted with heavy brasses. Ample provision is made for lubrication and exclusion of dust. The brake gear is of specially heavy design, as it plays an important part in the work that the locomotive has to handle, which is chiefly on heavy grades. Blocks are fitted to each side of each wheel, and all gear is heavy enough to stand operation by air pressure. The wheels are of the cast steel disc type, balanced and fitted with roll steel tires 5½ ins. wide by 2½ ins. deep on tread, held in place by retaining rings and also by eight set-screws. The motors are carried on the transoms by cast steel brackets, in which the nose of the motor rests, being held there by a forged strap. The shoe beams are of oak and bolted to the axle boxes, the shoes being hung outside the wheel base. All holes are drilled, edges of plates planed and rivets hand riveted.



CONNECTIONS OF SPRAGUE THOMSON-HOUSTON CONTROL TYPE M, FORM A, WITH C-12 CONTROLLER, AND FORM GE 55 MOTORS FOR THIRD-RAIL CIRCUIT

The underframe is constructed of steel sections and ballasted with cast iron blocks to bring up the weight desired. Each side sole is formed by a girder 12 ins. x 6 ins. x 54 lbs. and of I section. There are two center longitudinals each 8 ins. x 3½ ins. x ⅝-in. of channel section, these four longitudinals being connected at their side couplers and buffers are of the standard English pattern. The center cab is constructed of ⅛-in. steel plate and angles and is separate to the sloping ends, which are also constructed in a similar manner, all three portions being bolted to the underframe. The cab is provided with two side windows on each side, the one



ONE OF THE ELECTRIC LOCOMOTIVES WITH BOW COLLECTOR AND THIRD-RAIL SHOES, FOR THE NORTH-EASTERN RAILWAY COMPANY

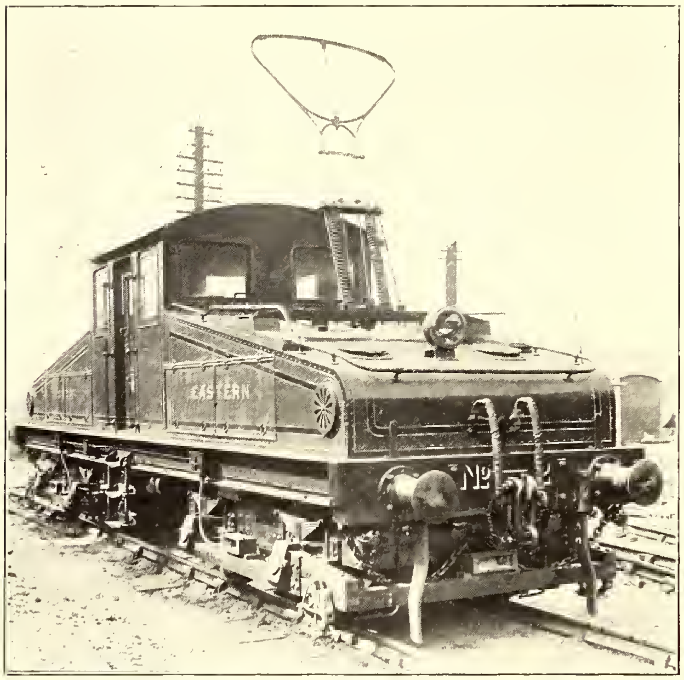
ends by headstocks 15 ins. x 4 ins. x ½-in. of channel section. To the front of these are bolted oak headstocks 15¾ ins. x 8 ins. The whole frame is firmly riveted with steel angles and gussets, all holes being drilled and edges of plates machined. The underframe bolster is formed by two girders each 6 ins. x 5 ins. x ½-in. at the driving corners being arranged to lower. A sliding door is fitted on each side, of ash, glazed at the top and paneled at the bottom, bearing on the outside the arms of the company in transfer. The doorways are 2 ft. 4 ins. wide and 6 ft. in the clear. At the ends of the cab are two windows arranged to slide transversely. Arrange-

