Street Railway Journal

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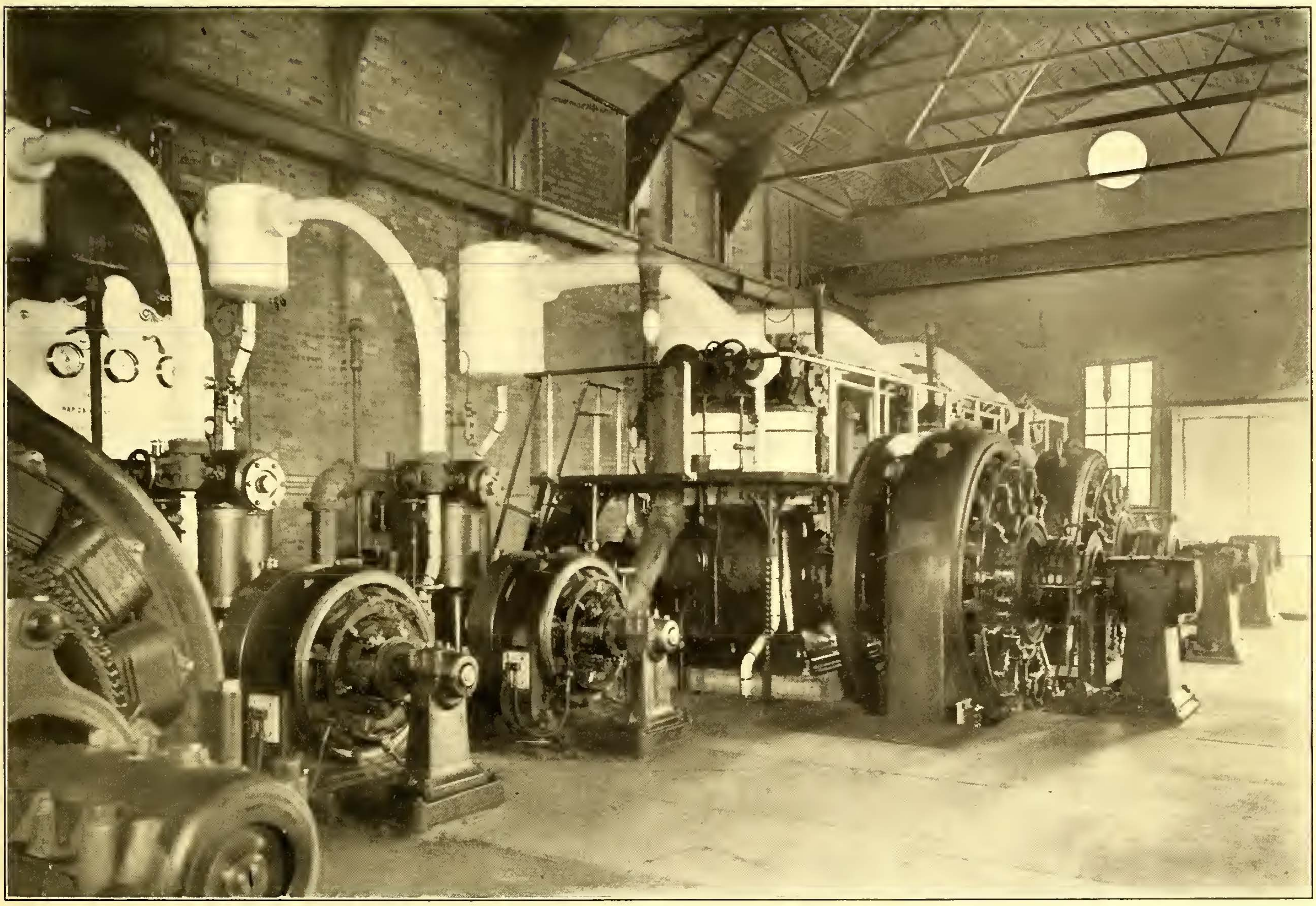
GRAND RAPIDS, GRAND HAVEN & MUSKEGON RAILWAY

One of the most interesting examples of electric interurban railway construction in the United States is presented in the Grand Rapids, Grand Haven & Muskegon Railway system, which has lately been opened for passenger and freight business. This line connects the two most important ports on the east coast of Lake Michigan with Grand Rapids, which is the second largest city of Michigan and a very important manufacturing center. The principal offices of the company are at Grand Rapids, and the railway may be considered one of that city's enterprises, as it is identified very closely with its industries.

The road extends from Grand Rapids in a northwesterly direction to Muskegon, with a branch leading to Spring Lake and Grand Haven from Grand Haven Junction, which is a point on the main line near Fruitport, passing in its course through a number of small towns and villages and a rich farming country. It will be noticed that the route, which is traced on a map presented on page 3, follows a very direct course, and this gives the company a material advantage over competing lines which deviate considerably for the purpose of reaching smaller points.

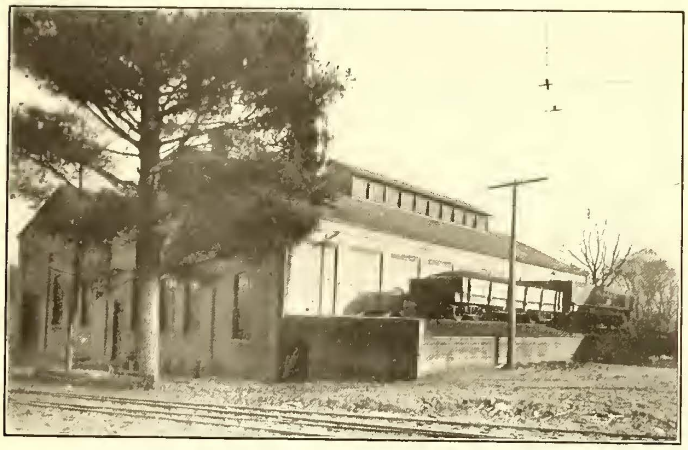
The road was designed primarily to be operated along the same general lines as a steam railroad, and to engage in general passenger and freight business. It is an innovation in electric railroading in many respects, and the selection of this territory proved exceptionally favorable for carrying out the idea of the builders. It presents an opportunity to operate an electric railway as a factor in a general system



ENGINE ROOM IN POWER HOUSE AT FRUITPORT

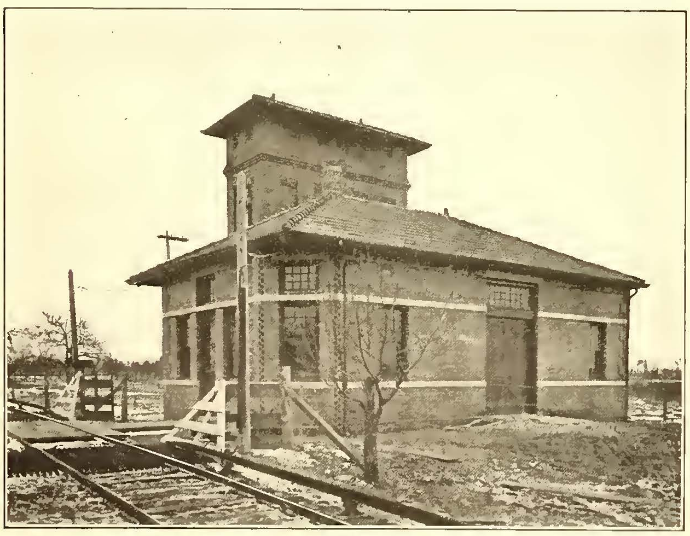
of transportation in conjunction with steam and lake traffic under favorable conditions, at the same time competing with steam lines for the business between Grand Rapids, Muskegon, Grand Haven and other important points along the line. The company has already developed a large passenger business, and it is now handling considerable freight, although its terminal facilities have not yet been entirely completed.

An idea of the possibilities of this system and the scope of its operation may be gathered from consideration of the value, character and volume of the industries located in the cities and towns which this line reaches. First of all is Grand Rapids, the second city in Michigan in population and the largest furniture manufacturing city in the world, It also produces more plaster paris than any other city or section of the United States, and the milling and railroad interests are extensive. The city has the additional advantage of being the wholesale distributing center for the northern and western portions of the lower peninsula of Michigan. Next in importance is Muskegon, on Muskegon Lake, one mile from Lake Michigan, which, with Muskegon Heights, comprises a population of upwards of 26,000.



EXTERIOR OF POWER STATION AT FRUITPORT

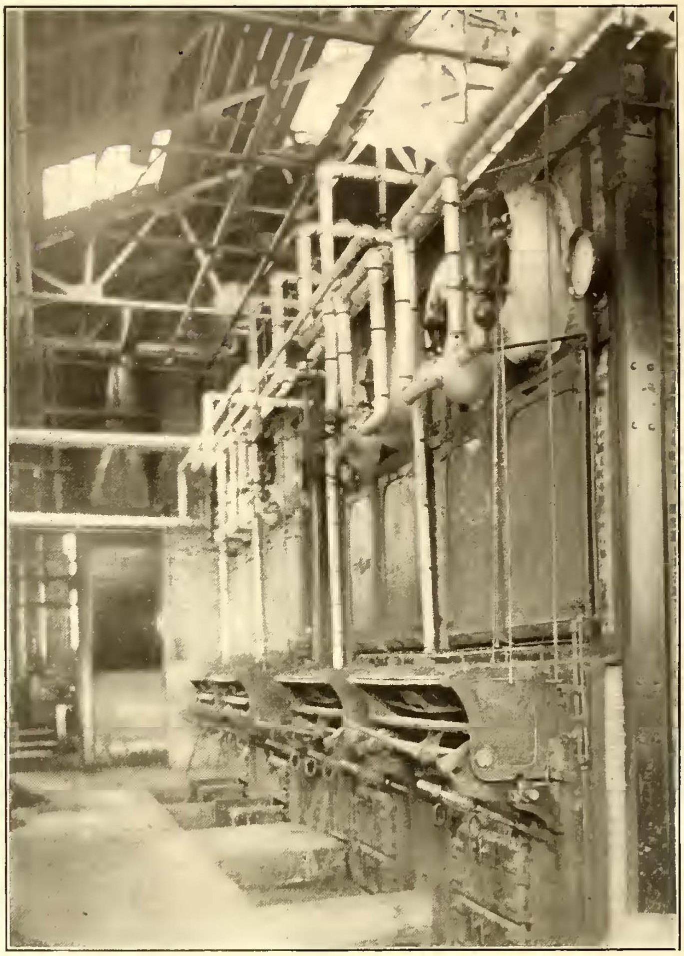
This section was formerly prominent for its great lumber cut, and while there are still a number of mills cutting lumber, the relative importance of the industry has lessened with the disappearence of the timber, and the industries of the place have been changed so that they are now quite diversified, and include rolling mills, tin plate mills, sulphite and paper mills, knitting factories, furniture and machine shops, which is really a favorable transformation for railroading. Grand Haven, which has 5000 inhabitants, has not made as good progress as Muskegon in rearranging its industries since the disappearance of the timber from the surrounding country, but it has done considerable toward recovery from the depression that followed the completion of its cut. Several large factories have recently been built, and others are contemplated, as the city offers many inducements to manufacturers. Ferrysburg, across the river



WALKER SUB-STATION, SHOWING THIRD RAIL CONSTRUCTION

from Grand Haven, contains a shipyard capable of building the heaviest dredges used by the government on the lakes, and this adds to the general volume of freight for this section.

In the matter of passenger service the road is equally fortunate, as it passes through many points where attractions may be offered that will stimulate patronage, especially during the summer months. Across Spring Lake outlet from Ferrysburg, for instance, is the village of Spring



BOILER ROOM IN POWER STATION AT FRUITPORT

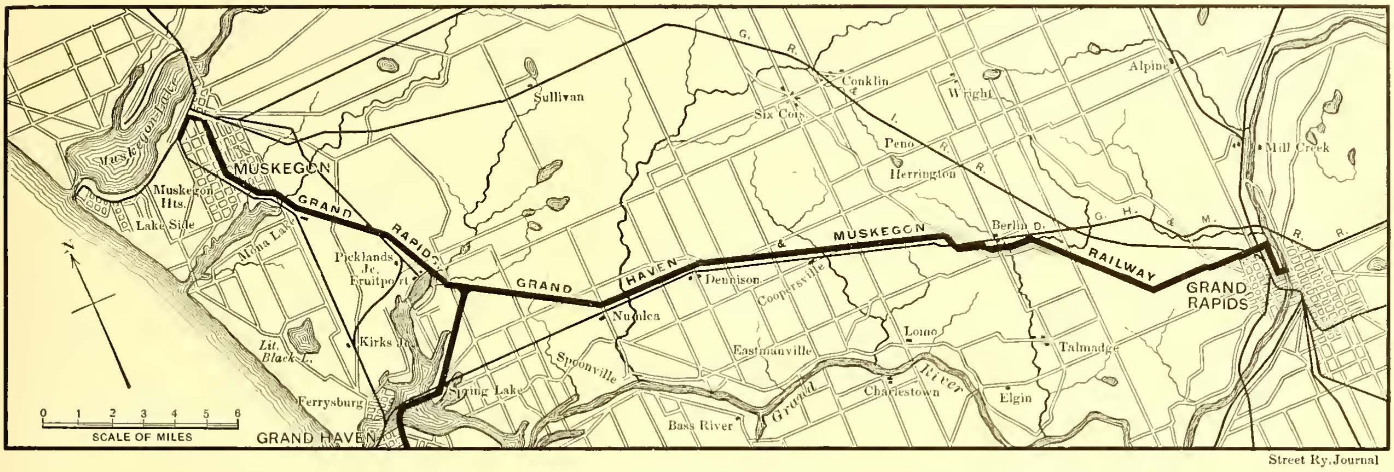
Lake, beautifully located on Spring Lake, and containing several summer hotels, making it quite popular as a summer resort. The shores of Spring Lake are well built up with summer cottages owned by Grand Rapids, Chicago,

COOPERSVILLE SUB-STATION, SHOWING OVERHEAD CONSTRUCTION

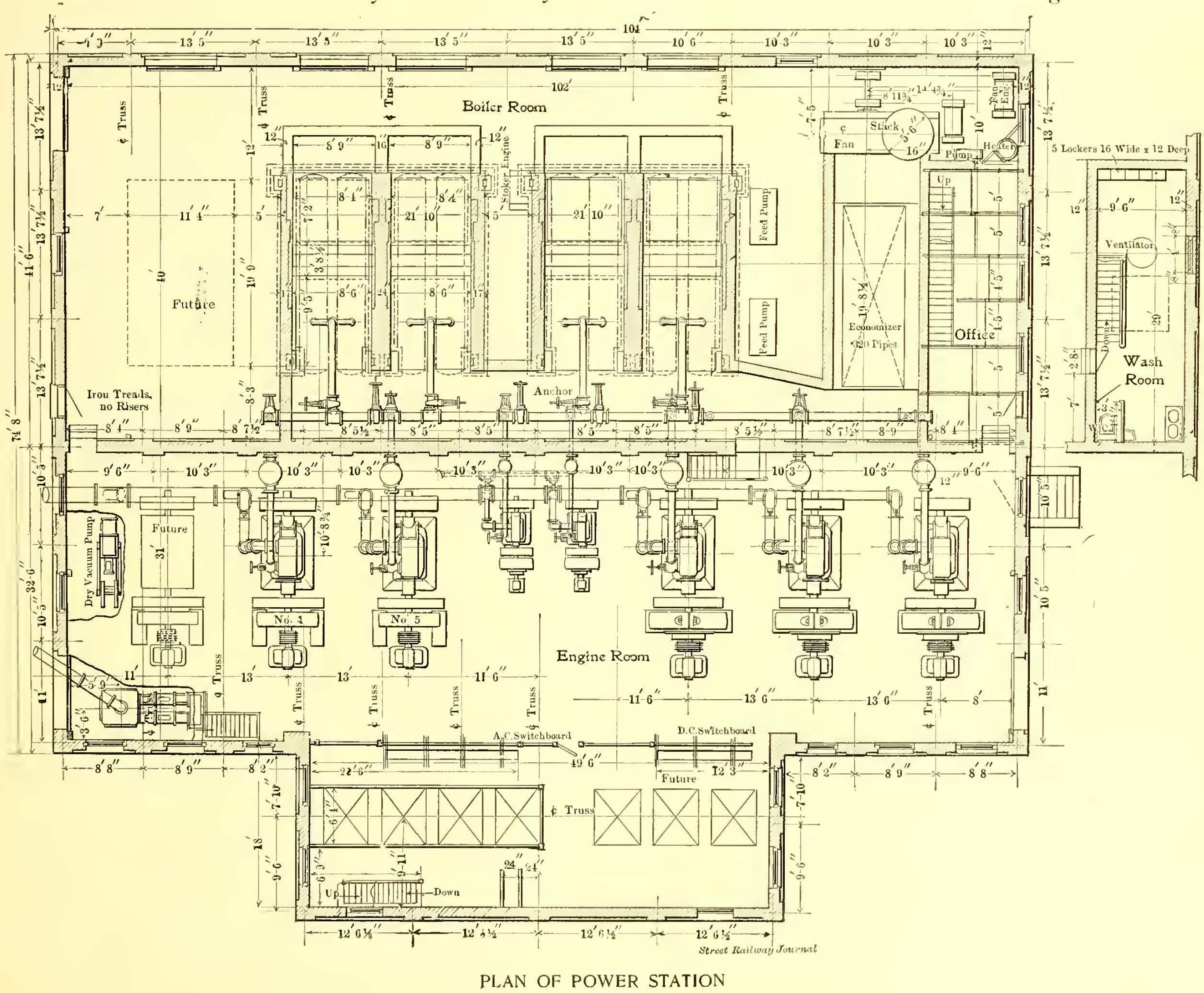
Milwaukee and Louisville people, and there are several good summer resort hotels at well selected points. The lake is probably the most beautiful sheet of water and presents the finest natural scenery in Michigan. The railroad company operates boats in conjunction with its cars, both for giving access to the several landings along the lake and to afford a cool evening boat ride as a part of an excursion trip from Grand Rapids. Spring Lake extends from the village of Spring Lake in a northwesterly direction with jutting arms a distance of seven miles in its longest axis to the main line of the road at Fruitport. At this point the power house and car shop and car storage buildings are located, and from here direct current is transmitted northwest to Muskegon and southwest to Grand Haven and east to Coopersville. Sub-stations, illustrated on page 2, for the distribution of direct surrent are located at Coopersville and in the township of Walker.

The construction features of the system are worthy of special attention. The road is a single track line with frequent turnouts, and follows the shortest route rather than the highway in traversing the country. This enables high speed to be made, although stops are frequent, as it tends to localize stopping places. In the small towns combination freight and passenger stations have been constructed. Those at Walker and Cooperville are combined with the sub-stations, containing the rotary converters and other transforming equipment required for the distribution system.

The main line of the railway is 35 miles in length, and the branch to Grand Haven is seven miles long. The distance

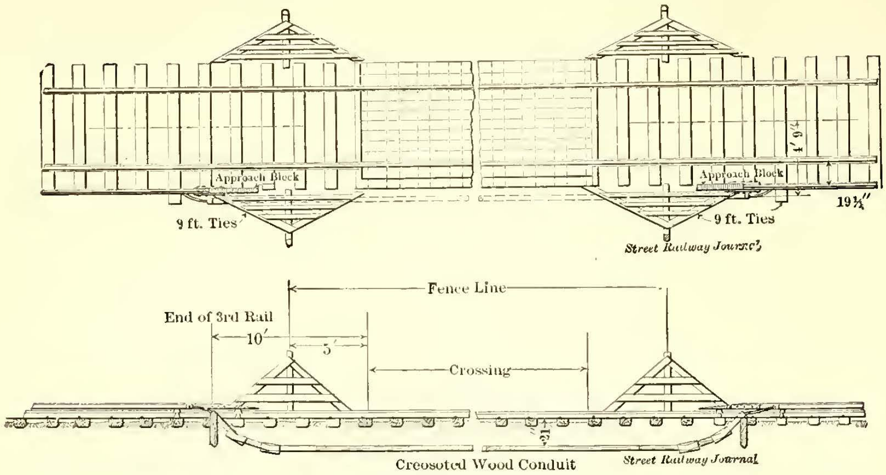


MAP SHOWING ROUTE OF GRAND RAPIDS, GRAND HAVEN & MUSKEGON RAILWAY

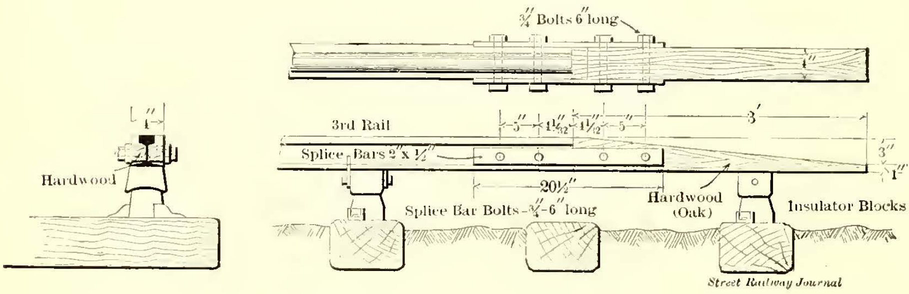


PLAN OF POWER STATION

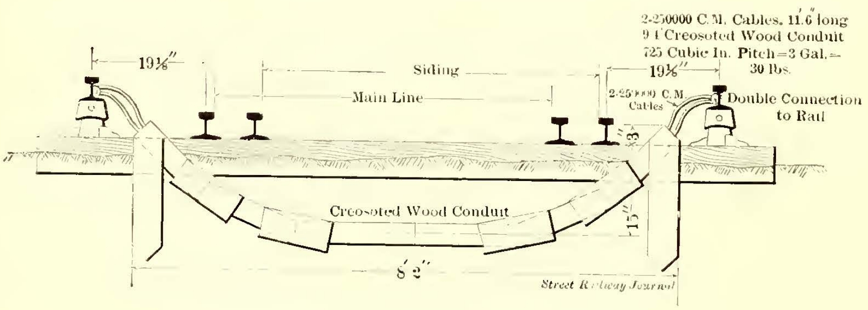
from Grand Rapids to Muskegon is one mile less than the shortest steam road between those points, but the distance



HIGHWAY CROSSING



DETAILS OF APPROACH BLOCK



CROSS CONNECTION FOR THIRD RAIL

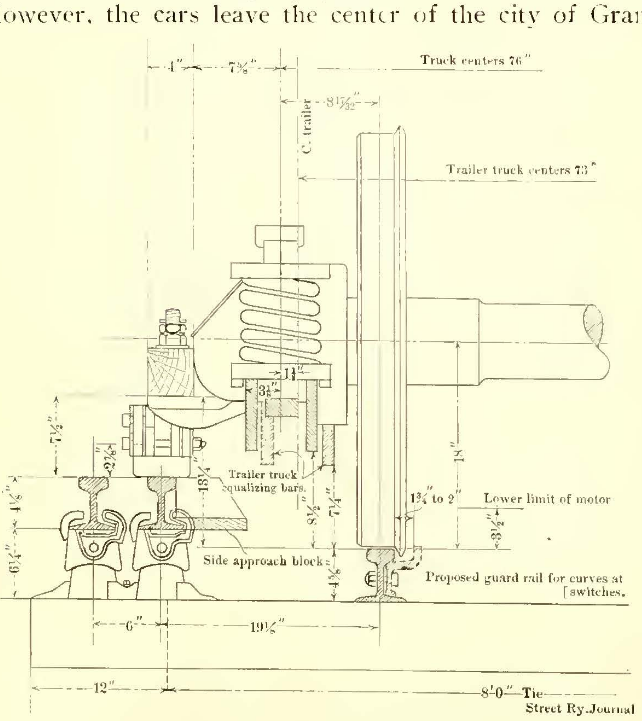
to Grand Haven is slightly greater than the steam road. However, the cars leave the center of the city of Grand Rapids, and the actual running time of the electric road is not far from that required to go by steam trains, while the greater prominence of the terminal cities makes it possible to operate a much more frequent service for Grand Haven than would be possible had an effort been made to make the Grand Rapids-Grand Haven route shorter. The line from Muskegon to Grand Haven has been found to be quite popular with the traveling public.