A VIEW OF THE FREIGHT YARD AT NEWCASTLE, SHOWING OVERHEAD WIRES AND THIRD RAIL

of I section, held together on the top by a plate 3 ft. wide and ¾-in. thick, and on the lower side by a plate 17 ins. wide x ¾-in. thick. Between the bolsters evenly spaced there are three cross girders each 8 ins. x 3½ ins. x ⅝-in. of channel section, backed with a plate 15 ins. wide x ½-in. thick. On the top of the frame is a floor of fireproof wood 1⅞ ins. thick, fixed transversely with a top or lining floor of ⅞-in. thickness laid longitudinally. The draw gear, ments are made for driving the locomotive from each end of the cab, and it is therefore fitted complete in duplicate with master controller, air brake, sand and whistle valves. In the center of the cab is fitted a cast iron column to carry the hand brake gear. There is on each side a panel for the control and pump circuit accessories with a main panel at one end for main and control switches, etc. Air gages and ammeters are also fixed in each driving position.

Under the sloping ends are fixed the contactors, reversers and rheostats. The apparatus for each two-motor equipment is fitted in its own end of the cab, the four-motor equipment being thus split up into two equipments as far as possible. The contactors are supported from an angle-iron framing built on the floor of the cab, the reversers and resistances being bolted to the floor but raised above it so that the cable runways may run underneath them. The air brake is of the quick-acting pattern. Air is supplied by a British Thomson-Houston electrically driven compressor of the CP 14 type, which is hung underneath the frame. This compressor will compress against a pressure of 90 lbs. per sq. in. with a cylinder displacement of 20 cu. ft. per minute. The air reservoirs and sand hoppers are fixed in the ends of the sloping cabs. The sand is carried by flexible tubes to the fixed pipes on the trucks, the air operating pipes being connected to the same at the base of the hoppers.

A shaded lamp is fixed in each driving corner with three lights



AN END VIEW OF ELECTRIC FREIGHT LOCOMOTIVE USED BY THE NORTH-EASTERN RAILWAY

in each of the sloping ends and a headlight on each end. All lamps are of 32-cp and arranged for working six in series on a 600-volt circuit. Two portable lights are also provided.

As the locomotives have to operate over sections fitted both with overhead line and third rail, a sliding bow trolley has been provided in addition to the usual shoe-collectors. This bow automatically reverses according to the direction of travel of the locomotive, and is also capable of being lowered when not in use from the cab by a hand-wheel. Fig. 2 shows the diagram of connections and method of installing the apparatus and the wiring. All cables are asbestos covered, and are run either in wood troughing lined with uralite or in steel tubing. Besides being fitted with the nine-wire coupler at each end for the control circuit, bus or main line and pump line couplers are also provided, so that two locomotives can be coupled together if necessary and operated by one man

EXPANSION OF THE RAILWAY WORK OF THE FORD ELECTRIC & MANUFACTURING COMPANY OF ST. LOUIS

The Ford Electric & Manufacturing Company has purchased of the Rossiter-MacGovern Electrical Company its entire St. Louis manufacturing plant as well as all equipment and business pertaining to the manufacture and repair of electrical and steam machinery. It has reorganized the entire plant and now has one of the largest and best equipped electric railway repair shops in the Southwest. The company's plant is connected by switch with the tracks of the Terminal Railroad Association, and where necessary cars can be run into the shops for loading and unloading. Exceptional facilities enable the company to execute promptly all kinds of repair and constuction work.

PROGRAMME OF THE ST. LOUIS CONVENTION

The conventions of the American Railway Mechanical & Electrical Association will be held on the second floor of the Transportation Building, World's Fair Grounds, on Oct. 10, 11 and 14. The meeting for the first day is called at 10 a. m., and delegates are requested to register as soon after 9 a. m. as possible. The opening address will be delivered by John I. Beggs, vice-president and general manager of the Milwaukee Electric Railway & Light Company. In addition, the "Question Box" will be discussed and papers will be presented on "Maintenance and Inspection of Electrical Equipment," by John Lindall, of Boston; "Wheel Matters," by J. Millar, of Buffalo; "The Ideal Shop," by W. D. Wright, of Providence, and "Universal Car Body," by W. W. Annable, of Grand Rapids. The meeting on Oct. 14 will be a joint meeting with the Accountants' Association to discuss "Shop Records and Accounts." The report on this subject has been prepared by H. H. Adams, of Baltimore, and H. E. Farrington, of Boston, for the Mechanics, and H. M. Pease and W. G. McDole for the Accountants. This meeting will convene at 9:30 a. m. The headquarters of the American Railway Mechanical & Electrical Association will be at the Inside Inn.