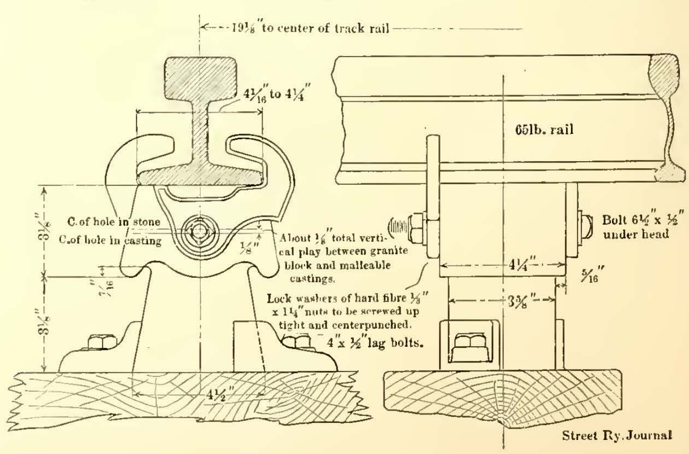
The road is constructed with standard steam railroad ties and 70-lb. T rail, double bonded at the ends for the return circuit.

An interesting feature of the equipment is the fact that both overhead and third-rail construction are employed. The road controls its own right of way for the greater part of the distance between the several cities and towns along the line, but in passing through these towns and in entering the cities it uses the lines of the local system. For this reason it has been found necessary to have motor cars equipped with an overhead trolley arm as well as a contact-shoe. The third-rail system is employed on all portions of the line where it is practicable. In the towns and villages, of course, it is not practicable, as there is no difference in the grade at the crossings, and on these portions of the line an overhead trolley is used. Nearly all of the right of way outside the villages and towns is enclosed by wire fences, except at the crossings, which are all provided with cattle guards. The third rail is open at crossings, of course, and at such points the ends of the sections of third rail are connected by large copper conductors, well insulated and embedded in pitch, which is poured into an underground conduit. Details of the construction and insulation of the third rail are illustrated on this page. The rail is of 65-lb. section and standard composition. It is supported upon reconstructed granite insulators, and has been exceptionally free from trouble through the bad washouts and trying months of the spring.

There are no railroad grade crossings on the line, all steam roads being crossed on steel bridges.

The power house is of brick, iron and tile construction throughout. The carefully laid red brick walls, with red





DETAILS OF THIRD-RAIL INSULATOR, SHOWING LOCATION OF RAIL tile roof, present a very neat appearance. Along the boiler room side of the building is the coal bunker, capable of holding 500 tons of coal, which is reached by an elevated track connecting with the steam railroad. This provides for the storage of coal in front of the boilers and protects it from the weather. Coal is handled from the cars into the bunker by gravity and shoveled directly from the bunker into the mechanical stokers, the plant not being large enough to require coal-handling machinery.

The power plant contains five 250-kw Westinghouse generators, three of which are double-current machines and two regular alternators. They are engine-type machines, and are directly connected to Westinghouse vertical compound engines, having steam cylinders 18 ins. and 30 ins. in diameter, by 16-in. stroke of piston. They are arranged for operation in multiple.

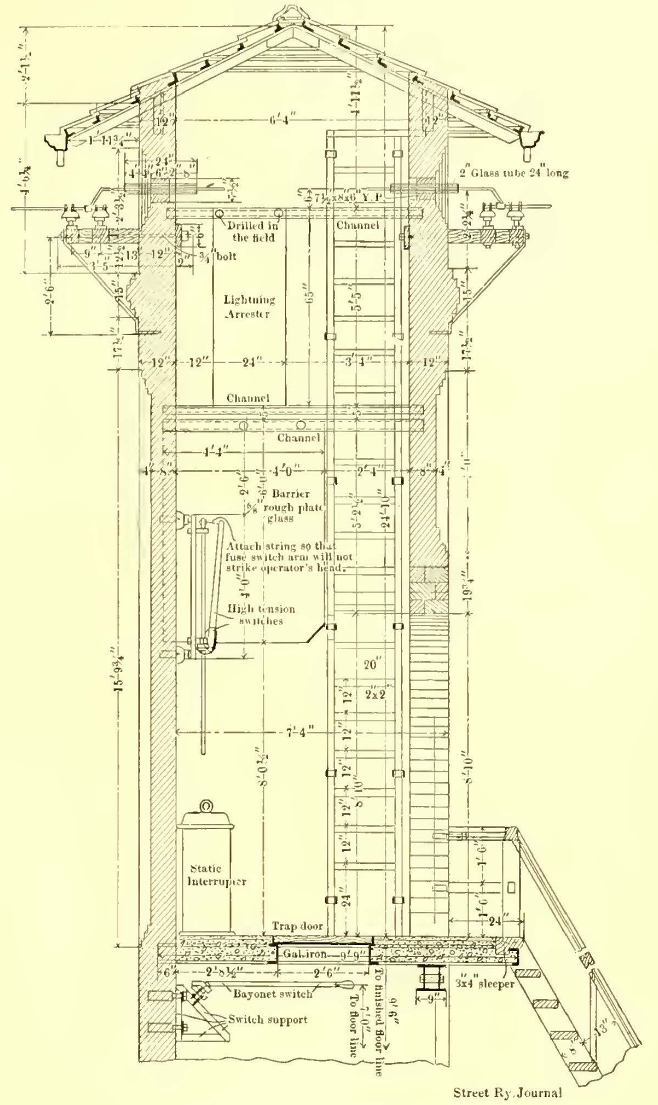
Excitation current is furnished by two 37½-kw Westinghouse engine-type exciter generators, directly connected to Westinghouse vertical compound engines.

Steam is supplied by four 250-hp Babcock & Wilcox boilers equipped with Roney mechanical stokers, and condensation is effected by means of a Worthington elevated jet condenser. Economizer and mechanical draft plant supplies draft and heated feed water for the boilers, and the waste exhaust from auxiliary engines is saved. The economizer is of the circulating type and heats the water nearly to boiler temperature. The feed pumps are of the Henry R. Worthington outside end-packed pressure pattern, and are in duplicate. The piping of the station is on the feeder and main principal, and any section of pipe can be easily isolated and repaired. All valves are of outside screw and yoke pattern, even to the smallest drip valves, and are furnished by the Chapman Valve Manufacturing Company.

The switchboard is of the regular Westinghouse type, and, as at present installed, appears as two boards, but when the power house is extended the board will be continuous and fill the gap in the alcove shown in the plan of the power station, which will be found on page 3.

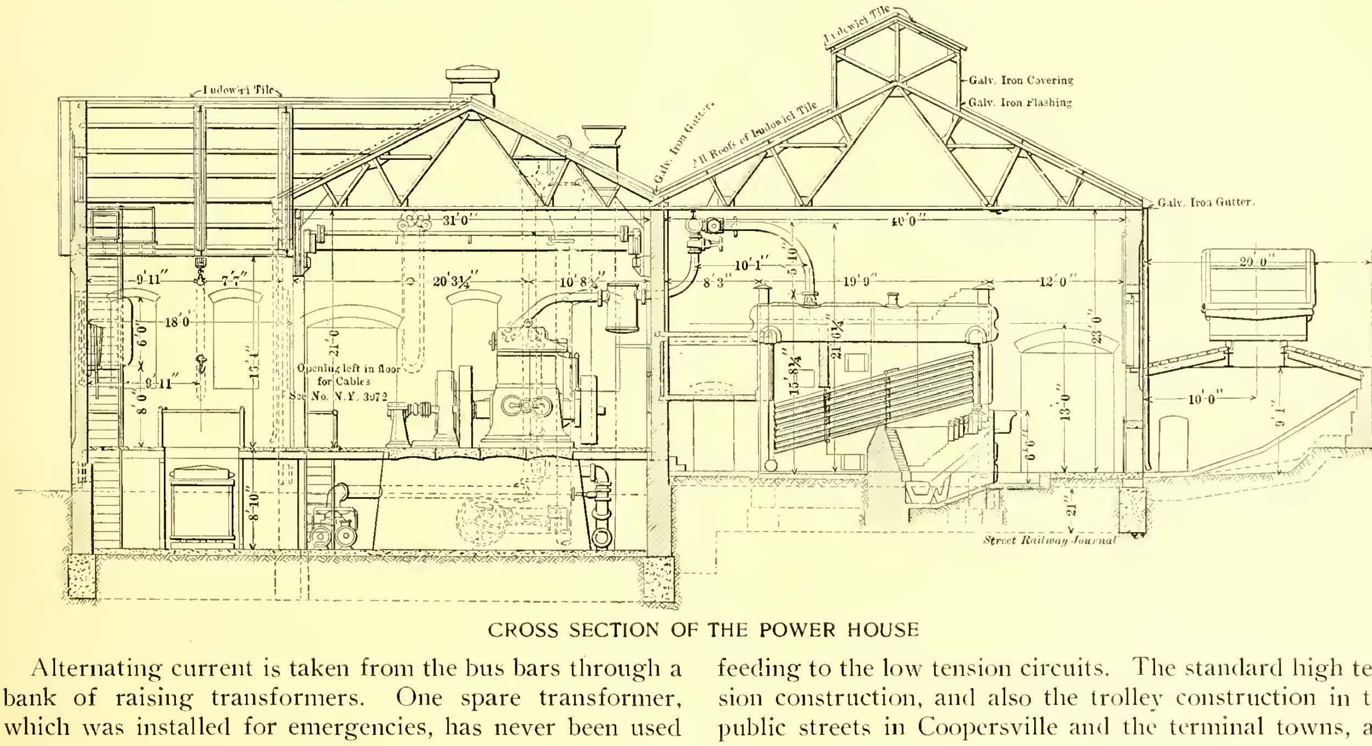
Direct current is generated at a pressure of 650 volts, and is fed directly to the third rail through two panels, one connecting with the rail toward Muskegon and the other reaching toward Grand Rapids, the arrangement of feeders being such that if the circuit in one direction is in trouble it may be cut out without interfering with the other section.

except to test it for assurance that it is ready for service. The transformers raise the voltage from 370 volts to 16,500



TOWER OF A SUB-STATION

volts, and transmit it directly to the sub-stations at Coopersville and Walker, where it is reduced and converted for



CROSS SECTION OF THE POWER HOUSE

Alternating current is taken from the bus bars through a bank of raising transformers. One spare transformer, which was installed for emergencies, has never been used

feeding to the low tension circuits. The standard high tension construction, and also the trolley construction in the public streets in Coopersville and the terminal towns, are shown in the detail on this page. The standard construction of a farm or highway crossing with third rail is shown on

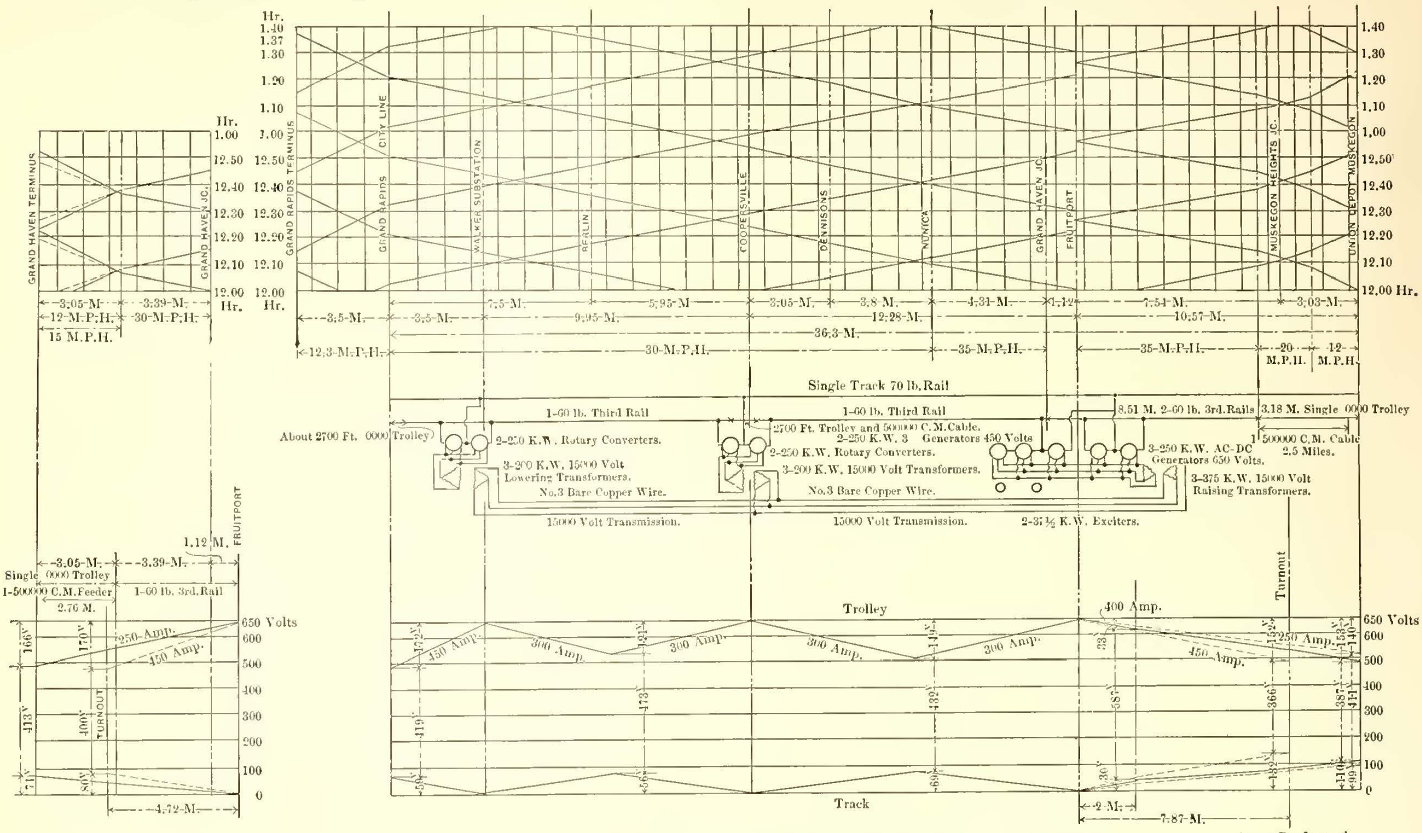
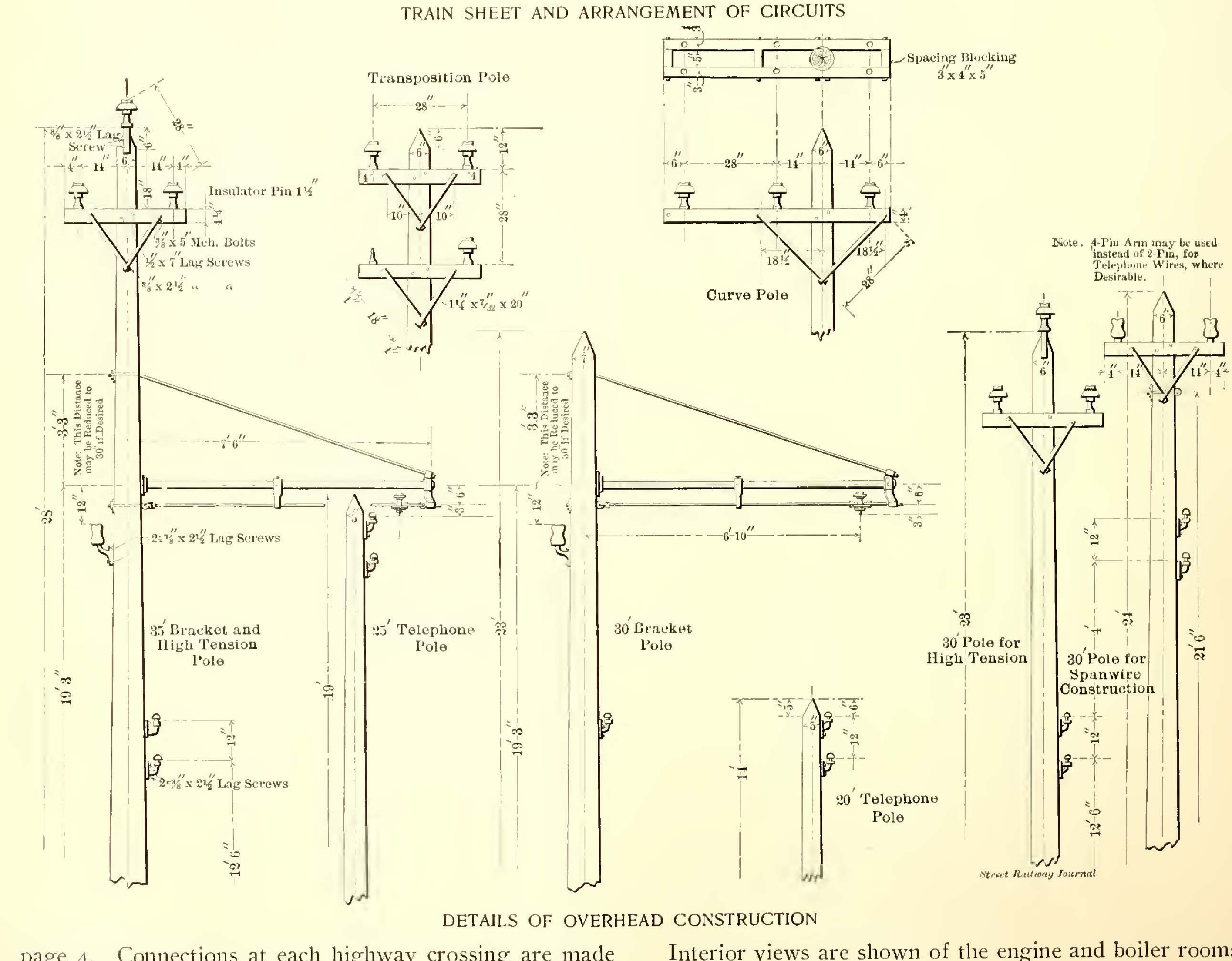


Diagram of Fall of Potential in Feeders and Track.

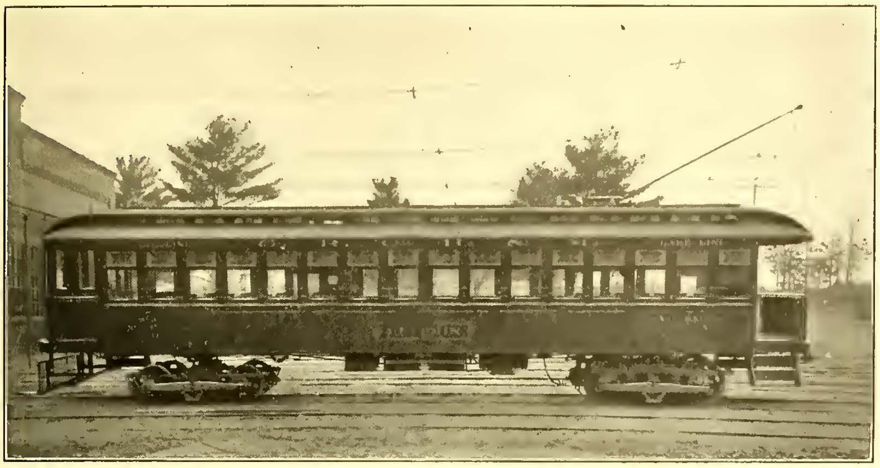
TRAIN SHEET AND ARRANGEMENT OF CIRCUITS



DETAILS OF OVERHEAD CONSTRUCTION

page 4. Connections at each highway crossing are made with two 500,000-cm copper cables. The general arrangement of the circuits is illustrated on this page, together with the schedule and low-tension drop in voltage.