The convention of the American Street Railway Association will also be held on the second floor of the Transportation Building, and will be called to order at 10 a. m. on Oct. 12 and 13. On Wednesday the association will be addressed by Hon. D. R. Francis, Hon. Rolla Wells, Mayor of St. Louis, and Prof. W. E. Goldsborough. In addition, papers will be presented on "Steam Turbines," "Reciprocating Engines," "Gas Engines," "Transfers" and "Signals." The banquet has been abandoned, owing to the difficulty of finding any place where a caterer could take care of a large number of people and the uncertainty surrounding the question as to the number of persons who would care to attend. The headquarters of the association will be at the Southern Hotel, where members should register and obtain their badges and other credentials, together with programmes of the meetings and entertainments. The registration office will be open all day Monday and Tuesday and on Wednesday morning.

The first meeting of the Accountants' Association will be held at 3 p. m., Oct. 13, in the parlor of the Inside Inn., at which the annual address of the president will be given and a report will be rendered by E. M. White, of Hartford, on "A New Collection of Blanks and Forms." The meetings on Oct. 14 and 15 will be on the second floor of the Transportation Building. That on Oct. 14 will be devoted to the joint report of the A. R. M. & E. A., mentioned above. On Oct. 15 the meeting will convene at 9:30 a. m. and a report will be received from C. N. Duffy on the "Standard System of Accounting." The "Question Box" will also be discussed.

PERSONAL MENTION

MR. D. W. McWILLIAMS has been appointed treasurer of the Interborough Rapid Transit Company.

MR. C. D. MALEADY has resigned as secretary, treasurer, general manager, superintendent and purchasing agent of the West Chester Traction Company, of Ossining, N. Y., to become connected with McMullen & Company, contractors, of Hartford, Conn.

MR. ARTHUR HARTWELL, who for a number of years has been general sales manager of the Westinghouse Electric & Manufacturing Company, has resigned that position to accept the position of general manager of the Sterling Varnish Company, of Pittsburg.

MR. MORIZ MARHOLD, operating manager of the Grosse Berliner Strassenbahn, of Berlin, Germany, is making a short trip of inspection of the street railways of this country. Mr. Marhold will visit Boston, Chicago, St. Louis, Philadelphia and a few other cities.

ANNUAL REPORT OF THE PHILADELPHIA RAPID TRANSIT

The stockholders of the Philadelphia Rapid Transit Company held their annual meeting last week. William H. Shelmerdine and J. J. Sullivan were re-elected directors for four years. The by-laws were amended to do away with the finance and executive committees and give the directors power to operate the road as a body. It was also agreed to have the directors meet on the first and third Mondays of each month instead of once a month.

The report for the fiscal year ended June 30, 1904, compares with the figures of that company for 1903 and with those of the Union Traction Company in 1902 and 1901, as follows:

	1904	1903
Gross	$15,923,507	$15,277,806
Operating expenses	7,993,314	7,234,892
Net	7,930,193	8,042,913
Other income	172,854	158,766
Total net	8,103,048	8,201,680
Taxes and licenses	1,060,896	990,701
Fixed charges	6,821,301	6,805,089
Surplus	220,849	405,888
Number of passengers carried	390,532,689	365,908,051

The Philadelphia Rapid Transit balance sheet as of June 30 compares as follows:

ASSETS	1904	1903
Cash	$598,150	$326,014
Fire insurance fund	850,000	850,000
Adv. leased lines	428,613	323,187
Supplies	569,742	905,598
Construction and equipment	7,266,308	2,013,458
Real estate	503,327	334,212
Accounts receivable	82,515	128,567
Sundry stocks	1,588,559	1,578,059
Franchise account	115,325	115,325
	$12,002,543	$6,574,424
LIABILITIES		
Capital stock	$8,984,680	$3,000,000
Second instalment account capital	......	79,370
Accounts audited not due	144,430	307,719
Fixed charges and taxes accrued	1,951,287	1,954,391
Operation accounts	299,470	827,055
Profit and loss	622,674	405,888
	$12,902,543	$6,574,424

At the annual meeting of the Union Traction Company, held just in advance of the Philadelphia Rapid Transit Company meeting, the stockholders approved of the mortgage for $1,000,000 on the new Philadelphia & Willow Grove Street Railway line and re-elected the directors without change as follows: Alex. M. Fox, John B. Parsons, Wm. H. Shelmerdine, J. J. Sullivan, P. A. B. Widener, George D. Widener, Geo. W. Elkins, Robert J. Balfour, John M. Mack, Geo. H. Earle, Jr., Joseph E. Widener, James H. Gay.

The Union Traction balance sheet as of June 30 compares as follows:

ASSETS	1904	1903
Cash	......	......
Fire insurance fund	......	......
Adv. leased lines	$4,417,956	$4,548,436
Supplies	......	......
Construction and equipment	6,868,362	6,856,308
Real estate	624,573	624,573
Accounts receivable	2,202	2,202
Stocks and bonds	5,220,467	5,220,673
Franchise account	90,248	90,248
Totals	$17,223,810	$17,342,447
LIABILITIES		
Capital stock	$10,500,000	$10,500,000
Union Traction 4s	1,500,000	1,500,000
Open account due Co.'s, 999 years	1,030,737	1,269,869
Deposits underlying companies	249,776	......
Trustees' accounts	120	......
Profit and loss	3,943,177	3,072,577
Total	$17,223,810	$17,342,447

The report of the treasurer of the Union Traction Company shows the following receipts and disbursements for the year ending June 30, 1904:

RECEIPTS	
Amount received from Philadelphia Rapid Transit for fixed charges	$6,294,449
Rental account	900,000
Total	7,194,449
DISBURSEMENTS	
Fixed charges paid	6,294,449
Dividend paid	900,000
Total	$7,194,449

The Philadelphia Rapid Transit report says:

The high prices of material and labor and the severe weather of the past winter materially increased the cost of operation.

Twelve and seventy-six one-hundedths miles of additional trackage were built and are now being operated.

About 15 miles of track were reconstructed—10 miles of the 15 miles with the new standard girder rail (137 lbs. to the yard).

Twenty miles of new conduits were laid, 3600 kw of new electrical machinery added and 134 large double-truck cars.

The work on the Market Street Subway "progressed favorably," and details of it are given.

Work on the line of the Philadelphia & Willow Grove Street Railway Company has been started, and that road should be ready for business next spring.

The fact is recited that on Oct. 1, 1903, $100,000 Thirteenth and Fifteenth Streets 7s fell due and were paid off, and $100,000 of 3½s issued in their place.

In regard to the law suit against the company over the purchase of the Doylestown & Willow Grove Street Railway Company, and the charge that $1,000,000 was paid for the property, the report says:

"The entire capital stock of the company, $500,000, was purchased for $20,000, and this company guaranteed the interest upon an issue of $500,000 4 per cent bonds."

The fire insurance fund consists of the following: 3650 shares Philadelphia Traction Company stock, 4674 shares Union Traction Company stock $100,000 Electric and Peoples' 4 per cent stock trusts, $20,000 Union Traction Company 4 per cent collateral trust mortgage gold bonds, $420,000 in first mortgage on real estate, $1,437.60 in ground rents, and $47,393.71 in cash.

AMONG THE MANUFACTURERS

THE SOUTHERN CAR COMPANY is a new industrial establishment located at High Point, N. C., in the finest timber section of the South. The company has secured the services of skilled car builders from the North, and is prepared to furnish high-class electric cars for both Southern and Eastern delivery.

SOUTHWORTH BROTHERS, of Portland, Maine, makers of the American transfer punch, a number of which are installed on Boston street railways, state that if railway companies will send them a pad of transfer slips they will be pleased to show wherein their machine is superior to other transfer punches.

THE LUMEN BEARING COMPANY, of Buffalo, N. Y., is building an extensive addition and reconstructing its old plant, and a large amount of improved and new machinery is being installed. When completed, the factory of this company will be a model of its kind for manufacturing anti-friction metals and bearings of every description.

COL. GILES S. ALLISON, president of the Security Register Company, left New York for St. Louis a week ahead of the convention. He is making extensive preparations to entertain liberally his many customers and friends during convention week. Delegates will be cordially welcome to inspect the exhibit of the Security Register Company in the Transportation Building, Section 29, Aisle C.

THE HEIL RAIL-JOINT WELDING COMPANY, of Milwaukee, reports contracts recently finished as follows: The Pittsburg Railway Company, of Pittsburg, Pa.; United Power Company, East Liverpool, Ohio, and the Cincinnati Traction Company, Cincinnati, Ohio. This company has installed over 8000 joints during the present year, and has contracts for welding in Illinois, Ohio and New Jersey.

THE MACON-EVANS VARNISH COMPANY has been organized in Pittsburg for the manufacture of high-grade varnishes and insulating materials, with office and works at Esplen Borough. L. S. Macon is president of the company, and Cadwallader Evans, Jr., secretary and general manager. Mr. Macon was for a number of years secretary of the Sterling Varnish Company, and Mr. Evans was formerly with the Oliver Iron & Steel Company, of Pittsburg.

THE JORDAN COMMUTATOR TRUING DEVICE for truing commutators can be applied to any dynamo or motor for truing the commutator, thereby saving the labor, expense and delay of removing armature and placing it in a lathe. It also does away with the danger of the diamond-point tools digging into the bars of the commutator and also the dragging of copper across insulation between bars, thereby short circuiting same. This device is especially recommended by its makers, Jordan Brothers, of New York City, for Siemens-Halske dynamos and all dynamos having large diameter commutators on same.

IN THE ARTICLE ON THE CINCINNATI CAR COMPANY'S EXHIBIT at the St. Louis Exposition, which appeared in the STREET RAILWAY JOURNAL for Sept. 24, mention of the Wm. C. Baker heater was omitted through oversight. The car in question is equipped with Wm. C. Baker double-coil perfected heaters. The car will be found on the test track, just north of the Transportation Building, and all delegates to the street railway conventions are invited to inspect it.

A TEXT BOOK ON STORAGE BATTERIES could not treat the subject in a more valuable fashion than has been done in the neat celluloid-covered pocket booklet given out by the Electric Storage Battery Company, of Philadelphia. Consideration is given to the construction and use of storage batteries for varied kinds of work, together with appropriate illustrations. Additional value is lent to the book by the well-compiled electric railway engineering data, supplementary to the main topic.

THE BURT MANUFACTURING COMPANY, of Akron, Ohio, reports that it has recently sent one of its large oil filters to the National Steel & Wire Company, at New Haven, Conn., where it has already sold a number of its Cross oil filters. It has also recently sold two Warden oil filters to the Lehigh Valley Coal Company. Two of its 150-gallon oil filters have also been sent to the LaBelle Iron Works, Steubenville, Ohio, for use in connection with an oiling system which this plant operates.

THE SCOTTDALE FOUNDRY & MACHINE COMPANY, successors to Kenney & Company, Scottdale, Pa., has recently added to its already extensive line a very up-to-date design of Corliss engine built in all combinations to suit various kinds of service. The company makes only the heavy-duty style of bed, believing that the girder frame is becoming obsolete. It has published a neatly illustrated catalogue describing the principal features and construction of its improved Corliss engines.

ALL THE TIMBER to be used as the permanent floor of the new Morrison Street Bridge at Portland, described in the Sept. 24 issue, comprising some 400,000 ft. of lumber, as well as the Nicholson paving blocks covering the surface of the roadways, is to be treated with Avenarius Carbolineum as a preservative against dry or damp rot. The Carbolineum Wood Preserving Company, which supplies this compound, guarantees that it will keep the timber and blocks in perfect repair for a number of years.