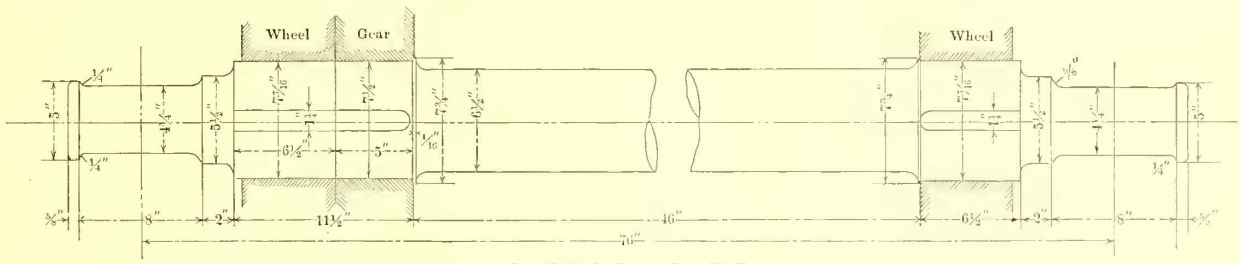
Interior views are shown of the engine and boiler rooms on pages 1 and 2, and an exterior view of the power house on page 2. The sub-stations are of brick, iron and tile throughout, and have been carefully arranged. General views of the exterior of the Walker and Coopersville sub-



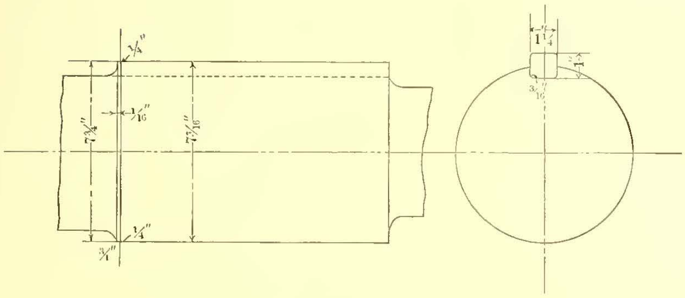
TYPICAL PASSENGER COACH

stations, as they appeared during construction, are shown. The surroundings have been somewhat improved since these pictures were taken.

The details of the arrangement of the apparatus in the

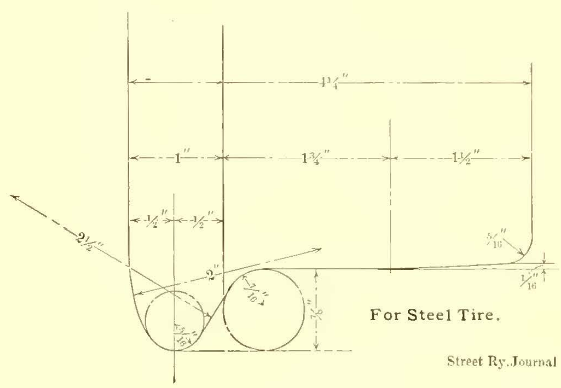


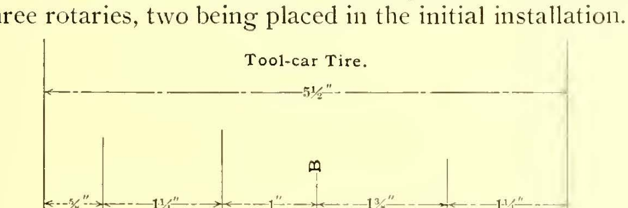
PASSENGER CAR AXLE

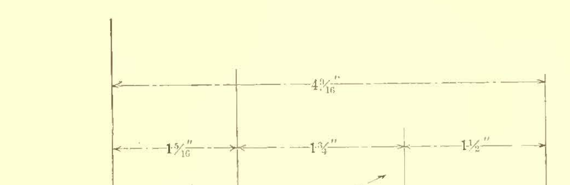


WHEEL FIT

towers of the sub-stations are shown, page 5. Each sub-station is provided with sufficient space to accommodate three rotaries, two being placed in the initial installation.



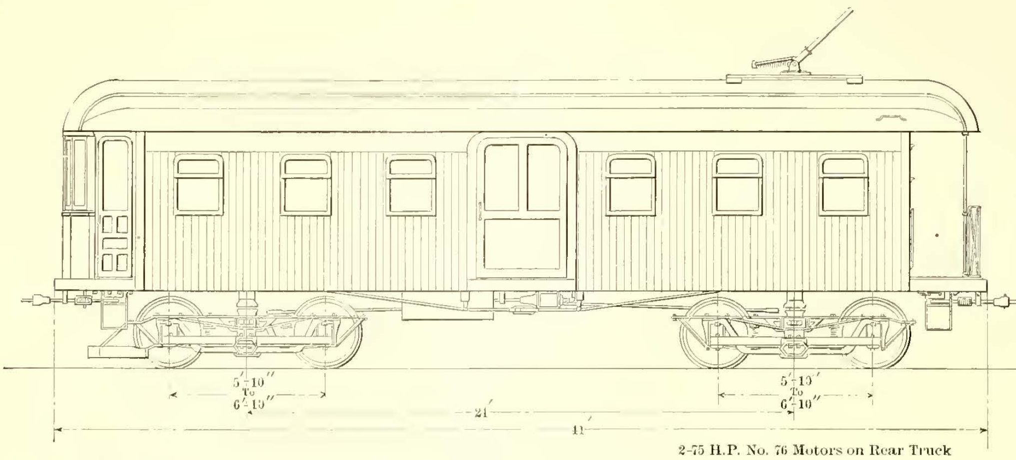


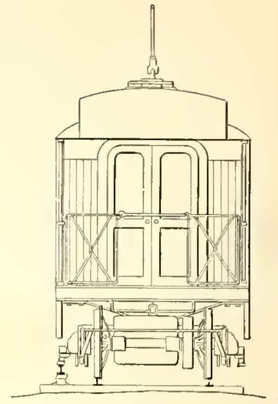


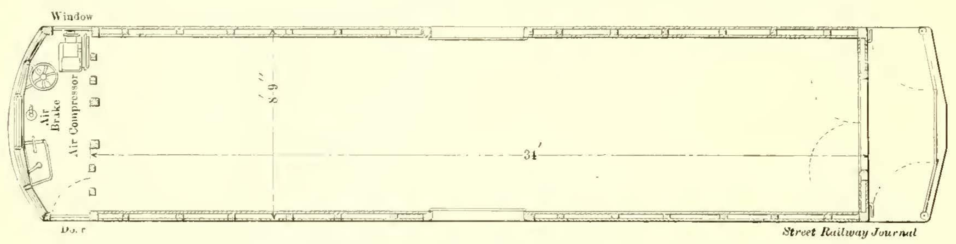
DETAILS OF THREE TIRES FOR TRUCK WHEELS

Combined freight and passenger stations have been provided in all towns and villages except at the terminals, where the patronage has been considered sufficient to warrant the separation of the freight business from the passenger business.

The rolling stock consists of fifteen passenger coaches, three express cars and one work car. The passenger cars are each 52 ft. in length and 8 ft. 9 ins. in width, and the bodies were built by the Barney & Smith Car Company, of Dayton. They are finished in white oak, medium grade, with plate glass windows. Each car contains twenty-eight double seats. The seats are upholstered in red plush and are arranged to be non-reversible. Each car is equipped with a telephone and extension cord which may be plugged into cast-iron telephone jacks at all sidings and important points, while in event of trouble on the line connections can be made promptly to the telephone circuit by means of pole and cords provided. Space is allowed for the accommodation of a considerable amount of hand baggage without crowding. The cars are divided so that the forward twelve seats may be used as a smoking compartment. The smoking compartment is ventilated forward through a transom by a peculiar action of the curved vestibule, inducing a flow of air from the main body of the car through the smoking room and vestibule to the external air. The cars are warmed by electric heaters. The trucks were furnished by the Baldwin Locomotive Works and represent a high standard of practice for electric railway service. The motor truck wheels are steel tires, while the leading truck wheels are spoked chilled iron wheels.







EXPRESS CAR

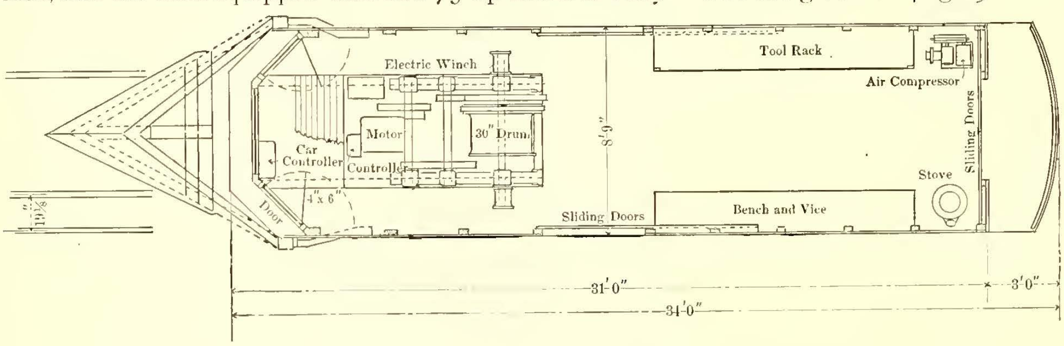
The motor equipment of each passenger car consists of two 50-C Westinghouse, 150 hp capacity. These motors are carried by Gibbs suspension and both motors are applied to the rear truck.

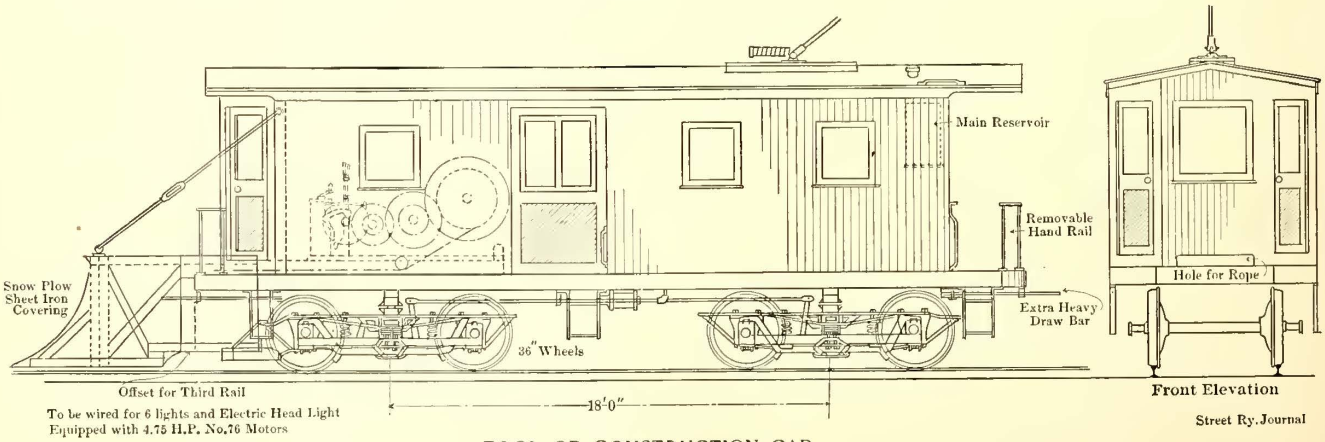
The express cars are 45 ft. in length and 8 ft. 9 ins. in width, and are each equipped with two 75-hp motors. They have electric heaters. The trucks are of the Barney & Smith class F. The cars are provided with large side doors and large double doors in the rear for loading scenery.

The tool, or construction, car is 30 ft. in length and is provided with a detachable snowplow and with a winding drum and motor for use in pile-driving, pulling cars on the track or for other work where great pulling capacity is required. This car is equipped with four Westinghouse No. 76 motors, and is capable of a sustained speed of upward of a mile a minute on the line.

The standard sections of the tire for the three classes of equipment are illustrated on page 7, and details of the express and construction cars are shown on this page. All cars are equipped with Westinghouse air brakes.

A car shop and storage building is situated at Fruitport near the power house, and an exterior view and cross section are given on page 9. Half of the building is devoted to the shop and the balance to storage. A fire wall 18 ins. thick, with heavy pilaster, rises through the building to separate the storage from the shop space. The trusses are of iron and the roof is of 3-in. planking tarred and covered with gravel. The tracks in the shop portion are served by two traveling cranes, each crane having two trolley hoists so arranged that one crane can lift a car body and thus permit the removal of the motor from the truck or the substitution of another truck when desired.





TOOL OR CONSTRUCTION CAR

The shop is equipped with a long skeleton pit, but no heavy lifting is done, the pit being used for purposes of inspection and cleaning only. The shop equipment consists of a 60-in. universal radial drill, 24-in. drill press, a sensitive drill, a lathe with 12-in. swing and 6 ft. between centers and a larger double-spindle lathe 12 ft. between centers of a suitable size to handle any machinery on the road. In addition to this, there is a Niles wheel press and an 18-in. shaper.

CAR HOUSE AND SHOPS AT FRUITPORT

The blacksmith shop is in the end of the main repair shop, partly separated by a curtain to prevent drifting of sulphurous gases which may escape from the forge. The armature-winding room, stock room, with bins for the supply of salt and sand, are provided, and are served by an overhead traveler and trolley in the front of the building, and in the corner of the shop is the office of the master mechanic. Above this are the men's quarters, provided with lavatory, toilet facilities and with expanded metal lockers.

The road began carrying passengers in February, and has been doing a good business from the start. Freight service has only been in operation a few weeks, and is still considerably hampered by lack of terminal facilities in Grand Rapids and Muskegon, where unavoidable delays have been encountered.

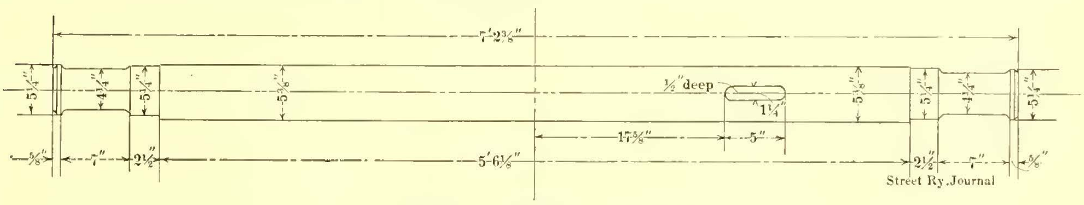
The road was designed and constructed throughout by Westinghouse, Church, Kerr & Co., who located the line and conducted the negotiations for the right of way.

Methods for Heavy Electric Traction

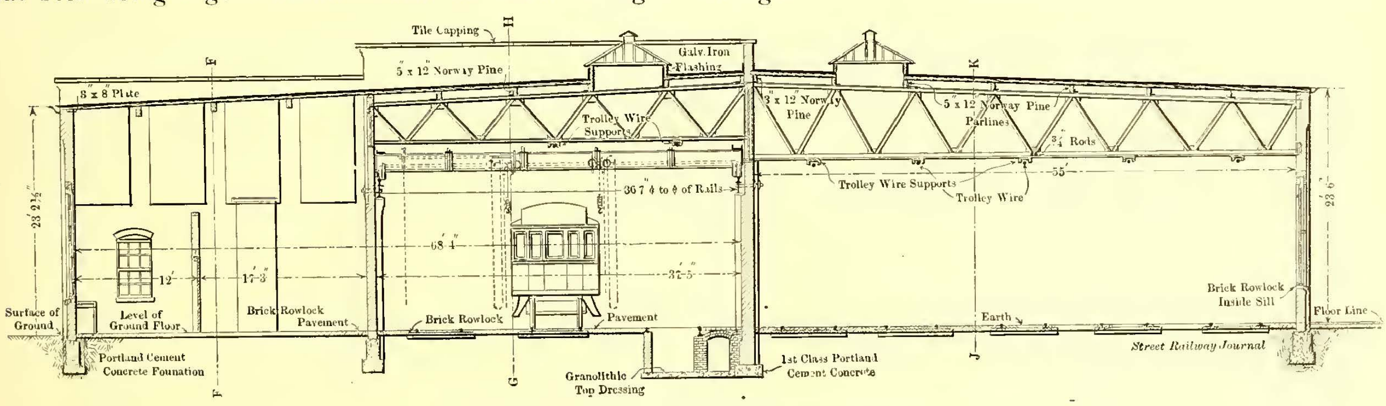
BY LOUIS BELL, PH. D.

I have read with great interest Huber's proposition for the conversion of trunk lines to electric traction. It is not altogether new, for the essential part of the project was set forth by Leonard in 1894, nor can it be called by any stretch of the imagination simple; but it has been carefully worked out as is Herr Huber's wont, and must receive serious consideration. It differs from Leonard's scheme mainly in the use of a high-voltage working conductor, which has heretofore been many times suggested, and which is obviously necessary to economy. The burden of fixed charges must always be great in any system that uses low-voltage working conductors, and since it is well known that current can be taken off high-pressure conductors without material difficulty, there is no good reason why they should not be used in any case where the weight of the transformer on the moving car is not objectionable. The present scheme I had occasion to refer to casually on page 282 of my "Power Distribution for Electric Railways," and I see no reason now to change the opinion there expressed.

There is no doubt whatever that continuous-current motors, particularly with the Leonard control, which is very readily applied to the case in hand, give far more exact and efficient speed regulation than has yet been attained with any form of alternating motor. It may turn out that the Ganz concatenated system will secure ample regulation at a good efficiency, but it certainly cannot do any better than an ordinary series parallel control, which, however, is good enough.



STANDARD EXPRESS CAR AXLE



CROSS SECTION OF SHOP AND CAR SHED

The real point of Huber's work lies in the use of a single-phase current and a single-working conductor to avoid the complication of polyphase-working conductor. The price paid for this is (1) inability to use alternating motors, if one wanted them, and (2) the complication and loss of efficiency entailed by a motor generator or rotary converter on the car. That this is a complication there is no doubt, and it must add materially to the weight and cost and also lower the efficiency by 10 per cent or so. Huber's figures show small apparent extra weight, but, since polyphase motors can be made as light as or lighter than continuous-current motors of similar output and efficiency, it needs no argument to show that the total weight of the motor generator or rotary converter is added dead weight whatever it may be. Of course, if weight is needed to give adhesion, well and good, but a motor generator is an expensive form of ballast.

I hope that Herr Huber will have an opportunity ere long to put his locomotive into regular service and give the scheme a trial. It certainly will give excellent speed regulation and a very simple system of working conductors, but whether this gain is worth the price of admission is, in my opinion, rather open to question. Granted that the speed control is necessary and cannot be obtained with polyphase motors, it still seems to me doubtful whether the single-phase system is advisable for a general system.

Personally, I would rather pin my faith to polyphase-working conductors, for I think the gain in capacity and efficiency of the rotary converters if it were considered desirable to hire continuous current for freight locomotives, the lessened loss in the conductors, and the ability to use polyphase motors for certain classes of service, rather outweigh the objections to a polyphase trolley system. In equipping a road with polyphase-working conductors one would gain the power to use induction motors while improving the conditions for operating continuous current ones. The Zossen experiments seem conclusive on the practicability of polyphase-trolley lines, and experience should secure entire reliability in such service.

However, I trust the Huber plan will be given a good trial, for it is singularly easy to apply, and anything that will improve the chances of electric traction for a fair test on large railway work is worthy of encouragement. At present there is an enormous corporate inertia to overcome, and the art is making painfully slow headway.

Electric Interurban Lines in Northern Illinois

While a map of Northern Illinois showing the electric interurban lines does not by any means present such a network as similar maps of Ohio or Southeastern Michigan, it discloses the beginning of a healthy growth. Perhaps one reason the accompanying map of Northern Illinois does not show a greater network as compared with some maps that have been published of other States is that it shows only the roads actually in operation or under construction, or so far along in organization as to be practically in the beginning of the construction period and hence almost assured. A map of all the proposed electric interurban lines in Indiana, Illinois and Iowa would be almost as complex as a map of the present steam roads in these States, because they have been a most active field of labor for the electric interurban promoter for the last twelve months.

Looking at the accompanying map of Northern Illinois we see that the only region which has anything near approaching a network of electric interurban lines is that just west of Chicago. Strange as it may seem, the building of interurban and suburban lines has never progressed as rapidly in the neighborhood of Chicago as around several much smaller Ohio cities. A number of local conditions have been responsible for this. The companies already in the field in the city of Chicago have not seen fit to extend their operations far outside of the city limits. The steam road suburban service in various directions from Chicago has also been excellent and has tended to discourage electric competition until very recently. Further than this, it is necessary to go about 40 miles in any direction from Chicago before reaching any manufacturing towns large enough to tempt capital into electric interurban railways. Franchises in the neighborhood of such a large city were naturally more difficult to obtain upon reasonable terms than around smaller cities, and purchased rights of way were expensive. Steam roads doing a suburban business, and hence opposing any new lines, and village councils putting excessive values on franchises, have been discouraging elements. Recently, however, the lack of interurban lines near Chicago is being rapidly filled in.

The most notable of these roads, as well as the latest to be constructed, is the Aurora, Elgin & Chicago Railway (No. 10 on the map), a complete map of which was given in the STREET RAILWAY JOURNAL of Feb. 1, 1902. This road, which is almost ready to begin operation, will probably be the finest example of high-speed electric interurban service to be found in the world. Something like 40 miles an hour average schedule speed, including stops, is expected, and the running time from Aurora, 39 miles, to Chicago, using the Metropolitan West Side Elevated Railway for entrance to the city, will probably be one hour and fifteen minutes. This is about the time in which the Chicago, Burlington & Quincy Railroad's fastest trains deliver passengers at the Union Depot, Chicago, which is some distance from the heart of the city. From Wheaton to Chicago this line is double-tracked and will serve a good line of suburban towns, paralleling two steam roads. The Pomeroy-Mandlebaum Syndicate at Cleveland is behind this enterprise, Will Christy, of Akron, Ohio, being general manager, and, with his assistant, W. E. Davis, responsible for the many excellent engineering features incorporated in this road. The population of cities and towns which will be served by this system, according to the census of 1900 (from which all the population figures given in this article are obtained), is as follows: Chicago, 1,698,575; Oak Park, 7500; River Forest, 1539; Maywood, 4532; Melrose Park, 2592; Elmhurst, 1728; Lombard, 590; Glenellyn, 793; Wheaton, 2345. The population of the Fox River towns forming the western terminals of this road is given in the following paragraph under the Elgin, Aurora & Southern Traction Company, which will operate its system in conjunction with the Aurora, Elgin & Chicago Railway, as it is controlled by the same capitalists. The same power house will also supply both systems.

The Elgin, Aurora & Southern Traction Company (11) connects a number of good manufacturing towns located up and down the Fox River Valley for a distance of about 40 miles. The present system is a consolidation of several roads. This populous Fox River Valley was among the first in Illinois to enjoy the benefits of an electric interurban system. Beginning at the northern end of the line there is Carpentersville, with a population of 1002; Dundee, 2765; Elgin, 22,433; St. Charles, 2675; Geneva, 2446; Batavia, 3871; Aurora, 24,147; Oswego, 618; Yorkville, 840, and Bristol, 427. These lines up and down the Fox River have done a good business for a number of years. With such a large population scattered along the river within a comparatively few miles it was natural that the first extensive interurban building in Illinois should be done in this locality.