THE UNITED RAILWAYS & ELECTRIC COMPANY, of Baltimore, has recently placed an order with the Mayer & Englund Company, Philadelphia, for 300 International single-type fare registers, which are to be used in the new cars recently ordered of the J. G. Brill Company. This makes a total of 1100 International registers purchased by the United Railways, so that nearly all the regular scheduled cars in Baltimore are equipped with International registers. The Mayer & Englund Company has, in addition, secured numerous smaller orders for those registers recently, including seventy-five for the Coney Island & Brooklyn Railroad, seventy-five for the Brooklyn Heights Railroad, fifty for the Capital Traction Company, Washington, D. C., and fifty for the Conestoga Traction Company, Lancaster, Pa.

THE TROLLEY SUPPLY COMPANY, of Canton, Ohio, has just issued a fine catalogue thoroughly describing its various types of the Knutson trolley retriever and American catcher. The booklet contains many enthusiastic testimonials from railway managers evidencing their satisfaction with the reliability of the Knutson retriever under all kinds of operating conditions. In this connection it is interesting to note that the cars of the Intramural Railway at the St. Louis Exposition have been equipped with Knutson trolley retrievers. The manufacturer invites those who are not familiar with them to take advantage of this opportunity to study their action under actual service conditions. The retrievers and American catchers are also on exhibition at the exhibit of the company's agents, the Wesco Supply Company, of St. Louis, who will give courteous attention to all inquiries, and take pleasure in demonstrating and explaining the machines.

THE ANNUAL MEETING OF DICK, KERR & COMPANY, LTD., was held in London, on Sept. 27, 1904. The profits earned during the year ending June 30, 1904, amount to £84,170 17s. 2d. The debenture and loan interest and trustees' fees and premium payable on the redemption of the present debenture stock absorb £14,441 11s. 9d., leaving a balance of £69,729 5s. 5d., to which must be added the profits brought forward from last year, viz., £35,544 18s. 7d., making a total of £105,274 4s. available for appropriation as under a dividend of 6 per cent per annum on the preference stock, and a dividend of 10 per cent on the ordinary was declared. In addition, £21,051 was charged to reserve, leaving a balance of £39,922. During the past year the company has completed, among other important contracts, the electrification of the Lancashire & Yorkshire Railway, between Liverpool and Southport, and the Hong Kong and Mandalay electric tramway systems, and is at present busily engaged in Tokyo, Singapore, Bangkok, and other places in Great Britain and abroad.

THE POWER & MINING MACHINERY COMPANY has been awarded a contract by the Western Gas & Fuel Company for one two-cylinder American-Crossley gas engine, 28 ins. x 36 ins., single-acting; speed, 130 r. p. m.; normal brake-hp, 510, maximum, 570; direct connected to two Ingersoll-Sergeant 14¼-in x 36-in. single-acting compressors; cylinders located in tandem to the gas cylinders. This plant is to be used for compressing gas entering the cylinders at an initial pressure of 50 lbs. and discharging at 350 lbs. Making the compressors single acting and in tandem with the gas-engine cylinders not only gives the advantage of direct connection, but does away with the necessity of high-pressure stuffing boxes in the gas compressor cylinder heads. The gas will enter the compressor cylinder at the end nearest the gas engine, and will pass through the piston inlet valve to the other side on the forward stroke of the engine, compressing on the return stroke. This construction permits of minimum clearance in the compressing end of the cylinder, and at the same time effectually prevents any chance of leakage of gas into the room; any leakage past the piston, as will be seen, returns to the inlet side. The company's guarantees cover the gas consumption of the engine when operating at rated load, at 500 brake-hp, at which load it has guaranteed a gas consumption of 11½ cu. ft. of natural gas having a calorific value of 1000 B. T. U. per cubic foot. The company has further guaranteed that with 1000 cu. ft. of gas used in the gas engine, of this value, 36,480 cu. ft. of gas per minute, measured at atmospheric pressure, will be delivered. It is a well-known fact that gas-pumping plants in Indiana and Ohio at the present time are using practically 25 per cent of the output of the wells for pumping. The plant to be installed by the Power & Mining Machinery Company will easily do the work on 3½ per cent.