The first interurbans of any kind in the State were, of course, short. That from Champaign to Urbana (1) was of this class. This could hardly be called a true interurban railway, however, because the cities of Champaign and Urbana were joined so as to make practically one town. This line is operated by the Urbana & Champaign Railway, Gas & Electric Company, of which W. B. McKinley, of

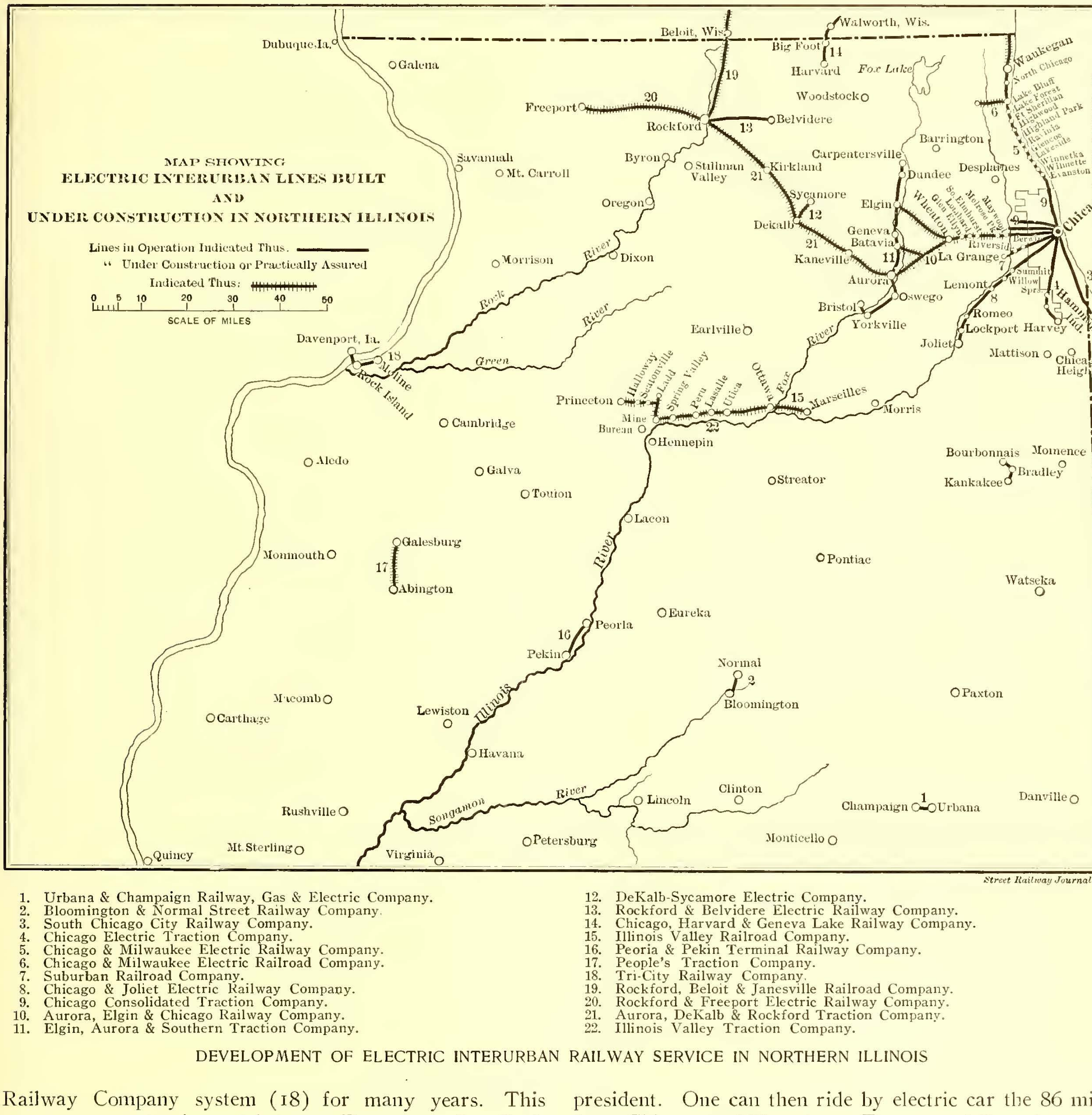
Champaign, is the head. He is also interested in many other street and interurban railway projects. Operation is in charge of H. J. Pepper. The population of Champaign in 1900 was 9098, that of Urbana 5728.

Of a similar nature was the early extension of the Bloomington city lines built between Bloomington and Normal. This company is now known as the Bloomington & Normal Street Railway Company (2), of which John Eddy is the manager. The population of Bloomington is 23,286 and that of Normal 3795. The State Normal Institute at Normal helps to swell the traffic between the two towns.

Rock Island and Moline have been a part of the Tri-City Railway Company system (18) for many years. This company operates in and between Davenport, Ia., Rock Island and Moline, Ill.

These short lines just enumerated were, however, so short that it may be truly said that the first real extensive interurban building in the State was that between Aurora and Elgin, in the Fox River Valley, before mentioned.

After the Fox River roads, the next long line to begin operation was the Chicago & Milwaukee Electric Railway (5), which occupies a magnificent territory along the shore of Lake Michigan north of Chicago between Evanston, the first suburb beyond the Chicago city limits, and Waukegan. The name, Chicago & Milwaukee Electric Railway Company, so far represents only the ambitions of the promoters. An electric line has been built from Milwaukee south as far as Racine, Wis., but the gap between Waukegan, Ill., and Racine, Wis., has not as yet been filled. From Racine to Waukegan progress has been blocked for several years by franchise difficulties in Kenosha, but as this matter has recently been straightened out there is prospect that the connecting link between Waukegan and Racine will soon be built by a company of which B. J. Arnold, of Chicago, is president. One can then ride by electric car the 86 miles from Chicago to Milwaukee. The present lines, however, are not built for very high speed, but are suited only to local travel and passengers from suburban towns to whom time is no great object. The road fills an important place as to local transportation, however, as will be explained later. It is not unlikely that some day a high-speed frequent-service electric railway between Chicago and Milwaukee and the principal intermediate cities will be constructed. The only thing that could prevent such a line being built would



Street Railway Journal

1. Urbana & Champaign Railway, Gas & Electric Company.
2. Bloomington & Normal Street Railway Company.
3. South Chicago City Railway Company.
4. Chicago Electric Traction Company.
5. Chicago & Milwaukee Electric Railway Company.
6. Chicago & Milwaukee Electric Railroad Company.
7. Suburban Railroad Company.
8. Chicago & Joliet Electric Railway Company.
9. Chicago Consolidated Traction Company.
10. Aurora, Elgin & Chicago Railway Company.
11. Elgin, Aurora & Southern Traction Company.
12. DeKalb-Sycamore Electric Company.
13. Rockford & Belvidere Electric Railway Company.
14. Chicago, Harvard & Geneva Lake Railway Company.
15. Illinois Valley Railroad Company.
16. Peoria & Pekin Terminal Railway Company.
17. People's Traction Company.
18. Tri-City Railway Company.
19. Rockford, Beloit & Janesville Railroad Company.
20. Rockford & Freeport Electric Railway Company.
21. Aurora, DeKalb & Rockford Traction Company.
22. Illinois Valley Traction Company.

DEVELOPMENT OF ELECTRIC INTERURBAN RAILWAY SERVICE IN NORTHERN ILLINOIS be the adoption of electric traction by the two steam roads which now run several fast trains daily between the two cities, but which would surely have to yield the cream of traffic to an electric road offering fast and more frequent train service and freedom from soot and cinders.

One notable thing about the present electric road from Evanston along the north shore to Waukegan is that while it is not a high-speed line (the maximum speed of cars being 24 miles per hour on the level) it captures not only a large part of the local business between suburbs, but also many of those passengers who are bound for Chicago and who take the electric road to Evanston or some other convenient steam-road station at which the train service is more frequent than at other stations along the line of the steam road. The trouble of changing cars at Evanston is met by the cheaper fare on the electric road and the fact that the cars stop for passengers at any street crossing, while the steam road depot may be a mile or more distant. From Lake Bluff, on this road, a branch road (6) 6 miles long to Libertyville is being built this summer to get the lake-resort traffic from the inland lakes from that region.

The populations of the towns traversed by the Chicago & Milwaukee Electric Railway are as follows: Evanston, 19,259; Winnetka, 1833; Wilmette, 2300; Glencoe, 1020; Ravinia, 75; Highland Park, 2806; Highwood, 750; Fort Sheridan, 1575; Lake Foust, 2215; Lake Bluff, 490; North Chicago, 1150; Waukegan, 9426.

The larger towns in Northern Illinois are found scattered almose entirely along the valleys of certain larger rivers. These towns were originally started because of small water powers to be found along these rivers at the points where the various towns were located. It is therefore natural that some of the important interurbans should follow these river valleys, not for civil engineering reasons, but because the population of the towns justify the location of the interurbans. Next after the Fox River Valley in importance as an interurban center the present prospects are that the Rock and Illinois Rivers will come next. Rockford is destined to be the most important interurban town in the northern central part of Illinois.

The Rockford & Belvidere Railway (13) has been built by the same interests that control the Rockford Railway Light & Power Company, of which R. N. Baylies, of Chicago, is president, and T. M. Ellis, of Rockford, is manager. The same people have surveyed a line from Rockford to Freeport (20). The population of Rockford, which is called the "Lowell of the West" on account of its extensive factories, is 31,051, and that of Belvidere is 6937.

Running north from Rockford is the Rockford, Beloit & Janesville Railway (19) soon to be in operation from Beloit, Wis., to Rockford, Ill. Its northern terminus is to be Janesville, Wis. This is a road in which the Pomeroy-Mandelbaum Syndicate, of Cleveland, is interested, and of which Will Christy is president. The construction is under the immediate charge of G. W. Knox, consulting engineer, of Chicago.

It is likely that before many years there will be a continuous chain of electric interurban lines from Chicago to Joliet, and thence through Morris, Marseilles, Ottawa, LaSalle, Peru to Princeton, thus joining Chicago with an important set of towns along the Illinois River.

From Chicago to Joliet, the Joliet Electric Railway (8) has now been giving service for over a year. This road in the main follows the highway, and the route of the famous Chicago drainage canal. Unfortunately this company's terminal connections in Chicago at present are such that a large part of the time between Chicago and Joliet is taken up within the city limits of Chicago. This company is controlled by the American Railways Company, of Philadelphia, F. E. Fisher, of Joliet, being general manager. The population of Joliet is 29,353. The population of the intermediate towns is as follows: Lockport, 2659; Romeo, 113; Lemont 2449; Willow Springs, 163; Summit, 547.

The Illinois Valley Railroad Company (15) of Ottawa is building a line 6 miles between Ottawa (population 10,588) and Marseilles (population 2559). Weston Bros., of Chicago, are engineering and supervising this work. The officers of this company are men interested in the Ottawa Railway, Light & Power Company, of which L. W. Hess is general manager.

Further down the Illinois Valley is the Peoria & Pekin Terminal Railway (16), giving an electric service between Peoria and Pekin, and also operating a number of miles of steam road around these two cities. L. E. Myers, of Chicago, is the general manager of the road. The population of Peoria is 56,100; that of Pekin 8420.

The People's Traction Company (17), of Galesburg, is considering a line from Galesburg south to Abington. Galesburg has a population of 18,607, and Abington 2022. The Chicago, Harvard & Lake Geneva Lake Railway (14) has a line 10½ miles long from Harvard, Ill., north to Lake Geneva, Wis. Further details of this road were given in the STREET RAILWAY JOURNAL of June 7, 1902. H. T. Windsor, of Walworth, Wis., is general manager. Its chief business is that of taking passengers from Harvard on the Chicago & Northwestern road to the southern shore of Lake Geneva, in Wisconsin, and a freight business in which it exchanges cars with steam roads.

The Chicago Consolidated Traction Company (9) reaches as far north as Evanston, and as far west as Melrose Park, with its regular street railway service, which covers all the outlying parts of the north and west sides of the city.

On the south side of Chicago, the South Chicago City Railway (3) operates the Hammond, Whiting & East Chicago Railway, which reaches down just across the State line to Hammond, Ind.

The Chicago Electric Traction Company (4) is another line operating in the city of Chicago which reaches Morgan Park (population 2329), Blue Island (6114) and Harvey (5395), to the southwest.

The Suburban Railroad Company (7), in connection with the West Side Elevated roads of Chicago, gives electric service to LaGrange and intermediate points along the Chicago, Burlington & Quincy Railroad. This, together with the competition of elevated and surface lines, has caused the taking off of quite a number of the Chicago, Bulington & Quincy suburban trains.

A short line is under construction, 6 miles, from DeKalb to Sycamore. This is the DeKalb, Sycamore Electric Company (12), of which W. B. Ullmann is president; L. Chaldecott, secretary and treasurer; John W. Glidden, superintendent. The population of DeKalb is 5904, and that of Sycamore 3653.

The Aurora, DeKalb & Rockford Traction Company (21) is preparing to build from Aurora, northwest through Kaneville, DeKalb and Kirkland to Rockford. That between Aurora and DeKalb will be built first. W. D. Ball, of Chicago, is consulting engineer. The company is backed by a syndicate composed of V. A. Watkins and William George, of Aurora; R. S. Vivian and G. B Shaw, of the American Trust & Savings Bank, of Chicago.

An important road joining the Illinois valley chain of cities is the Illinois Valley Traction Company (22), which is building from Ottawa (population 10,588) west, through Utica (1150), LaSalle (10,446), Peru (6863), Spring Valley (6214), Ladd (1324), Seatonville (909), and Holloway (207), to Princeton (4023). This is one of the Portland Syndicate roads, of which W. B. McKinley, of Champaign, Ill., is president.

Collectors for Heavy Traction

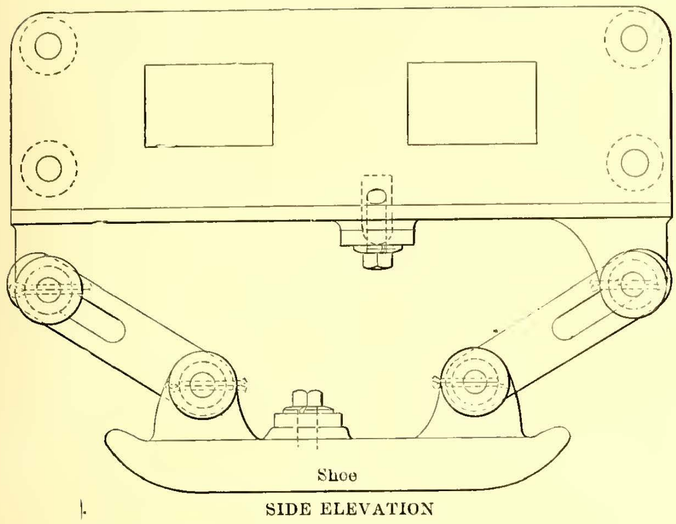
BY GEORGE T. HANCHETT

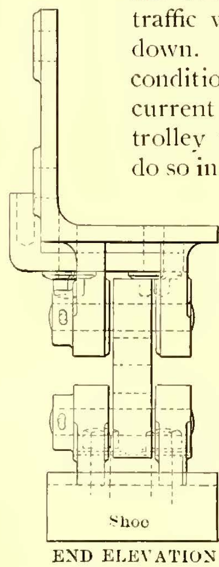
When an electric car or system of cars requires more than 200 amps. for its propulsion, heating and lighting, the problem of collecting this current by means of a movable contact begins to become interesting, and the necessity for its careful consideration increases with the amount of current to be collected.

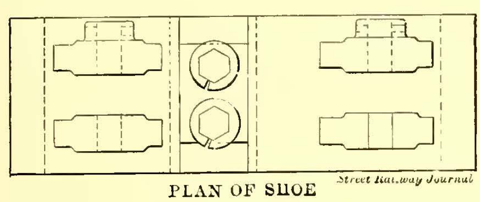
The heaviest instances of electric traction usually comprise situations which have been previously handled by means of steam, but where the latter form of motive power has become inadequate, either by reason of its inability to accelerate the trains sufficiently to make a rapid schedule possible in congested sections or because the noise, smoke and steam have become objectionable to the tenants of the rapidly increasing number of buildings along the line of travel, or positively unendurable to employees and passengers on account of tunnels which cannot be adequately ventilated for numerous reasons. The entrance of great railway systems into the large cities present most formidable problems which usually involve all of these objections with reference to steam. The increasing traffic has aggravated the conditions to such an extent as to compel the adoption of electricity in several notable cases, and experience gained in these cases will serve as a precedent for future enterprises. It is, therefore, not inappropriate to consider the problem of collecting current and discussing its possibilities, for it constitutes one of the problems, and perhaps not the least, which will require satisfactory solution before electric traction can be adopted for any of these purposes.

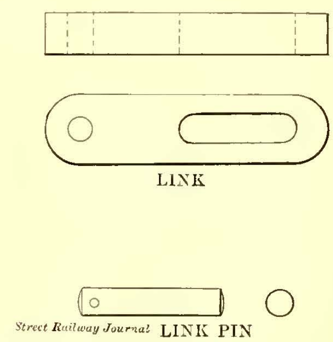
The overhead trolley is of course inadequate. Its limit has been reached in suburban and interurban traffic with heavy equipments of from 300 hp down. Even with two trolleys under favorable conditions it becomes difficult to collect all of the current that can be supplied through a 0000 trolley wire, and it is practically impossible to do so in case of a sleet storm. Beyond this point the heavy overhead contacts and correspondingly heavy overhead structure become items of such great expense that recourse must be had to the third rail.

The third rail in the open air on an elevated structure is a proved success, and no difficulty is found in collecting current from 300 amps. to 500 amps. with a shoe weighing from 15 lbs. to 25 lbs., and dependent for its contact upon its weight. These shoes are usually suspended by two links and carry a flexible connection bolted fast to the shoe itself. Such shoes usually operate on third rails having a clearance above the tread rail of from 1½ ins. to

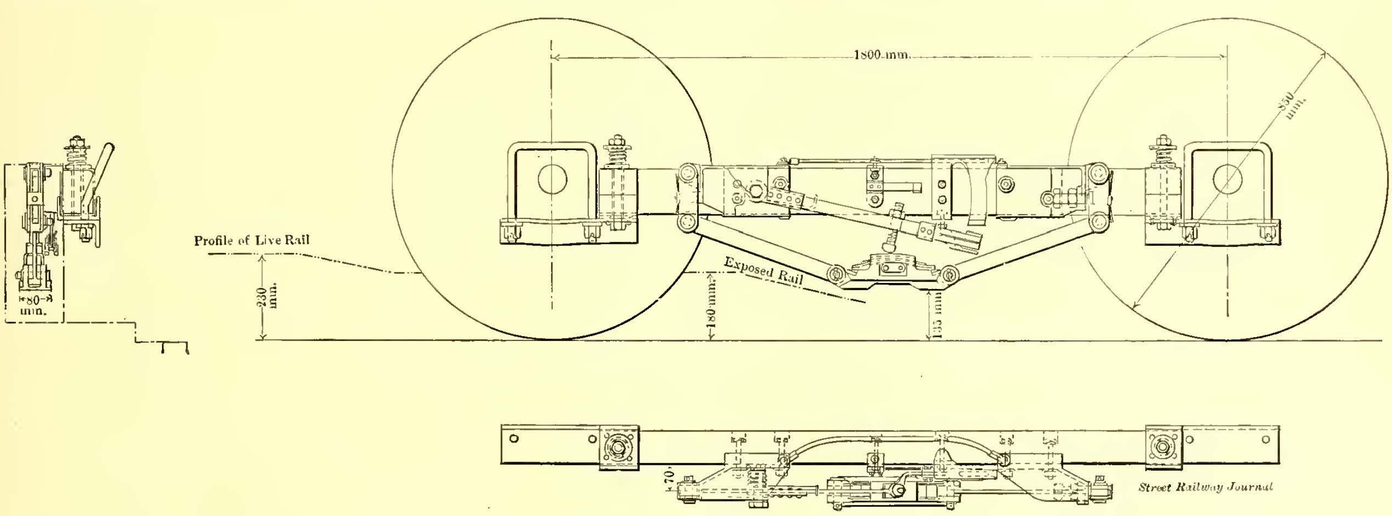








DETAILS OF CONSTRUCTION OF BOSTON ELEVATED CONTACT SHOE



DETAILS OF CONTACT SHOE ON BERLIN ELEVATED AND UNDERGROUND ELECTRIC RAILWAY

3 ins. A shoe of this class is illustrated herewith, a side elevation plan, end elevation and link and linkpin details being included.

An interesting modification of the shoe commonly used on German railways is illustrated on the preceding page. In this case the shoe is supported in toggle arms, which are somewhat longer than those in common use in the United States, and the shoe itself is provided with a switch which drops to an open position whenever for any reason the shoe drops below any predetermined level. This is a valuable feature, for it can be so set as to make the shoe itself dead whenever it leaves the live rail, even if other shoes on the same car are in contact. In work of this kind the shoe, having cleared the live rail and traveling by simply hanging from the truck, is likely to encounter grounded metal or to be touched by an individual, and by this simple device serious arcs or shocks are avoided. It is a device which might be profitably adopted in this country.

It must be appreciated that shoe clearance is a most important matter to consider. It is plain that if the shoe strikes any grounded metal the result is a formidable short circuit, which, besides throwing circuit breakers and possibly setting woodwork on fire, has a very damaging effect if it occurs in full view of a station full of passengers. It must not be forgotten that the public regard electricity as an exceedingly powerful and destructive agency, and that there is still considerable mystery about its manifestations, so far as the majority of people are concerned; they look upon it as being chained and brought into useful service by the strongest means and requiring the utmost ingenuity of man, and under the circumstances it is not to be wondered if pyrotechnic exhibitions of this character are regarded as a frantic attempt of a caged monster to break loose and sweep the locality with devastation. Any such occurrence is therefore not calculated to inspire confidence and increase traffic. The writer may be charged with indulging in a little romance in the foregoing paragraph, but the words are based upon actual experience, under circumstances favorable for learning public opinion of such demonstrations.

In any event short circuits must be avoided, and due regard to shoe clearance must therefore be had. The shoe must evidently clear the tread rail by a reasonable margin. It must also clear interlocking mechanisms, not only in their final but in their intermediate positions. Of course it is easy to comply with these requirements in the case of elevated work or light interurban work by raising the third rail about 3 ins. or 4 ins. above the tread rail, but when a trunk line problem arises an inspection of clearance sheets from the mechanical department will show that the margin is very narrow indeed, and opportunities for raising the third rail are very limited.

The bulky cylinders of large compound freight engines, the projecting doors of steel coal cars, which must, by the way, be considered in an open position, and numerous other things which might be mentioned, make it necessary to keep the height of the third rail down; the clearance underneath the cars is always so limited that it is impossible to have a section of third rail between the tread rails.

With a margin of from 2 ins. to 2½ ins.—and the third-rail engineer must consider himself fortunate if he secures as much as this—it is plain that the shoe cannot be allowed to drop more than 1 in. below the level of the third rail, and this rail must, therefore, be set so that in no place shall it be lower than ¾ in. from the level its surface was designed to occupy. If this is not heeded the shoe will arc on the low place very formidably if heavy current is carried, and this will result in burning both the rail and the shoe so badly that the conditions will be aggravated when the next shoe traverses the low place. In heavy locomotive work these arcs are very noisy and brilliant, and if they occur in front of a station and, perhaps, set the platform on fire the performance is not reassuring to passengers.

From the foregoing it will be easily seen that in a third-rail installation among other requirements the following are necessary:

The third rail must not be so high that there will be any possibility of the ironwork of the moving trains striking it, and on the other hand it must not be so low that there will be any danger of the shoe on the motor car striking projecting ironwork in the trackway. This height is one of the most difficult problems to be determined and requires special consideration.

Closely related to the height is what is known as the third-rail gage, that is to say, the distance between the centers of the third rail and the nearest tread rail. If very near the tread rail the third rail must be set low in order to clear the cars, and if set too far from the tread rail the overhanging shoe structure extends so far from the track it is likely to strike switch lamps, signals and even the wall of tunnels or the girders of bridges. There is just one spot on the clearance diagram where the center line of the head of the third rail should come, which is locatable, according to the conditions, with as much accuracy and precision as is the center of a circle.

On the elevated roads clear of mud, dirt or dust the third-rail surface can be kept clean, and the collection of sufficient current with a shoe of moderate weight and dimensions is not troublesome, but where large currents are to be collected from third rails placed on the ground on roads traversed by steam trains passing through damp tunnels the problem is by no means as easy. In the case of electric locomotives taking from 1200 amps. to 1500 amps maximum in such locations, the least dirt or rust on the third rail causes terrific arcs at the shoe and corresponding heating; and, if such performances continue across long stretches of track, the shoe may become red hot, although weighing from 50 lbs. to 60 lbs. In damp tunnels this is particularly the case, and it is noticeable that if the rail is left untraversed by the shoe for a single day the first few runs will be marked by excessive arcing, after which, when the surface of the rail has been cleaned by the friction, this trouble will disappear. The deposit from steam locomotives on the third rail, mixed with water, seem to form a peculiarly suitable substance for the promotion of arcs. It covers the third rail with a crust and is a partial conductor, and when vaporized by the intense heat seems to lend itself to the propagation and intensification of the arc that is formed. Clay or earth, on the other hand, such as accumulates on the rail in cuts and places where excavations have been going on, does not act in this way, as its refractory powers seem to be greater, and while it undoubtedly does not improve the contact of the rail and shoes it does not vaporize and lend fuel to the flame; in fact, it is very striking to note how a shoe carrying a heavy current will sputter savagely on traversing a little moist crust of deposited cinders in a tunnel, and, emerging therefrom, will ride over a third rail covered with a mass of earth and produce scarcely a scintillation.

A glance at the accompanying half-tones will show how serious arcs and consequent shoe-heating enter into the problem. The photographs from which the cuts were made represent pieces of slag taken from a shoe carrying from 800 to 1000 amps. and traversing a dirty third rail. These pieces of slag are found either under the surface of the shoe, thereby spoiling its contact with the third rail, or attached to the shoe as trailers, and consist of melted iron particles and impurities found on the third rail. They usually get white hot, throwing off scintillations like iron at welding heat. If proper attention is not paid to shoe contact and clean surface the third-rail shoe becomes little more than an arc furnace.

The conductivity may of course be somewhat increased by making the shoe of copper or some of its alloys. From what follows, however, it will be seen that copper or brass will not stand the wear, its surface tearing to pieces very rapidly under the heavy friction from the rough surface, and what is still more important it does not grind through the film of rust and dirt and secure complete contact with the rail itself.

In one case with which the writer is familiar this problem has been satisfactorily solved by the use of a heavy brass shoe with a renewable steel face, held thereto by a dove-tailed joint, the conductivity of its contacts being reinforced by a large number of heavy copper rivets. This combination has the wearing qualities of the steel and the conductivity of the copper combined, and it seems to be the best arrangement that has yet been used.

In the case of heavy currents it is necessary to have the shoe bear heavily on the rail so that it will grind itself down to a metal to metal contact in spite of all dirt and obstruction. If the shoe is too light it will ride over the particles of dirt, ironing them down on to the third rail. If the foreign substances are semi-conducting, as in the case of cinders, they will be deflagrated, and if practically insulating and refractory, as in the case of clay, they will either lift the shoe clear of the rail, causing an arc, or increase the resistance in the other parts of the contact, causing those places to overheat. In a case where much current is to be collected pressure on the shoe surface must be increased almost to the point where mechanical pressure becomes a serious source of heat; 125 to 150 lbs. is not too much.

The shoe-holding mechanism must be designed so as to allow the shoe great flexibility of motion, but still the shoe must not be abandoned and given universal motion in every direction. It should move freely up and down in order that it may rise and fall with the irregularities of the surface of the rail. Its downward motion should extend to a point where it will be absolutely certain to bear with its entire weight on lowest portion of the rail at all times. It should have as much margin beyond this point as will insure its safely clearing grounded metal. Its upward motion in case of a simple third rail need not be limited except as the convenient arrangement of the mechanism shall dictate. If the rail is hooded in places for protection it should not be allowed to rise so as to create danger of its striking the protectors above the rail.

The shoe must be capable of tilting, that is to say, to enable one end to be raised so that the face of the shoe comes on an angle with the horizontal, in order that it may smoothly take the approaches to the third-rail sections. If the third-rail section is such that the shoe has to traverse through slots or between guard boards it must be capable of horizontal motion in the direction of the axle to allow for irregularities in the gage and flange play of the wheels. Finally, it must occupy a normal position to which it will always be restored by springs or other equalizing devices.

The insulation of the shoe must be exceptionally secure. The breaking down of the insulation between the shoe and the support constitutes a permanent short circuit as the current traverses the third rail through the shoe hanger to the truck frame. This short circuit cannot be removed until the shoe itself has been removed or the car has been drawn off the third rail so that the shoe hangers clear.

With the large current the question of the order of contact becomes important. If two plane surfaces are pressed together two points only may be all the mechanical contact that obtains. It may possibly be a line or may be several points, but it never is a contact throughout the entire surface. As such surfaces ride one upon the other these points of contact are continually changing. Such a point of contact constitutes a little isthmus through which the current must pass, and if this current is large the isthmus will get hot, and if very large it will be vaporized, when another point of contact will obtain with similar phenomena, the result being a sparking and sputtering shoe.

In the writer's opinion it is doubtful whether the rounded head of the third rail and the plane surface of the shoe are best adapted to deal with the case of heavy current collecting. It is true that an enormous amount of current can be collected through very inferior contacts, especially if this contact is a rubbing one, bringing cool metal continually into play. A flat shoe obviously contacts with a curved rail-head only on a line, but as the shoe wears it conforms in a measure to the shape of the rail-head and the order of contact becomes higher; but it must not be forgotten that it is impossible to set third rails truly to gage, and that therefore the curved surface which the rail-head was intended to fit may be shifted laterally by the irregularities of the gage or flange play of the wheel, and even though compensating motions have been provided in the shoe mechanism the contact may become inferior. The writer therefore does not hesitate to recommend a truly plane third-rail surface for heavy traction work. This not only improves the order of contact, but takes a great deal of responsibility from the means which it is ordinarily necessary to provide to permit the shoe to compensate for lateral motions.

As the traction problem becomes heavier a new system of power distribution will become necessary, for it will not be feasible to transmit or collect large currents by conventional methods, and recourse must therefore be had to the device of supplying the power by means of collecting lesser current at higher pressure.

Five hundred and fifty volts is the present practical pressure limit for railway commutators, but that trouble can be readily obviated by the use of motors in series, and the pressure can be advanced to 750 volts or even 1000 volts. When pressures of 800 volts to 1000 volts are reached the support and insulation of the third rail becomes a much more difficult problem than has heretofore been presented, and one which has very little precedent. Even at 600 volts and 750 volts leakages which were unimportant at the lower

SPECIMENS OF METALLIC FORMATION ON CONTACT SHOE voltages become very formidable, and it is therefore necessary to provide means to circumvent them. Serious short circuits are also much more likely to occur. It is absolutely necessary, in the first place, to protect the third rail by surrounding it with guard boards, which make it impossible to lay a straight bar between the third rail and tread rail.

It is unwise to place dependence on the third-rail insulator of the common type, and it should be reinforced by a filled wood block. It is possible for a third-rail section only 300 ft. to 400 ft. long to leak 4 amps. or 5 amps. at these high voltages, and the simple device of cleaning the few insulators on which such a section is supported may make this leak entirely disappear. Usually the leak is due to moisture film, supplemented by dirt, and oftentimes under continued voltage will disappear itself by reason of the moisture drying out. Occasionally, however, and particularly in tunnels where much carbonaceous matter from steam locomotives accumulate, the leakage will increase instead of diminish, and finally establish a fairly good circuit between the third rail and tread rail or between the third rail and adjacent piping, the line of flow being marked by incandescent scintillating earth and the flaming of any combustible matter in the vicinity. Such a leak is usually accompanied by arcs over the non-conducting gaps, and in many cases it is impossible to extinguish it by any means other than cutting off the current, the application of sand and kindred common methods being futile. As cutting off the current means suspension of traffic these matters are important.

That the leak on a section of third rail is a very evanescent quantity is a matter of common knowledge. With ordinary voltage it is usually small. The writer has seen lengths of 3 miles of rail show a leak of 150 amps., which reduced after twenty-four hours' application of pressure of 10 amps. or 15 amps., but immediately increased when the pressure was taken off for a few hours and then reapplied. This is undoubtedly due to the drying out of moisture. If, however, high voltages are used it is almost certain that the heavier currents which will flow through the leaks will not only dry out the moisture, but will tend to carbonize any material capable of such decomposition which lies in their path, increasing rather than reducing the leak, possibly to the extent of short circuit.

It behooves the profession, therefore, in view of the heavy third-rail problems which are shortly to come, to make a particular study of third-rail and shoe construction with all of these points taken into consideration.

Interesting Temporary Installations

The Hudson Valley Railway Company, which is a consolidation of the Stillwater & Mechanicville, Greenwich & Schuylerville, Glens Falls, Sandy Hill & Fort Edward, and Warren County Railroads and the Saratoga Traction Company, has now in operation over 100 miles of electric road, running north from Albany and Troy to Saratoga, Lake George and the Adirondacks. At the present time power for operating the road is derived from several independent power stations located at Stillwater, Saratoga, Middle Falls, Glens Falls and Caldwell. Ultimately power for operating the entire system will be developed on the Hudson River near Waterford.

For the operation of the road until this Hudson River power station is completed a somewhat unusual and interesting method will be used. The company has increased the capacity of the direct-current power station at Glens Falls by installing a 250-kw direct-connected engine-type generator, and has increased the capacity of the Caldwell station by installing a 170-kw direct-current, belted generator. In the power station at Glens Falls there will be installed a 250-kw rotary converter, changing direct current to alternating current with raising transformers. Power will be transmitted by a three-phase, 11,000-volt transmission line to Caldwell, where lowering transformers and a second 250-kw rotary converter will be installed to supplement the power of the Caldwell direct-current generating plant.

At the company's power station in Saratoga there is to be installed a 400-hp engine and 250-kw, 2200-volt, belted, alternating-current generator with raising transformers. From this plant power will be transmitted by a three-phase, 11,000-volt transmission line to a sub-station at Round Lake, where lowering transmformers and a 250-kw rotary converter are to be installed. This sub-station will supply power to the recently-completed Saratoga division of the system, connecting the main line at Mechanicville with the Saratoga-Balston line at Balston Spa. After the alternating-current generating plant is installed next year on the Hudson River the generating and sub-station apparatus, now in use and in course of installation, will be displaced by eight 300-kw, 600-volt rotary converters. All of the electrical apparatus for the temporary installations and also for the permanent equipment of sub-stations is to be built and furnished by the Westinghouse Electric & Manufacturing Company, of Pittsburgh, Pa.

Pennsylvania Railroad Tunnel

It is intimated that the Board of Aldermen will hold up the Pennsylvania Railroad contract and thus delay work upon this improvement for several months. The contract between the Rapid Transit Commissioners and the Pennsylvania Railroad Company for a franchise for the tunnels which the company wishes to construct for the purpose of providing an entrance into Manhattan Island, has been signed by the Commissioners and railway officials and transmitted to the Board of Aldermen for approval. The delay will probably be explained on the part of the aldermen by a desire to secure better terms for the city, but the real ground for objection is said to be jealousy on the part of the aldermen because of the powers vested in the Rapid Transit Commission. When the latter body was formed it deprived the aldermen of some of their most important powers, and the Board not only resented this invasion of its rights and privileges, but it has frequently gone outside its usual course to show antagonism by blocking measures recommended by the Rapid Transit Commission. In the present case it is said that the aldermen planned to refer the contract to a committee and then adjourn for the summer. This, of course, would postpone definite action until the fall, and then if the aldermen returned in the same mood further delay might be caused by insisting upon having public hearings, which might be strung out indefinitely.

Much pressure is being brought to bear upon the aldermen, and it is hoped that they may be induced to reconsider this plan and act upon the measure at once. The Pennsylvania Railroad Company is prepared to begin the work of construction immediately upon the approval of the contract, and it is particularly anxious to get the work under way during the summer, as it hopes to makes sufficient progress in the work of excavations before the cold weather sets in to enable it to continue the work throughout the winter. If the contractors are delayed now, however, it will be impossible for them to do this, as they would scarcely get the ground broken before they would be compelled to suspend operations during the winter months.

TABLE I.

AVERAGE DRAW BAR PULL, IN POUNDS PER TON, FOR DIFFERENT RUNS ON N. Y. C. AND H. R. R. R.

Division, Key H., Hudson. A., Harlem.

Run.	† Out. In +	Train.	Division.	Tons.	Pounds.	G. C. Station and 110 St. 3 42 M.	110 St. and 125 St. 0.96 M.	G. C. Station and 125 St. 4.38 M.	125 St. and 138 St. 0.57 M.	G. C. S. and 138 St. 4.95 M.	138 St and Jct. 0.35 M.	G. C. S. and Jct. 5.3 M.	Jct and 125 St. .92 M.
10	+	120	H.	107.8	4180				25.0				
"		"	"	"	2480			14.8					
22	†	111	H.	130 5	3080		22.3						
"		"	"	"	2240				16.4				
"		"	"	"	3620						26.5		
13	+	110	H.	176.4	1840						14.55		
"		"	"	"	2820				22.18				
"		"	"	"	1800			14.75					
18	†	113	H.	121.5	4000						32.9		
"		"	"	"	2800				22.1				
"		"	"	"	1840			15.12					
52	†	115	H.	108.6	2180	20.05							
"		"	"	"	2880		26 5						
"		"	"	"	2820				25.9				
"		"	"	"	3280						30.2		
53	+	130	H.	193 1	4385						22.0		
"		"	"	"	4800				24 8				
"		"	"	"	5240		27.1						
"		"	"	"	2430	12.0							
55	+	153	H.	125.8	920						7.3		
"		"	"	"	3360				20.7				
"		"	"	"	3280		20.						
"		"	"	"	1640	13.01							
12	†	111	H.	124.0	2300	18.6							
"		"	"	"	2780		22.4						
"		"	"	"	2600				21.0				
"		"	"	"	4020						32.4		
23	+	110	A.	188.5									
"		"	"	"	3140				22.7				
"		"	"	"	1540			11.11					
40	+	28	A.	95									
"		"	"	"	2340				24.7				
"		"	"	"	1250			13.2					
41	+	88	H.	102.2	1884							11.62	
40	†	83	H.	231.3	3910			10.01					
"		"	"	"	3826				10.5				
"		"	"	"	6340						27.4		
39	+	84	H.	248.5	3500								14 2
"		"	"	"	2410			9.7					
38	†	87	H.	230.5	8015							13.03	
37	+	120	H.	117.0	2260								19.22
"		"	"	"	1488			12.21					
33	†	107	H.	143.8	2500			18.05					
"		"	"	"	3120								21.75
21	+	84	H.	267.8	4020								15.7
"		"	"	"	2925			10.92					
11	+	104	H.	223.8	3088							13.82	
16	†	103	H.	167.6	3122			18.65					
"		"	"	"	3110				18.6				
"		"	"	"	2960						17.7		
17	+	114	H.	176.1	4290								24.3
"		"	"	"	2984			16 95					
20	†	85	H.	230.	2410					10.46			
"		"	"	"	4980						21.7		
10	†	117	H.	105.	2800			14.8					
"		"	"	"	4200				21.5				
"		"	"	"	5050						25.9		
46	†	17	A.	137.3	1830	13.3							
"		"	"	"	2780		20.2						
"		"	"	"	2550				18.58				
"		"	"	"	4500						32.7		
14	†	11	A.	103.4	2560			13.25					
"		"	"	"	2835				14.65				
"		"	"	"	4425						22.85		

TABLE I.—(*Continued.*)

AVERAGE DRAW BAR PULL, IN POUNDS PER TON, FOR DIFFERENT RUNS ON N. Y. C., AND H. R. R. R.

Division, Key. H., Hudson, A., Harlem.

Run.	† Out. In +	Train.	Division.	Tons.	Pounds.	G. C. Station and 110 St. 3.42 M.	110 St. and 125 St. 0.96 M.	G. C. S. and 125 St. 4.38 M.	125 St. and 138 St. 0.57 M.	G. C. S. and 138 St. 4.95 M.	138 St. and Jct. 0.35 M.	G. C. S. and Jct. 5.3 M.	Jct. and 135 St. 92 M.
15	+	24	A.	118.0	2725				23.05				
"		"	"	"	1495			12.7					
54	†	147	A.	213.2	3420	16.0							
"		"	"	"	4450		20.9						
"		"	"	"	37 0				17 35				
"		"	"	"	5100						23.0		
7	+	28	H.	425.	3500						8.25		
"		"	"	"	7440				17 25				
"		"	"	"	5510			13.0					
42	†	93	H.	316.0	3660			11.56					
"		"	"	"	5000				15.8				
"		"	"	"	6410						20.25		
43	+	70	H.	195.3	2780								14.22
"		"	"	"	1800			9.68					
44	†	69	H.	283.4	4150			14.66					
"		"	"	"	4700				16.9				
"		"	"	"	4920						17.37		
45	+	78	H.	142 7	2820								19.72
"		"	"	"	1365			9.06					
40	†	47	H.	235 1	3075					13.06			
"		"	"	"	5080						24.21		
47	+	2	H.	307.	4785								15.6
"		"	"	"	3405			11.1					
50	†	71	H.	400.	4980			12.45					
"		"	"	"	3380								8.44
51	+	62	H.	392.1	5140								13.1
"		"	"	"	3900			9.05					
56	†	7	H.	310.6	3890			12.52					
"		"	"	"	3200				10.3				
"		"	"	"	4840						15 58		

TABLE II.

SHOWING AVERAGE DRAW BAR PULL IN POUNDS PER TON, AND HORSE-POWER REQUIRED TO PROPEL ELECTRIC LOCOMOTIVES FOR DIFFERENT RUNS.

TERMINAL STATIONS Of run. 1	GOING OUT. 2 Draw bar pull per ton	GOING OUT. 3 Locomotive h.p.	COMING IN. 4 Draw bar pull per ton	COMING IN. 5 Locomotive h.p.
Between G. C. Station and 110th Street.	17 lb.	75. h.p.	12.80 lb.	71. h.p.
" " " " 125th "	16.13 "	88. "	12.10 "	65. "
" " " " 133th "	12.00 "			
" " " "Mott Haven Jc.	14.80 "	76. "	12.72 "	50. "
" 110th Street " 125th Street	22.46 "	95. "	24.00 "	98. "
" " " " 138th "				
" " " "Mott Haven Jc.			13.10 "	
" 125th " " 138th Street.	18.10 "	51. "	22.70 "	55. "
" " " "Mott Haven Jc.	16.00 "	73. "	17.00 "	58. "
" 138th " " " "	25 00 "	62. "	14.80 "	65. "

NOTE.—Figures given in columns 3 and 5 represent the average horse-power required to propel a 65 ton electric locomotive over that run, plus one horse-power for pumps.

TABLE III.

TABLE SHOWING DRAW BAR PULL, HORSE POWER REQUIRED, TRAIN WEIGHTS AND SCHEDULE SPEEDS, FOR TRAINS RUNNING BETWEEN MOTT HAVEN JUNCTION AND GRAND CENTRAL STATION ON THE N. Y. C. & H. R. R. R.—RESULTS OF DYNAMOMETER CAR TESTS.

H., Hudson Division. A., Harlem Division, N., N. Y. N. H. & H.

G. C. S. 110. 125. 138. Jct.

Division.	Train.	Weight. Light.	Weight. Loaded.	Bet. G. C. D. and 110 St. Schedule Speed.	Pounds per ton.	Pounds Total.	Horse Power.	Bet. 110 St. and 125 Sts. Schedule Speed.	Pounds per ton.	Pounds Total.	Horse Power.	Bet. 125 St. and 138 Sts. Schedule Speed.	Pounds per ton.	Pounds Total.	Horse Power.	Bet. 138 St. and Jct. Schedule Speed.	Pounds per ton.	Pounds Total.	Horse Power.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The System of the Elmira Water, Light and Railroad Company

The city of Elmira is the field of operation of a monopoly of municipal undertakings which if not run upon the most approved lines and able to give to the citizens an excellent service would result in a most unsatisfactory arrangement. It speaks, therefore, very well for the management of the Elmira Water, Light & Railroad Company, which controls the electric lighting, gas lighting and water supply of the town, as well as the street railway, that it has as pleasant relations with the city authorities and its patrons as if the various departments were run by separate companies in competition. The consolidation, which was arranged some years ago, has proved eminently satisfactorily to all concerned, and a description of the portion of the combination which is of particular interest to street railway men will prove of value in showing the possibilities which exist for the advantageous union of public enterprises by a private company.