THE STUART-HOWLAND COMPANY, of Boston, Mass., reports good business for the season in its overhead material and railway supplies. The company is at present equipping part of an electric railway in Canada, 120 miles long, with its brackets, cross-arms and other supplies pertaining to the overhead construction of the road. About 10 miles of this road has already been graded, poles set and Stuart-Howland overhead material strung. As soon as other sections of the road are built this company will furnish material for the overhead construction until the road is completed. This company, besides doing an extensive business in the Eastern States, as well as other parts of the country, has for the past three years paid particular attention to Canadian and foreign trade. Substantial foreign orders have been filled from time to time and shipped, especially to the eastern part of Canada. Ample storeroom, large quantities of all classes of railway material in stock and an efficient business organization enable this company to do business with promptness and despatch.

A FINE OPPORTUNITY is offered some park to get the World's Fair steel double "shoot the chutes," built by Capt. Paul Boyton. Capt. Boyton's reputation as the builder and patentee of the principal chutes of the world is well known, and this, his latest "chute," is said to be the largest and finest ever built. Instead of being a single one, it is double, so that the boats can race down the "chute" with each other and add fun and excitement to the attraction. The people are allowed to get in the boats at the bottom of the "chute," avoiding the walking up or riding up in cars and the change of boats. The new system has proved to be a great success at the Exposition, especially causing people to ride over and over again, as they do not have to get out of the boats at all. The "shoot the chutes" has been a great success financially. There have never been any accidents, in fact, the many protections that Capt. Boyton devised removed all dangers to such an extent that the company operating it at the Exposition did not take out any accident insurance. A. R. Rogers, president of the Pike Financing Company, at the World's Fair, has the matter in charge.

THE LOCKE INSULATOR MANUFACTURING COMPANY, of Victor, N. Y., is at present constructing an elaborate and extensive fireproof electrical and chemical laboratory. A 200-kw motor generator and an immense transformer are being installed. Current will be taken direct from the railway circuit of the street railway company, which passes through Victor. The main idea of the installation is to conform as closely as possible to actual operating conditions. Current from the railway circuit will be transformed to as high as 300,000 volts to 500,000 volts. With this enormous voltage, new and improved designs of insulators will be tested, primarily to find out how high a voltage an insulator can take before it crumbles or is punctured. After this fact is ascertained, designs of insulators of each particular class is completed, the insulators are manufactured, tested for the particular voltages they are to carry, and shipped ready for use. Elaborate and sensitive instruments have also been installed to test chemically the constituents and elements of the clay and other matter which enters into the construction of the insulators. The mechanical strength of insulators will also be investigated to the fullest extent. The officers of the company state that they intend to have a laboratory, when completed, whose duplicate can not be found in the United States or abroad for the class of work for which it was constructed.

WINTER PLEASURE TRAVEL

The tide of travel is now southward bound. The Southern Railway, as usual, has its schedules so arranged as to give those going South, Southwest, Mexico and California a most delightful service. Through Pullmans are operated daily from New York, touching all of the prominent cities South and Southwest. The Southern Railway operates its own dining-car service on all through trains, which is of the highest standard of excellence. For full information, call on or address New York offices, 271 and 1185 Broadway. Alexander S. Thweatt, Eastern passenger agent.***

THE RAILWAYS PROTECTIVE ASSOCIATION

In the STREET RAILWAY JOURNAL of July 9, under the heading "Protection from False Claims," reference was made to a proposed railway protective association suggested by L. E. Drummond, of Drummond's Detective Agency, New York. Full details were then given of the methods to be adopted to protect members of the association from accident fakirs. The association is now about ready to be launched. The agency has been collecting data right along for its files and agitating the matter among the Eastern railway companies, all of whom think very well of the idea, as it has appealed to them as a positive necessity at the present time, in view of the large amounts spent by them to satisfy accident claims.