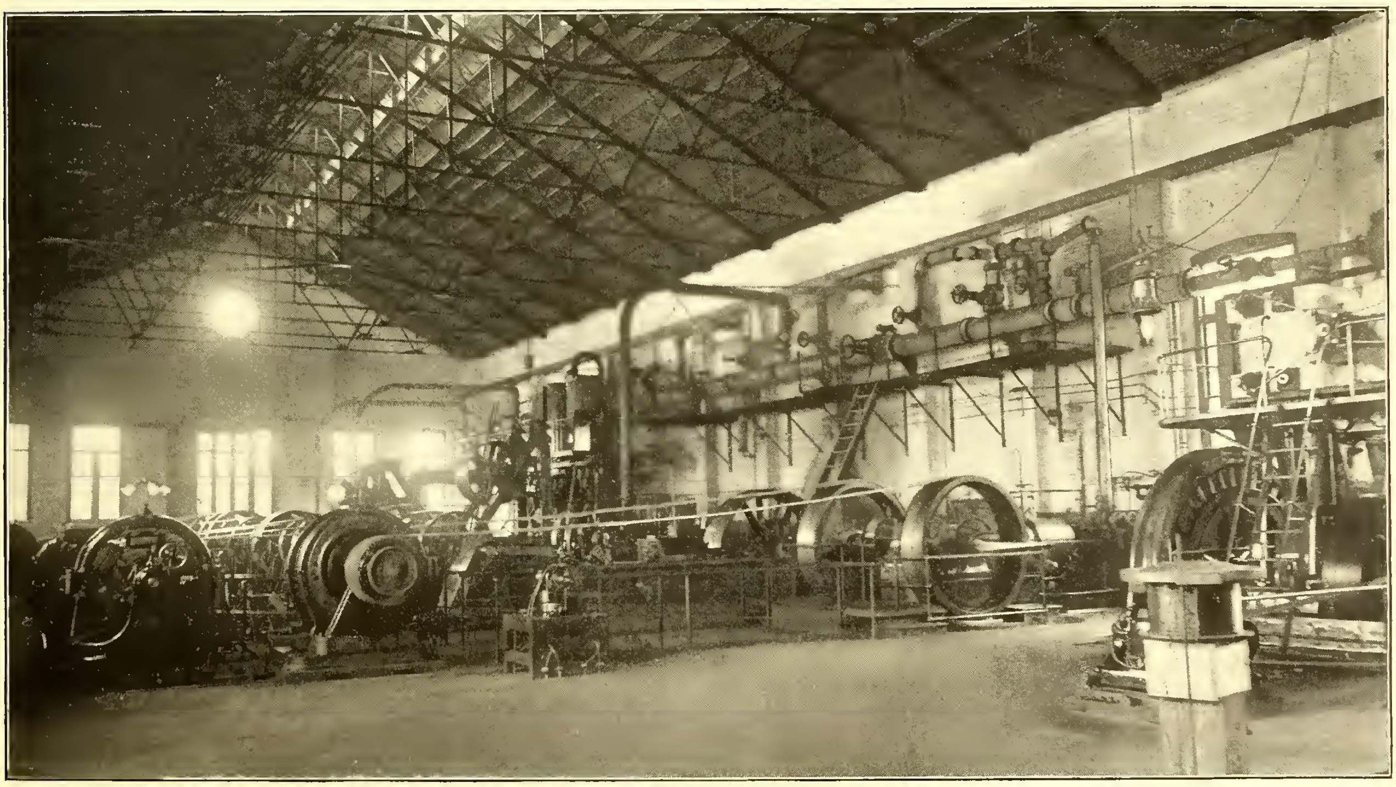
The town of Elmira, as seen by the accompanying map, is considerably longer than it is wide, and this fact gives the railroad company an opportunity to develop a system of practically parallel lines running from one end of the town to the other without necessitating the building of many transverse connections. The railway receives considerable revenue yearly from its park traffic, and the line which connects the center of the town with the cemetery is also a good payer. The traffic to the Interstate Fair Grounds and Eldridge Park, at opposite ends of the town, requires a large amount of accommodation, and the system also operates a park of its own, known as Rorick's Glen, some two and one-half miles from the center of the town, which, during the summer season, keeps this line very busy. In order to accommodate the extra loads the company has adopted a train system, and runs two or three trailers with very good success. This is only done, however, during the summer, the winter service being operated entirely with single cars.

The Elmira waterworks consist of a pumping station and an extensive filtering plant and are located a short distance away from the town. The system of distribution is similar to that employed in most towns having private water companies, each consumer having a meter and paying for the amount used. The gas works are situated adjacent to the power station, which supplies both the electric lights and power for the railway. This location is near the railway track and affords every facility for easily obtaining its supply of coal for both the gas works and power station.

EXTERIOR OF POWER HOUSE

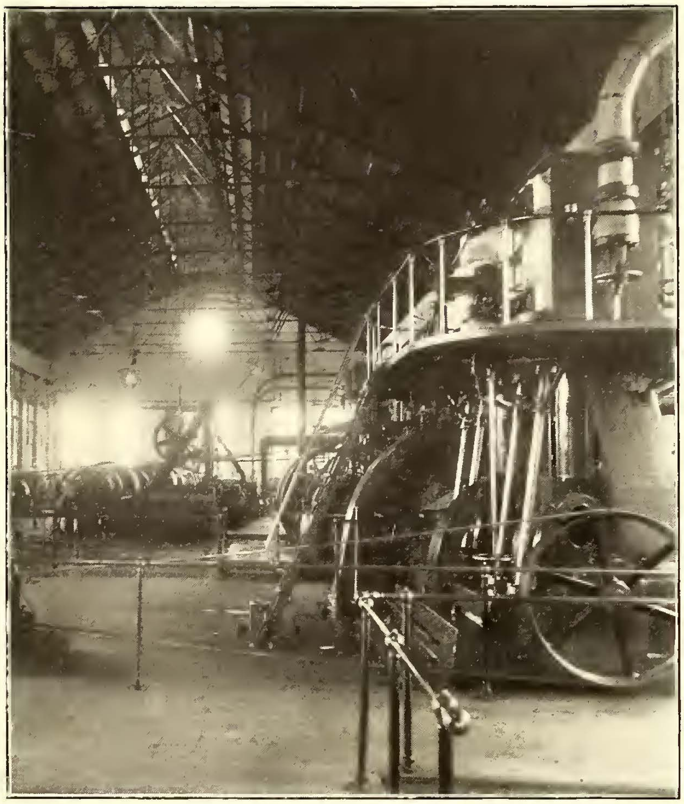
POWER STATION

The equipment of the power station is being at present considerably enlarged and the boiler room is having an addition built on it for the accommodation of a new battery of boilers. At present the capacity of the power station is about 2500 kw, including power for lighting and individual motors throughout the city and for the railway circuits. There are two tandem compound McIntosh & Seymour en-



GENERAL VIEW OF ENGINE AND DYNAMOS

gines of from 400 hp to 450 hp. One of these is belted to a 200-kw Stanley three-phase generator and a 75-kw, 250-volt Westinghouse power generator. The other is belted to three 165-light Brush arc machines for street lighting The third engine is a McIntosh & Seymour triple-expansion 700-hp to 800-hp marine type vertical engine and the fourth is a cross-compound 500-hp to 600-hp engine made by the Payne Engineering Company. These two engines are belted to a countershaft which runs lengthwise in the center of the building and to which are belted five Westinghouse railway generators. One of these is 190 kw in capacity, two are 150 kw and two are 200 kw. The fifth engine is a tandem compound McIntosh & Seymour 400 hp and is belted to a

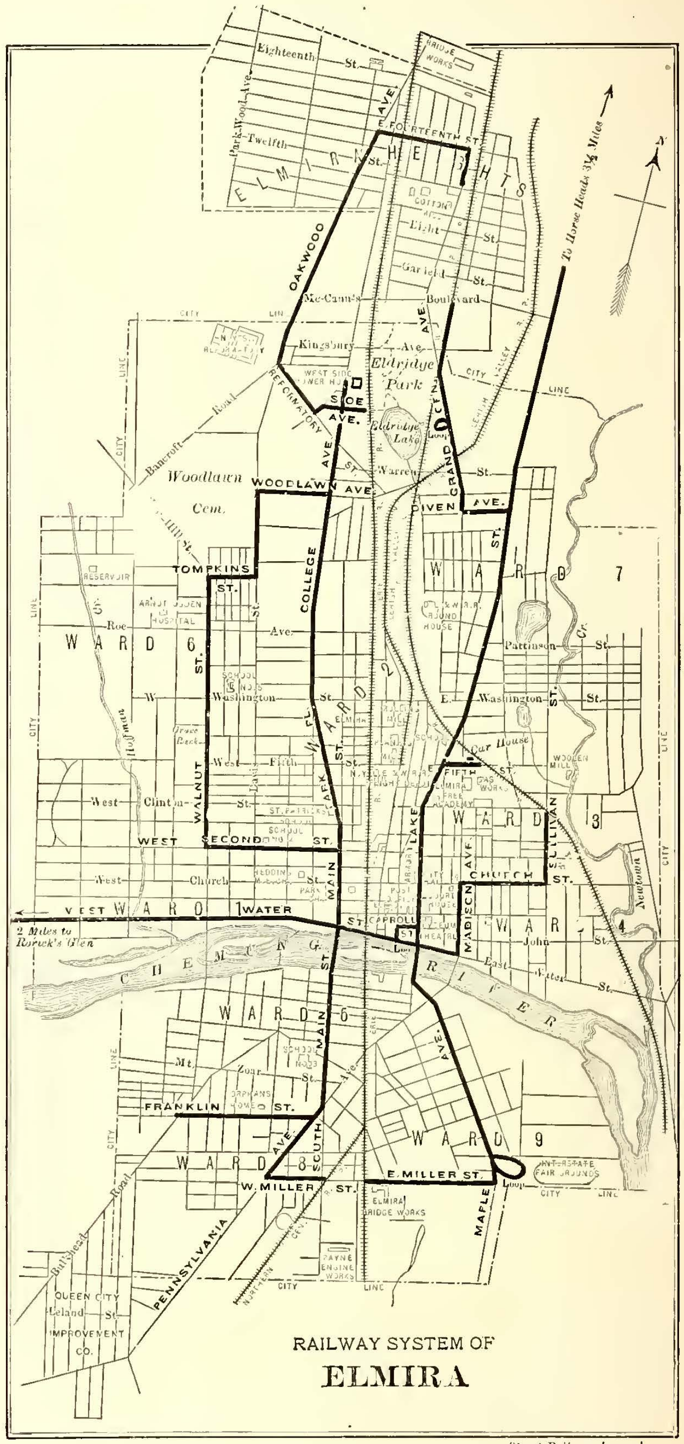


ONE OF THE LARGER ENGINES

200-kw Stanley three-phase alternator and 150-kw, 250-volt Westinghouse power generator. The Stanley alternator is excited by a 3 1-3-hp Crocker-Wheeler generator belted to its shaft. The equipment is completed by a sixth engine of 650 hp to 700 hp, direct-connected to a General Electric three-phase alternator having a capacity of 400 kw at 80 per cent power factor. The engine was made by the Ball & Wood Company and is of the vertical-compound type, a good view being shown of it in the illustration of the power station.

It will be seen from this resumè of the equipment that four distinct classes of service are given by this power station. The alternating current is generated at 2000 volts and distributed by means of a three-phase system. There is a three-wire system of 250 volts and 500 volts which supplies direct current to the power circuits connected to the various individual motors which are operated on the lines. This three-wire system is connected to the two 250-volt generators mentioned above, the loads being so distributed that the larger generator takes approximately twice as much as the smaller. The town street lighting is at present done by engine-driven Brush machines, but it is not unlikely that within a short time alternating-current synchronous motors will be substituted to drive the direct-current machines now in service. The commercial arc lighting is done by alternating current in parallel with the incandescent lamps. A total of 550 commercial alternating-current arcs, 23,000 incandescents, 387 direct-current arcs, 2040 hp in motors and 545 sixty candle-power incandescents are connected to the company's circuits.

The boilers are of a total capacity of 1325 hp and were supplied by the Babcock & Wilcox Company. After the extension of the plant which is under construction the capacity of the boilers will be 2000 hp at nominal rating.



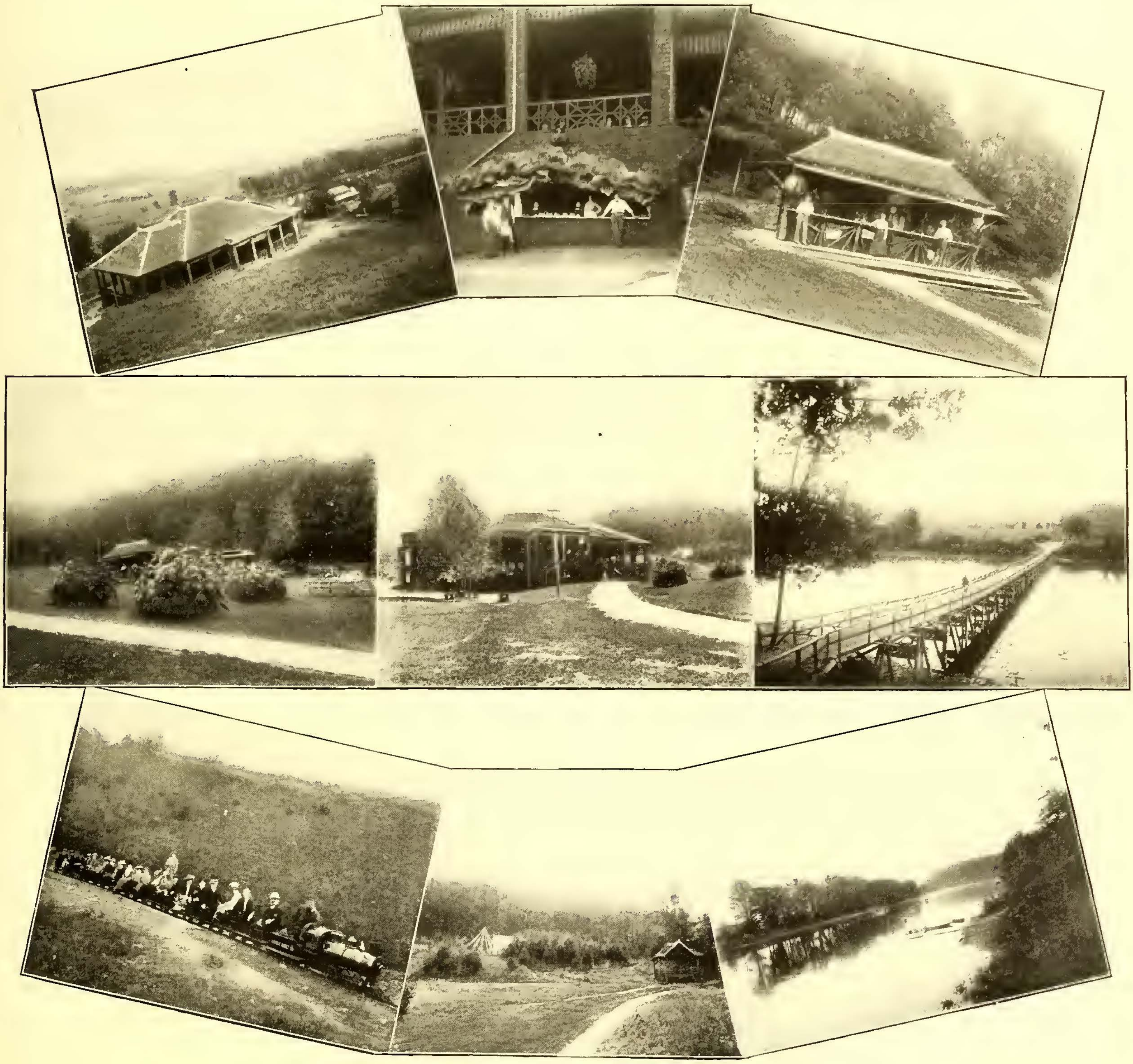
RAILWAY MAP OF ELMIRA, N. Y.

Forced draft is used, the fan, made by the Buffalo Forge Company, being placed at the base of the chimney and regulated by a Burke & Parker regulator. The water for the boilers is obtained from the city mains and is chemically treated by a compound prescribed by the Dearborn Drug & Chemical Company, of Chicago. The engines are run condensing, and some 700,000 gallons of water are used daily for this purpose, the water being piped for a distance of about 1 mile. Near the shore a small house has been built on piles. This house contains a 500-volt Ft. Wayne motor connected to a centrifugal double-suction pump made by the Lawrence Machine Company, which pumps the water through a pipe placed some three or four feet underground to the power station a mile distant.

Blake feed pumps of the duplex-compound type are used. The water enters the boilers at a temperature of 275 degs. F. There are three heaters, the first, or main heater, being a Wainwright, made by the Taunton Locomotive Manufacturing Company, which heats the water to 140 degs., the auxiliary heater, which is a Berryman, heating it to 190 degs., and a Wainwright even-flow heater using live steam brings it to the final temperature of 275 degs. The pressure in the steam headers is 165 lbs. Compressed air is used to clean generators and cars.

The switchboard is equipped with oil switches and oil-cooled feeder regulators, and until recently was on the main floor of the engine room. It has now been raised to a gallery, so that the attendants are away from the machinery and have a complete view of the room. The various classes of service given by the station necessitate a somewhat complex array of instruments and switches, but each department is kept entirely distinct on each division of the board.

A complete oiling system has been installed, which is connected to a 200-gallon tank in the roof. The oil is delivered at the bearings, etc., by gravity at a pressure of 10 lbs. per square inch and then returned to the filters in the oil house and used over and over.



SOME VIEWS IN RORICK'S GLEN

CARS.

The electrical equipment of the rolling stock was furnished almost entirely by the General Electric Company, of Schenectady. The total number of cars is thirty-six closed cars and thirty-nine open cars. There are eighteen 16-ft. vestibuled box cars built by the John Stephenson Company, seven 18-ft. closed cars built by the J. G. Brill Company, four 20-ft. cars most of which were furnished by the Brill Company and some by the American Car Company, six eight-wheeled closed cars (42-ft. over all) built by both the John Stephenson Company and the American Car Company and one closed trailer, which is sometimes used as a smoking car. The open-car equipment consists of six double-truck 12-bench cars made by the Brill Company and Jackson & Sharp Company, five 10-bench cars made by the Jackson & Sharp Company, sixteen 9-bench cars made by the Brill Company and the American Car Company, three 8-

bench cars made by the Brill Company and five 8-bench trailers made by the Jackson & Sharp Company and the John Stephenson Company. Eight 9-bench open cars which were in service last year have been condemned and will be placed around the loop at the end of the line which runs to Rorick's Glen to be used as waiting rooms by the company's patrons. Air brakes made by the Christensen Engineering Company, of Milwaukee, Wis., are installed on all of the heavier cars. These brakes are operated by motor compressors. The company has installed on its trailers axle-driven compressors, using an ingenious system of multiple-unit control. This enables the trains containing two or more trailers to be operated at a very high rate of speed with safety, and a much more efficient service can be given. A view of a train consisting of one of the large double-truck cars and two open trailers is given in the accompanying illustration.

TRAIN OF THREE CARS USED FOR PLEASURE TRAFFIC

RORICK'S GLEN.

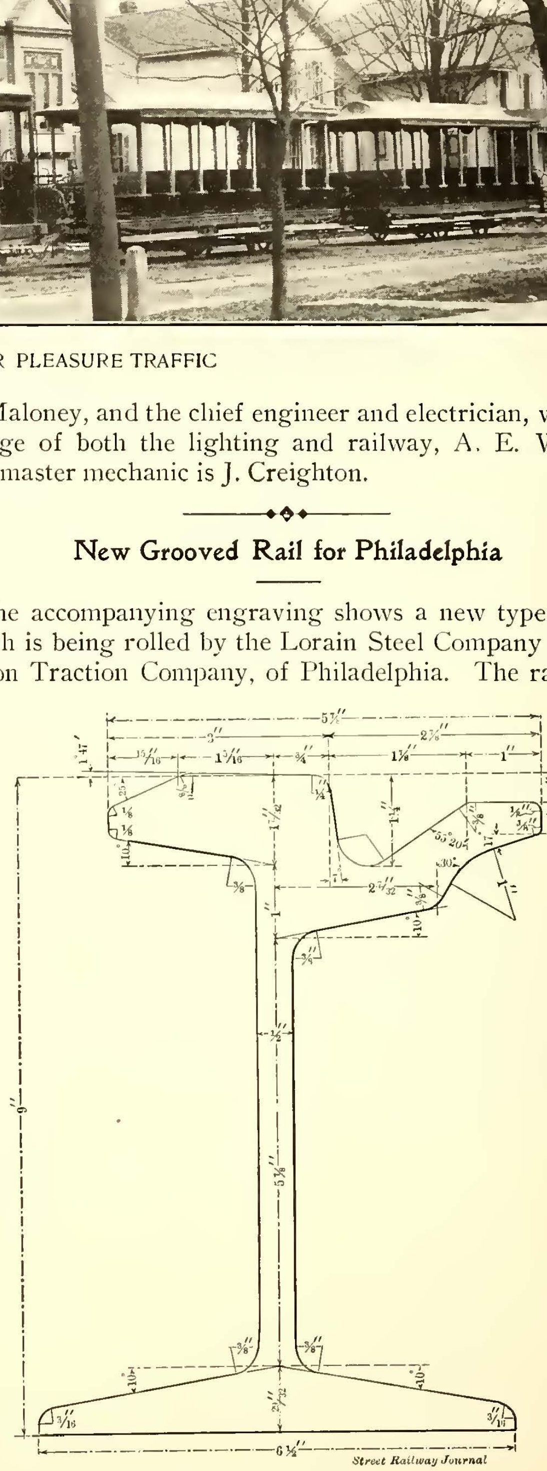
This park is one of the handsomest pleasure grounds in New York State, and a number of views taken therein are given in the group shown. As stated above, Rorick's Glen is placed at a most advantageous distance from the center of the town, about two and one-half miles, making it too long to walk and yet short enough for a profitable haul at 5 cents per passenger. The park contains a casino, at which during the summer entertainments of a light nature are given. These consist of both high-class vaudeville and regular performances of light opera, and are very well patronized. Last year there were few pleasant evenings when a seat could be obtained at any of the performances after commencing. Both afternoon and evening performances are given. Ten cents is charged for admission to the park to those who do not come on the cars, this price including the checking of bicycles. The park is entirely under the management of Henry F. Dixie, a retired actor and manager, who thoroughly understands the theatrical and amusement business and takes a personal pride in the performances which he superintends at the park.

ORGANIZATION.

A large portion of the street railway work is, of course, done by officers of the company, who are also in charge of the other departments, such as gas and water; thus the general manager, W. W. Cole, devotes only a portion of his time to the problems of the street railway, but is obliged to give his attention to the operation of the other works in which his company is interested. There are, however, a number of officers, such as superintendents and engineers in charge of the power station, who are entirely distinct from the other divisions of the organization. The president of the company is Ray Tompkins; vice-president and general manager, W. W. Cole, and secretary and treasurer, J. M. Diven. The superintendent of the street railway, who is in charge of all matters relating to operation, is Francis G. Maloney, and the chief engineer and electrician, who has charge of both the lighting and railway, A. E. Walden. The master mechanic is J. Creighton.

New Grooved Rail for Philadelphia

The accompanying engraving shows a new type of rail which is being rolled by the Lorain Steel Company for the Union Traction Company, of Philadelphia. The rail is to



A NEW RAIL SECTION

be used on those streets where the traffic is the heaviest, and contains several features of novelty. There will be in all about five miles of single track laid on Chestnut, Walnut, Front, Twenty-second and Arch Streets. The standard flange used on the wheels of the Union Traction Company is 11-16 ins., although there are a few ⅝-in. flanges in service. The groove on the new rail, therefore, which is 1¼ ins. deep, will, when new, accommodate a wheel having a flange considerably larger. In order that the groove may be kept clean the lip is made much lower than the head of the rail and the slope of the groove on the inside is very considerable. A peculiarity of the rail is the sloping edge on the outside of the tread. With this construction, as the rail wears down, it is expected that it will retain its form much better than if the tread were made flat throughout its entire width. In order to accommodate this sloping edge the outside dimensions of the head of the rail are made a little greater than ordinary.

Before adopting this section of rail the subject was very carefully investigated by the company, and it is thought that a type has been found which will have as long and efficient a life as is possible under the heavy traffic conditions found on the routes where it is to be laid. There are many localities in city streets where the wear on rails is necessarily very severe, and in the rail illustrated this fact has been given the greatest attention, so that until the rail is worn sufficiently to be unfit for service it will continue to offer to the wheels the most desirable form of head and groove. In laying these rails the zinc joint described some months ago in these pages will be used, and when the track work is finished it will be one of the finest examples of permanent-way construction in city streets in the country.

Train Resistance

BY A. H. ARMSTRONG.

The keen interest taken in the subject of train friction, especially at the higher speeds, insures a warm welcome for the first experimental curves obtained from the Zossen experiments published in the STREET RAILWAY JOURNAL While these curves do not in any way afford data for a complete study of high-speed car work, they are the first authentic published data of the kind carried up to speeds beyond 60 miles per hour.

The data is especialy welcome at this time owing to the wide divergence in opinion on the subject of high-speed car friction and the amount chargeable to wind resistance at speeds approaching 100 miles an hour. Some tests taken upon the Buffalo & Lockport tracks by the General Electric Company were published by W. J. Davis, Jr., in the STREET RAILWAY JOURNAL, together with his reply to criticisms upon his original article. This last contribution has also been criticised and the Zossen tests quoted as disqualifying the results obtained. Before comparing the data from the different tests let us briefly cover the question of train friction and see what constitutes the different elements making up the total friction to be overcome at constant speeds.

Repeated tests upon stationary apparatus have shown that the friction loss of rotating bodies may be taken as directly proportioned to the speed, or, in other words, the torque is approximately constant at varying speeds. The journal friction of cars will vary from 4 lbs. per ton for heavy units to as high as 8 lbs. per ton, or even more, for very light cars. Added to this journal loss there is a certain amount of flange friction which may be considerably increased by a transverse wind. As the roadbed is not perfect or rigid there is a further loss in bending rails, riding joints, etc., which is a function of the speed and could very well constitute a second factor in a train friction formula. By far the largest loss at speeds approaching 100 miles per hour occurs in pushing the car or train through the air, and it is this factor upon which we have the least experimental data and consequently the greatest disagreement of authorities.

It is unfortunate that so many train friction formulæ are based upon pounds per ton, as it is evident that the wind resistance is not measured by the weight of the car, but rather by its cross-section and length, and such formulæ are especially misleading when applied to trains composed of a different number of units from that pertaining to the test from which the formula was derived. This fact largely accounts for the conflicting results obtained by comparing different formulæ where these are of a general character. This is especially true when an attempt is made to apply general formulæ of different authorities to the operation of single cars at speeds approaching 100 miles per hour, as no experimental data has hitherto been published for single cars operating at this speed.

The total amount of data available for comparison consists of some laboratory tests made by the Siemens & Halske Company, the results of which were published Sept. 7, 1901, in the Electrical World and Engineer, wind pressure being obtained by revolving different shaped surfaces. These tests, together with the results given by Mr. Davis from the Buffalo & Lockport experiments, and the Zossen tests published in the STREET RAILWAY JOURNAL, constitute the available data for comparing the performance of single-car trains.

The results obtained by revolving different shaped surfaces gave a constant of $.001V^2$ for parabolic surfaces and $.004V^2$ for flat surfaces where "V" is velocity in miles per hour. The Zossen tests gave $.0028V^2$ and $.003V^2$, depending upon the shape of the car end, and the Buffalo & Lockport tests $.004V^2$. These results are tabulated below.

Parabolic rotating surfaces	$.0010V^2$
Zossen tests, Siemens & Halske car	$.0028V^2$
Zossen tests, Allgemeine car	$.0030V^2$
Buffalo & Lockport tests	$.0040V^2$
Flat revolving surface	$.0040V^2$

There is a considerable discrepancy between these results, and the difference between parabolic and flat surface shows that the shape of the end of a car has a very marked effect upon the friction. These values are, moreover, taken by three different methods, which in itself is enough to produce considerable variation.

The revolving surfaces must necessarily give too low a pressure to the square foot when applied to straight-line work, as they do not rotate in still air, but carry a considerable volume of air with them. We would look upon the Siemens & Halske experiment, therefore, as giving results somewhat too low, and, in fact, they serve only as an indication of what would be expected for actual friction of a car at high speeds. Moreover, they would consider only the head-on friction of the car and neglect the side and rear friction, which must amount to considerable, as is evidenced by the increased total wind friction when extra cars are added to a train. These tests point out, however, one fact very strongly, and that is that the wind friction increases as the square of the speed and that the third member of our train-friction formula should contain the second power of velocity.

The Zossen tests determine the wind friction by pressure tubes at the front end of the car and include only the head-on friction, neglecting the side and rear friction. The constants obtained ($.0028V^2$ and $.003V^2$) cannot therefore be used directly, but must be increased to take care of the additional friction of the sides and end of the car. The pressure in pounds per square foot given by the barometer tubes cannot be used directly either, as it does not necessarily obtain over the total cross-section area of the car.

The only correct method of securing the actual wind friction of the car is by means of power readings at different speeds checked by a coasting curve on a straight, level track.

The Buffalo & Lockport tests, on the other hand, measured the power to drive the train as a whole, deducted the rolling and journal friction and arrived at the constant of $.004V^2$ by including not only the head-on friction but the total wind friction of the train. This method of obtaining the power required to drive a car at high speeds is undoubtedly more accurate and more complete than either of the two methods given above. Further publication of the results of the Zossen tests will undoubtedly contain values of train friction depending upon the actual power required to drive the car, and hence will be directly comparable with the Buffalo & Lockport tests.

In his formula, Mr. Davis considers the constant of .004 as too high, it being obtained with a flat-end surface, and he assumes that it will be reduced to .0035 with a car having its ends adapted for such high-speed work, a figure not much higher than the Zossen constants obtained and not too high for conservative preliminary calculations.

The power required to drive the Siemens & Halske experimental car at a speed of 100 miles an hour has been given as 950 hp output of the motors. The car weighed approximately 104 tons of 2000 lbs. and had an effective cross-sectional area of about 119 sq. ft., which was determined by including the projecting starting resistances on the sides and current-collecting devices on top of the car. Using the constant obtained in the Zossen tests (.0028) the tractive effort due to wind friction alone at 100 miles an hour would be 3330 lbs., or 32 lbs. per ton of 2000 lbs. It is necessary to add a certain amount for journal and rolling friction of the car, and this latter item could be made somewhat larger than the figure given by Mr. Davis, as the rail used in the Zossen experiments was stated to be too light for the heavy cars and high speeds used. The Davis formula gives a constant of 5 for journal friction of a 45-ton car, and we may perhaps reduce this to 4 for such a heavy car as those used in the Zossen tests. The second factor of the Davis formula (.13V) could well be increased in this case, owing to insufficient weight of track for the high speeds maintained. Using, however, the same factor for the second member of the Davis formula and 4 for the first member we arrive at 17 lbs. per ton additional, which, added to our 32 lbs., brings the total up to 49 lbs. per ton total friction of the Zossen car. At a speed of 100 miles per hour this corresponds to 1368 hp output of the motors, or 44 per cent more than the 950 hp given as the experimental value for this speed.

Although it would seem that the constants of the first two members of the Davis formula are conservative, and they are below those given by some authorities, it may be that they are too high. Taking the wind friction of the Zossen experiments as being correct, 32 lbs. per ton at 100 miles per hour for the Siemens & Halske car, we arrive at an output of the motors of 877 hp for a speed of 100 miles an hour due to wind friction alone. This leaves 73 hp, or .83 lb. per ton, for journal and track friction, an amount which is obviously absurd. The data given as wind friction from the Zossen tests, therefore, seems to discredit what figures have been published regarding the horse-power required to drive the car.

Returning again to the Davis formula, we do not find any grounds for discrediting it due to the results of the Zossen experiments. The previous laboratory experiments made by the Siemens & Halske Company showed a variation between .001 and .004, depending upon whether a parabolic or flat surface was opposed to the wind. The Buffalo & Lockport test gives a constant of .004 with surfaces that are nearly flat, being reduced by Mr. Davis to .0035 for rounded-end cars, while Zossen shows a constant of .0028 as obtained from the car ends approaching a parabolic surface and .003 for the rounded-end car of the Allgemeine Company. In other words, the difference between the Davis constant and that obtained from the Zossen experiments is not as great as previously obtained with the same shaped surfaces in the Siemens & Halske laboratory experiments.

It is unfortunate that the Buffalo & Lockport tests could not be carried to much higher speeds in order that there might be no question concerning the elimination of track and journal friction from wind friction. As far as they went, however, they indicated that the wind pressure increased as the square of the speed, which has since been verified by the Zossen experiments, thus justifying the use of the second power of velocity in his formula. The constant of .0035, however, includes the total wind friction of the car or train, while the Zossen constants of .0028 and .0030 include only the end friction of the car and entirely exclude the side friction and whatever rear-end friction may obtain. Taking the Zossen constant as it is given, however, it does not agree with the horse-power required to drive the Siemens & Halske car so far as these figures are published as yet, and, furthermore, does not discredit the Buffalo & Lockport tests, but rather confirms the conclusions arrived at from these experiments.

It is obvious that any formula based upon pounds per ton must be used with considerable discretion for cars presenting different cross-sections, different shaped ends and different irregularities along their surfaces. Considerable error may also be made in selecting the effective cross-section of the car even after proper constants are found by exhaustive experiments.

Opposing a wind at a velocity of 100 miles an hour is a serious matter, as evidenced by applying the results of the Zossen tests directly to the operation of a 45-ton car at this speed, using the same constants of 5 and .13V, as given by Davis, but substituting .0028 for .0035. Assuming a cross-section of 110 sq. ft. we arrive at a total tractive effort of 86.5 lbs. per ton, corresponding to 1040 hp output required to propel a 45-ton car at 100 miles an hour. The same constants applied to the Zossen car gave a total of 1368 hp, but this car was over double the weight and practically the same cross-section as the 45-ton car, while it does not require so very much more energy to propel it at the same speed. Davis found that each trailing car added approximately 10 per cent to the wind friction value, and, assuming this to be correct, and using the Zossen wind friction curves, we obtain an output of 1390 hp for a train of two 45-ton cars, a figure which is practically the same as that required for the propulsion of the Zossen car, but carrying with it a greater seating capacity.

Very high-speed lines, 100 miles per hour or above, will probably use trains consisting of more than one car, as it is a question if it is not advisable to operate two 50-ton cars rather than a single 100-ton car, thus securing the advantages of distributing the load over a greater wheel base and the steadying action secured by trains at high speeds. The published results of Zossen experiments giving horse-power required to drive the car at different speeds and the subdivision of car friction into track, journal and wind friction, will be looked forward to with very great interest as giving much better working data than the results of wind pressure as measured by pressure tubes. It is to be hoped in the interest of future high-speed railroading that wind friction will show a constant not greater than .0028 even when total wind friction of the train is included. In the meantime, however, the constant of .0035 for total wind friction deduced by Davis from the Buffalo & Lockport tests seems justified for conservative estimate, and, in fact, checks up remarkably well with the results of the Zossen barometer tests if these should be increased to include as well the side friction of the train.

Train Resistance Formulae

BY JOHN BALCH BLOOD

In the May number of the STREET RAILWAY JOURNAL, Mr. Davis had an article based on a series of tests on the Buffalo & Lockport Railway. He does not give the test, but gives formulae which he deduced therefrom.

In determining his formula he starts with the principle that the different items going to make up the total resistance should be properly segregated, but falls down on the rock where most every one has before him, namely, in attempting to have the variables of the formula with integral exponents.

A formula for train resistance can be made with two distinct objects in view, one for the easy and approximate calculation of the resistance and the other the accurate determination of the resistance. In the first, simplicity is the desideratum, while in the second, functional accuracy is important as well as conformity to the conditions of the case.

The accuracy of experiment and observation has much to do with the form of the formula, as also has the limiting values of the speed. For instance, if the accuracy of the observation were measured by a probable error of one pound per ton, it would be useless to introduce a term whose total value in a given case was much less than one pound per ton. Again, if the range of the formula were very limited, it is useless to increase the complexity by multiplicity of factors of different exponents, as within a short range a single factor or two factors can be made to represent given observations within the accuracy of the observations.

Mr. Davis has attempted to get accurate results. He has introduced terms to increase accuracy, but at the same time has made assumptions which introduce larger errors than the accuracy of the terms he introduced.

The formula he uses is essentially the same as proposed by Mr. Armstrong, and is similar to the formula proposed by the engineers of the Eastern Railway of France, with the addition of a term giving the wind friction on the sides of the cars.

Mr. Davis gives the elements in train resistance as three: (A) Journal friction, (B) rail friction, (C) wind resistance. He mentions that the gear and bearing friction of the motors together with the motor losses should be calculated as a function of the motors rather than of the train resistance, and with this proposition I agree.

Mr. Davis in making this division assumes that the wind resistance is all of the same function. It would seem from reason and experiment that such is not the case.

It is pretty well established that there is a portion of the resistance which varies as the zero power of the velocity, which is independent of the velocity. This can be deduced by experiment and also on theoretical grounds, and represents as a basis the journal friction, but contains probably other portions of friction of less moment than the journal friction.

Again, it is pretty well established that a portion of the friction varies according to the first power of the velocity. This portion is the rail-rolling friction, and from a theoretical standpoint it seems that this should vary as the first power of the velocity, as it is practically the bending of a beam.

Mr. Davis's third function, wind resistance, he has taken as varying with the second power of the velocity. He does this because the wind pressure on a normal plain from tests varies approximately as the second power. He assumes that the friction resistance on the side of the train also varies as the second power. This last assumption is purely an assumption, and it is not borne out by tests or theory.

In ship resistance the head resistance or resistance through a fluid is found by experiment to vary as the third power of the velocity or some higher power, whereas the skin resistance or side resistance of the water is taken as the 1.83 power. This has been demonstrated, and this exponential figure, 1.83, is almost universally accepted as the proper exponent for the skin friction. If the side friction is deemed of sufficient importance to be put in the formula it should have its proper exponent to the velocity factor.

As to the second power being the result of Mr. Davis's curves, I would mention that from Fig. 2 the 1.9 power would represent the results equally as well as the second power. It will be noted that between 6 lbs. and 13 lbs. per square foot all of the points are above the line, and in no case is there a point below the line.

Taking the case up from experience it seems to me pretty well demonstrated that with the third term of the formula a second power term, the results by such formula give much too high resistance above 60 miles or 70 miles per hour. At the same time, with no term higher than the first power resistance above 50 miles per hour is lower than would be experienced.

At 60 miles an hour, with from three to five cars, the head wind resistance is probably less than 4 lbs. per ton. The side wind resistance is also much less than one pound per ton. The rail resistance is about nine pounds per ton, at 60 miles, and the bearing resistance about 4 lbs.

It will be seen then that up to 60 miles per hour the exponent of the third term will not vary the total resistance to a very great extent, but when we get to 100 miles per hour, we have the bearing friction 4 lbs., the rail friction 15 lbs., and the wind friction something like 30 lbs. Here it will be seen that the higher exponential factor is of larger importance, as a difference in exponent from one to two would make a total in the resistance of from 30 per cent to 40 per cent.

This matter of exponents for terms has been one which has troubled everyone who has endeavored to make formulae. D. K. Clark, in 1854, used a formula with two terms, the first independent of the velocity, and the second varying as the square of the velocity. This formula was in all probability deduced from theoretical reasoning, assuming that the bulk of the resistance was of the nature of wind resistance, or that it varied according to the same law.

With proper constants this formula would give reasonably satisfactory results within a small range, but it was found that when the range was increased the formula was wide of the mark. On this account we find a reaction, and several persons made formulae, using first power of the velocity as the only variable. This gave much better results at speeds less than 40 miles per hour, and was used in large measure in practice for many years.

Rankine's formula is of this form as is the one of Baldwin Locomotive Works. Engineering News, in 1893, gave a formula of this nature as did also D. L. Barnes, who had given great study to this matter of train resistance.

The engineers of the Eastern Railway of France, in 1885, made some very careful experiments to determine train resistance, at speeds varying from 12 km up to 80 km. They found that neither the formula with single first power or single second power term was applicable, and their formulae contains three terms, one with the zero power term, another with the first power term, and the third with the second power term, which has the weight factor in the denominator. This is theoretically as one would expect in determining the resistance in pounds per ton of train, as the head resistance would naturally be constant independent of the train wherein the resistance per ton of train would vary inversely as the weight of the train.

The Eastern Railway of France experimenters found that even with this formula satisfactory results could not be obtained, and in order to make it applicable were forced to change the constants of the first and second power term, giving different formulae for the different speeds. In all they have four formulae, one according to their statement for freight trains, with speed from 12 km to 30 km per hour. This formula has no second power term in it. The second formula is for passenger and mixed trains of speeds 32 km to 50 km per hour. The third is for passenger trains with speed from 50 km to 65 km per hour, and the fourth for express trains with speed from 70 km to 80 km per hour. This fact, namely, that the constants have to be changed with the speed, shows that the exponent of variable is not correct.

It seems to me that there is overwhelming evidence that a resistance formula with three terms, with the third term and second power term, will always give a much too high resistance above 60 miles per hour if the formula is correct for speeds below that.

In the STREET RAILWAY JOURNAL for March, 1899, I gave an article on "Train Resistance," mentioning this fact and giving as most reasonable general formula where three terms were the limit, the formula as follows:

$$R = 4 + .15M + .30 \frac{M^{1.8}}{T}$$

Where

R = resistance in lbs. per ton.
M = speed in miles per hour.
T = weight of train in tons.

I believe this formula, as it stands, would give reasonable results, but in all cases where extreme accuracy must be obtained, as in cases of single cars, the importance of each factor must be considered and proper co-efficient used accordingly. For instance, a 10-ton car with four wheels would have less bearing friction per ton than a 10-ton car with eight wheels, and again, a single car running on a 100-lb. well-laid rail would have much less rail friction than if it were running on a 50-lb. rail in bad condition.

Again, for extreme accuracy, I believe that we need four terms, one representing the head resistance, and another representing the side resistance of the train. For single cars I believe that the side resistance term should be eliminated, and here we would need three terms only, but for trains of from five to ten cars two terms of different exponential value are necessary.

In conclusion I would say, that I do not think it possible to develop a formula for accurate work to take in speeds from zero to 100 miles per hour without introducing one factor with the exponent of the velocity fractional between one and two.

Again, I think that without doubt the wind-side friction varies with the different power of the velocity and the head friction. Further, I believe that it is useless to introduce complications into the formula for the side friction until the proper exponents for side friction and head terms are determined.

It seems to me that while the engineering work in this branch has not produced satisfactory data at high speeds, with exponential factor for the third term of 1.8, it will give as accurate results between 60 miles and 100 miles per hour, as we have had with other formulae of only two terms up to 60 miles per hour.

With reference to experiment I think that the effort should be to show the exponents of the wind factor both as regards head friction and side friction.

Argument on Subway Injunction

The application of Charles T. Barney for an injunction to prevent the completion of the Rapid Transit subway along its present line in the section which passes his residence, at Park Avenue and Thirty-eighth Street, New York, was argued before Justice Giegerich in the Supreme Court of the City of New York, on June 26, by A. H. Masten, who appeared for Mr. Barney, and Edward M. Shepard, who represented the Rapid Transit Commissioners. Corporation Counsel Rives also appeared as the representative of the Mayor and Comptroller.

Mr. Barney contends that the original plans of the Subway Commission have been modified, and that these changes are of such a radical nature as to really endanger the safety of the residents along the line; consequently he asks that the excavations, which he claims were unauthorized, be filled in. He also says that the plans upon which the contractors are now working call for four tracks, where only two were authorized, and that the wall of the tunnel instead of being 35 ft. from his house is only 7 ft. Mr. Masten, his attorney, says that while it may be wise to enlarge this part of the tunnel so as to provide for connection with the tracks at the Grand Central, it is not lawful to do so on the decision of the chief engineer alone, that when the modification of the original plans was contemplated, the change should have been announced publicly, and the matter should have been submitted to the Rapid Transit Commissioners for consideration and approval.

Mr. Shepard, opposing the petition of Mr. Barney, said that the interests involved in the construction of the subway were of such magnitude that an individual's loss or annoyance ought not to be considered, as there could be no comparison between these losses and the benefits which would accrue to the general public. He declared that the change in the plans was considered and ratified by the Board, and that these modifications were absolutely necessary in order to carry out the mandate of the appellate division, which had directed the Rapid Transit Commissioners to make some provision for the accommodation of the East Side and interurban traffic. Mr. Shepard said that if the section of which Mr. Barney complained had to be refilled, in accordance with his wishes, it would mean a delay of at least eighteen months in the completion of this portion of the work. In summing up the case Mr. Shepard said:

> We insist that Mr. Barney can never maintain this action, or, indeed, be greatly listened to. He is a large stockholder and a director of the Rapid Transit Subway Construction Company, which has constructed this section. If the work has been done without the route and general plan it has been done under his direction and he is without redress. This change was advised and concurred in by the engineers of the company of which he is a director. If he was ignorant of the location of the tunnel that was simply because he refrained from knowing what his company was doing.

The corporation counsel, who appeared for the Mayor and Comptroller, corroborated the statement of Mr. Shepard that the modifications in the line of the tunnel had been made in strict conformity to law, and he urged that the action of the Commission be supported by the court. He declared that much harm would come from any protracted delay in the completion of the tunnel work at this time.

Decision was reserved.

STREET RAILWAY ACCOUNTING

CONDUCTED BY J. F. CALDERWOOD, ASSISTANT TO THE PRESIDENT, BROOKLYN RAPID TRANSIT COMPANY, AND MEMBER INSTITUTE OF SECRETARIES OF LONDON

Creation of Reserve Funds

BY JAMES MANNING.
Member of the Institute of Accountants and Actuaries of Scotland and Fellow of the Institute of Secretaries of London.

I have read with interest the article by H. C. Mackay, president of the Street Railway Accountants' Association of America, entitled "Creation of Reserve Funds." The suggestions expressed by Mr. Mackay are so thoroughly in accord with my personal opinions that I should be at a loss to find a point on which to take issue with him but for the title, which affords me a pretext for writing a few words.

In my experience as an accountant in railroading I invariably raise the point so effectively treated by Mr. Mackay, that provision should be made for the proper maintenance of track and also of equipment, machinery and buildings. Without doubt ample provision should be made each year for the wear and tear on these and for their renewal. Once the average life of the different material in the track is settled by the engineer and the approximate cost of labor required in making repairs and renewals is ascertained, the accountant can make his calculations as to the appropriation that should be made on each account, so as to provide for renewals as they become necessary. In so far as the ascertained amount is not expended in renewing the track, a charge should be made to operating expense and a corresponding credit to a track renewal fund. This fund may be subdivided so as to show the funds available for rail renewals and other items separately. In practice it is well to make these adjustments monthly. Similarly a regular charge "per car mile" may be established for repairs and renewals of cars and motors, regulated according to class of car, and any expended balance charged to operating expenses and credited to a car renewal fund. Renewal funds for buildings and machinery may be similarly established. But these funds must not be regarded as reserve funds, for they differ materially from the reserve fund proper. The renewal fund represents definite depreciation. It is ear-marked for all time, so that it will only be used for the specific purpose for which the charge was made. Essentially it forms a primary charge to the operating account, one that must be made before any surplus can be shown. Now, it is only from the surplus that the reserve fund proper can be voted, and therein lies the difference.

To emphasize this point, I might call attention to the paragraph in which Mr. Mackay refers to making provision for the liability on unpresented or unsettled claims for injuries and damages. Where one has to deal with accidents that have occurred and involve unsettled claims, the charge is one which should strictly be made against operating expenses. But where it is desired to form a reserve fund in view of the possibility of serious accidents occurring in the future, the case is different. Here no actual liability exists. Therefore, any provision voted from the surplus may be regarded as a reserve fund in the strict sense of the term.

In estimating the charge that should be made to provide for the wear and tear of electrical equipment it might be well to allow some margin for replacing equipment that may have become obsolete before it is actually worn out. This, too, might be provided for in a general reserve.

It is certainly most important that a proper sinking fund should be created to replace capital invested in plant and machinery that may have to be abandoned on the expiration of a lease or franchise. In this case the payment of an annual premium to some well-established and substantial trust company commends itself to me. A premium can be adjusted that will be based on a reasonable rate of interest. When the premium is so adjusted and regularly paid the investor can rest satisfied that the repayments of the amount of his investment is assured. As an example of what may be done in this direction, I might state that you could insure the payment of $650,000 on the expiring of a lease or franchise in 40 years by the payment of thirty-nine annual premiums of $9,250 to the trust company. Such an arrangement precludes any possibility of trouble in the adjustment of sinking funds.

I fully agree with Mr. Mackay that, as a general rule, it is well to have all renewal funds especially set aside, so that the actual cash be available at any time that it may be required. There is, however, a special occasion for setting aside the amounts appropriated to general reserve funds. Where amounts are voted from the surplus to form a reserve fund that may be used for equalizing dividends or any other purpose affecting the general welfare of the stockholders, it may be found to be more to the advantage of the business to use the fund in the ordinary course of business as working capital. By so doing the fund may earn several times the amount that would be derived from it if invested in high-class securities. It would appear poor financing to set aside a fund that would only return say 2 per cent. interest, if, on the other hand, you were borrowing money at 6 or 8 per cent. to purchase supplies or carry a floating debt.

The Auditor and the Stockholders

The auditor of a public company or corporation is in theory and by right an agent of the shareholders. In Great Britain, by "the Companies Act, 1900," he is made directly responsible to the general body of shareholders, and it is made compulsory upon him to report to them as well as state on the balance sheet whether the requirements of a full and free auditing of accounts have been strictly complied with in letter and spirit. He is made a watch dog upon the financial operations of the officers and directors. He is to report errors, misleading bookkeeping and malfeasance. He is to report to the stockholders the concealment of essential facts, the payment of unearned dividends, the wasting, misdirection or overvaluation of assets, the covering up of liabilities and the performance of official acts not authorized by the stockholders or by the articles of incorporation. In short, the function of the auditor is to safeguard the interests of the stockholders and protect them from official error and malfeasance.

In order to perform the function of an independent and fearless auditing of accounts so as thus to safeguard shareholder interests, the first essential, of course, is that the auditor's official position comes not from the managing director whose financial acts he is appointed to examine, but from the stockholders themselves whose interests he represents; and right here is the fundamental error of the American practice and the danger to the professional standing of the American auditor.

The appointment of the auditor or comptroller of the average American corporation comes directly from the managing director. The appointee, therefore, is absurdly supposed to act as a watch dog upon the acts of his manager, to report to a miscellaneous investing public the errors and malfeasance of the official upon whom he depends for both his salary and his job. Is it to be supposed for an instant that where crookedness existed an honest and independent audit under such conditions could be accomplished? If the report of a fearless audit exposing the management were prepared, would it be allowed to go to the stockholders? How long would it take the manager in such a case to discharge his appointee and substitute another who would do his bidding? In short, under the current American system, the auditor of the average corporation is nothing more or less than the manager's financial clerk. He is not an independent official. He is not the fiduciary agent of the stockholders. He is not the financial watch dog of the corporation. He can report to the stockholders neither the errors, the deceits nor the frauds of the official management. On the other hand, he is made the cloak for errors, the servile agent of deceits and oftentimes the helpless scapegoat of frauds.

The duties of the auditor of the average corporation are:

1. To ascertain the correctness of the accounts.
2. To ascertain and verify the liabilities.
3. To examine and verify the values of the assets.
4. To present to the stockholders properly constructed accounts and balance sheets.
5. To certify that these accounts and balance sheets strictly accord with the facts.
6. To report to the stockholders any discrepancies that may exist between the books and the facts and the discovery of official errors or malfeasance.

But, suppose that the auditor is appointed to his position by the manager of the corporation, and that the accounts to be audited, the liability and asset reports to be verified and the discrepancies to be reported represent the will and acts of the manager. What, under such conditions, is the audit worth? Will it be an audit at all, or simply a false pretense aimed to cover up the missteps of the management and gull the stockholders and investing public?

The well-known Scottish accountant, Ebenezer Carr, explains the correct position of an auditor thus: "Certainly he should not undertake an audit unless he has a free hand to do all that is necessary for presenting a fair and full representation of the position of the concern under audit; anything short of this is worthless." But what auditor can have a free hand in examining and reporting the financial acts of the manager who controls his job? How large a proportion of the auditors and comptrollers of American industrial and public service corporations can boast that they have such free hand?

The auditor is supposed to ascertain if there are liabilities incurred bythe manager other than those shown in the books; to write off the proper proportion on all wasting assets and see that the assets are down for present bedrock values and not at inflated estimates; to reduce the estimates on the stock in hand to net values, and thereby guard the stockholders against the dangers of a false and fictitious balance sheet. But if the official management is the beneficiary of the misrepresentation, and, at the same time, has absolute control of the position of auditor, can the audit be anything else than a cover of falsification?

The audit is to ascertain if there is a voucher for every disbursement, an invoice for each item of the purchase book, a dollar in cash for each dollar in the cash book and a deed and abstract of title for each piece of real estate. The auditor is to ascertain that the bad debts have been marked down as such; that the depreciation in value of plant and fixtures has been properly written off; that there is no inflation in the value of the stock; that no liabilities are concealed; that dividends and cost of maintenance are not paid out of the capital; that the bank account is supported by the certificate of the banker; that all investments are verified at present market values; that contingent liabilities are given full showing; that the reserve fund reported is real and not fictitious; that the balance sheet is a faithful photograph of the books, and that the books give a true and complete record of the facts and of the company's condition. All this the auditor is to examine, ascertain and verify; and for what purpose? In order that the mistakes and malfeasance of the official management may not jeopard the investment interests of the stockholders. But when the official management controls the audit by controlling the auditor, what mistakes and malfeasances of official management are the stockholders going to ascertain from the audit? It is only too plain that, in fact, there is no audit at all. It is pure buncombe, a farce, so much advertising, and that is all.

Under such conditions the auditor might just as well be dispensed with. What is the use of an audit that does not audit, or an investigation that is never made, or, if made, is never reported, or if reported conceals the errors and malfeasance investigated. It is worse than no audit; it is a fraud to conceal a fraud.

It is perfectly clear that if the profession of auditor is to obtain in this country a high professional standing the auditor must be a free moral and financial agent. He must be beyond the control of the officials whose official acts he is to review. His position must come from the stockholders whose interests he is supposed to safeguard. He should report only to the stockholders and be responsible only to them. In that way, and in that way only, will the interests of the stockholders of American corporations be strictly safeguarded, and in that way only will the standing of the American auditor be worthy of the name.

Necessity for Audits

In keeping with the position which we have taken on the value of examination of accounts by independent auditors, the Wall Street Journal recently called attention to several special cases, particularly that of the Evansville & Terre Haute Railway, in which this necessity was emphasized. The increase in the number of industrial companies seeking investment demands that some provision be made for the protection of the general public. The writer of the article in question points out that an audit is one thing and an expert examination is another, the vital fact being the integrity of profits. While this is in one sense a bookkeeping matter, it is entirely different in another sense, for while the books may be kept with irreproachable correctness, so far as balance sheets and income statements may be concerned, the results disclosed thereby and the deductions drawn therefrom may be entirely incorrect in a larger sense. The ordinary audit means very little more than the verification of entries, as it does not go into the broader question of their original correctness, nor does it verify the accuracy of the books as a complete record of the transactions and the condition of the property. Those who are familiar with the situation will agree that the necessity for such independent audits of a thorough and comprehensive character is much greater in the case of street railway properties than in any other class. The difference between the work of the bookkeeper and auditor is very clearly illustrated in the following summary:

Profits mainly depend upon two things, the first of which is the valuation of inventories at the end of the year, and the second, the allowances for depreciation of plant. If a company chooses to over-value the inventories, the bookkeeper simply takes the statement as given to him and puts it on his ledger. The ledger balances agree all right with the profit and loss statement, but if the profit and loss statement is made on this basis, the profit as written is in excess of the real profit, and the excess will sooner or later have to be dealt with by writing off. Again, if proper allowances are not made for depreciation the profits are over-rated by the amount to which the allowances are short of the facts, and if dividends are made on the basis of the book profits trouble results sooner or later.

The ordinary audit, as far as our experience goes, does not sufficiently canvass the inventory value or the depreciation allowances—neither of which are subject to ordinary check by voucher—and as has been said, it is entirely conceivable that a merely bookkeeping audit might certify a set of accounts in which inventory values were wholly out of proportion with the facts, and in which depreciation allowances were altogether too small.

We think that every industrial company in making its report to stockholders should call in independent auditors, who should be instructed not merely to certify to the accounting, but should also be requested to certify to the profits. The auditor would in such case employ experts satisfactory to themselves on whose judgment they would be willing to issue their certificates. With such a certificate, stockholders could fairly feel that they had something on which they could rely besides the statement of the company's officers. The officers, moreover, could feel that a considerable part of the responsibility had been lifted from their shoulders, and we should imagine that this would be a strong inducement to all who were desirous of doing their duties conscientiously.

An insufficient audit is worse than none at all, because from the nature of things it induces the stockholder to believe that he has a guarantee when he has none. The principle of independent audit is good only in its complete application. We think, however, that such complete application of the principle ought to be practically universal henceforth. There is so much uncertainty involved in industrial corporation finance under the best conditions that whatever can be done to remove or diminish this uncertainty ought to be done. At the present time conditions in this respect are very unsatisfactory.

Corporate Dividends

BY CHARLES COLEBY RECKITT, C. P. A.

In the present age, when nearly 50 per cent of the title to property in the United States is vested in stock companies, it naturally follows that a large percentage of the incomes of the country are derived through the medium of dividends. Notwithstanding, however, the immense revenues derived through this source, there are, comparatively speaking, few court decisions bearing on the subject. What cases there are seem to be chiefly of a prohibitive nature given for the protection of creditors of insolvent companies. The court seldom intervenes to regulate the internal management of the company or to protect the rights of one class of stockholders as against another, the only exception to this case being where fraud actually exists. Upon the accountant of a corporation, therefore, devolves the responsibility of protecting the rights of all classes of stockholders' interests; and although in such matters his services are only advisory, whilst the decision of the directors is almost supreme, his efforts should always be directed to establish the rightful interests of each class of stockholders, to exhibit to the directors a full report on the condition of the affairs of the company and a correct statement in regard to profits of the current and previous years, as well as the condition of all reserve funds and contingent funds which are maintained for specific purposes. It is obvious that where a company is solvent and the capital stock is owned by only one class of stockholders, his task is comparatively an easy one; but where the business is of such a nature as to involve large contingent liabilities, or where the assets are of an exhausting nature, or where stockholders are divided into preferred, ordinary or deferred, or where the company is in the course of liquidation, the auditor has a complex problem to solve.

For the purpose of more intelligently dealing with the subject of dividends and its relation to the duties of auditors, I have divided the subject under the following headings:

1. Different classes of stock and dividends.
2. In what cases may or may not a dividend be declared and paid?
3. What redress have stockholders and creditors as against directors and auditors for improperly declaring dividends?

The most common forms of stock are:

1. Preferred stock.
2. Common or ordinary.
3. Deferred and founders' shares.

A corporation may, in general, make four different kinds of dividends, viz.:

1. A dividend payable in cash.
2. In certificates of stock.
3. In scrip.
4. In property.

In the absence of a special provision to the contrary, dividends will be presumed to be payable in cash and in lawful or current money.

DISCRETION OF DIRECTORS AS TO DECLARING DIVIDENDS

In general, it is for the directors and not the shareholders to determine whether or not a dividend is to be declared. When, therefore, the directors have exercised this discretion and declared or refused to declare a dividend, there will be no interference by the courts with their decision unless they are guilty of a wilful abuse of their discretionary powers or of bad faith or of a neglect of duty. Accordingly, the directors may, in the fair exercise of their discretion, reserve profits to extend and develop the business or for the purpose of meeting contingent liabilities. The free exercise of their discretion cannot be interfered with by the contracts of promoters or original incorporators as to the disposition of corporate profits.

Nevertheless, the discretion of the directors in the matter of declaring or refusing to declare a dividend is not absolute. The courts exercise a supervisory power in this matter, and where there is a clear abuse of power in refusing to declare the dividend a court of equity will, at the instance of any shareholder, compel the proper authorities to declare and pay the dividend. (Stevens vs. South Devon Railway.) Delay on the part of the shareholders in failing to commence their suit to compel the payment of a dividend until the corporation becomes insolvent is fatal. If the plaintiff shareholders are in the majority, and can reelect directors at the next annual meeting, the court will not intervene.

The discretion of the directors is not only governed by the courts, but by the statute and by the articles of association of the company, provided the latter do not conflict with any statute. It has already been stated that the courts will sometimes interfere with the discretion of directors in regard to dividends. The most common causes for intervention are as follows:

1. When the act of the directors in declaring a dividend is ultra vires.
2. When such dividend would jeopard outside creditors.
3. When the dividend is declared out of capital.

Numerous English and American jurists have decided that it is illegal to pay dividends out of capital, or have stated the same fact in reversed form "that dividends can be made only from net profits."

The relationship of the accountant's profession to the subject of dividends and profits naturally differs from the legal, his opinion being advisory only, whilst court decisions are compulsory. The former, however, is much broader and far-reaching, because it applies to individual cases, whilst the latter is given to control the actions of the general public. It is not enough that a declaration of a dividend is legal; it must conform to sound judgment and conservative financing. Moreover, it is especially within the accountant's province to regulate such questions as to profit which often form contentions between different classes and generations of stockholders, where the courts seldom interfere.

In the case of Lee vs. The Neuchatel Asphalt Company, the court refused to intervene between two different classes of stockholders, preferred and ordinary, to enjoin the declaration of a dividend on the ground that the dividend was paid out of capital. The common stockholders took the view that a reserve should be created for the purpose of making good the capital, as the company dealt in assets of an exhausting nature, consisting of asphalt, and their concessions were merely leasehold interests.

The court held that it could not interfere with the internal arrangements of the stockholders, and said that "it has been very judiciously and properly left to the commercial world to settle how accounts were to be kept." The court took the view that immediately the capital account was invested it was sunk, and if the receipts exceeded the current expenses it was a return of revenue and not of capital. This decision makes it necessary for investors to be careful how they invest in companies dealing in "wasting assets." They should either see that the articles provide for a special reserve for the maintenance of the capital assets or should only take stock that is preferred unless the capital of the company consists solely of common stock. Otherwise they might find that dividends were being declared out of capital, which the preferred stockholders would participate in, to the exclusion of the common stockholders, and they could obtain no remedy under these circumstances unless in case of actual fraud.

TO WHOM MAY CORPORATIONS PAY DIVIDENDS

Registration of stockholders is required by the articles of many corporations and a transfer fee payable upon registration. The company is not bound to deal with any but the registered stockholder, but the registered stockholder is regarded by a court of equity to be a trustee for a bona fide purchaser or mortgagee so far as the ownership of stock and receipt of dividends is concerned, and the latter, as well as the legal representative and judgment creditor, may enforce their rights against the company for unpaid dividends upon the presentation of proper proof and the payment of necessary transfer fees.

As a general rule, however, the party having possession of the stock certificate, and in whose name the stock stands, is the proper party to whom the dividend should be paid.

With respect to dividends of a married woman, the corporation must pay them to the husband or not, according to the domicile of the corporation and not according to the law of domicile of the married woman.

The heirs of a deceased stockholder must, in order to entitle them to dividends, procure a transfer of their ancestor's shares, but if the corporation should, without notice, pay over the same to the administrator, they will be protected in so doing.

TO WHOM THE DIVIDEND BELONGS

The purchaser of shares is entitled to all dividends declared after a sale to him, and the dividends are not apportionable unless by agreement. The same rule applies to a purchaser at a tax sale. A legatee takes all dividends declared after the testator's death. The administrators all declared previously. An offer to sell shares, which is subsequently accepted, entitles the purchaser to dividends declared by the corporation whilst the offer remained open; but a contract to sell on demand entitles the vendors to dividends declared before the demand was made.

The general rule in all such cases is that the time of declaration of such dividends governs, not the time of payment nor the time the profits were earned out of which they were paid. Profits have been likened by one writer to fruit on a growing tree, which would pass with the sale of such tree. Fallen fruit, however, would not pass with a sale of the tree; so dividends already declared would not be included in a sale of stock, although the purchaser has the benefit of all undivided profits.

LIABILITY OF DIRECTORS AND AUDITORS WHERE DIVIDENDS ARE ILLEGALLY DECLARED

The directors of a corporation may be sued for the recovery of dividends declared out of capital and for all directors' fees paid after the corporation has become insolvent. Such suit may be brought either by a creditor or a stockholder.

It is not sufficient defense for the directors to state that they relied entirely on the reports and statements of the auditors; they must satisfy themselves personally in regard to the conditions of the corporation's finances. (London and General Bank, Ltd.) Nor does it relieve the directors from liability, even though the dividend is declared with the acquiescence of all stockholders.

An action for fraud lies where the condition of the business is wilfully misrepresented for the purpose of declaring a dividend.

It is held that auditors are liable only for negligence in regard to statements and reports given in their professional capacity. They are not insurers, therefore they are only responsible for misstatements wilfully made or made through error, when, with proper diligence, they might have ascertained the true facts.

It is not sufficient for the auditor to prove the arithmetical accuracy of the books; they must ascertain that the assets on the balance sheet to which they certify represent something of substantial value; that all actual liabilities are included; that all the expenses of the fiscal period are taken into account, and that all profits stated in their certificate have been earned.

When an auditor relies on certain figures or statements of a previous auditor he should cover himself by stating so. An auditor is responsible for the valuations placed on inventories unless he especially exempts himself. His certificate covers every item on the balance sheet unless he makes exceptions in his certificate.

In this country, especially in the West, where the auditor has not received the same official recognition from the courts, it is doubtful whether his responsibility or liability is so great as in the East.

CONCLUSION

Corporations being of comparatively modern creation, this branch of the law usually designated corporation law is almost in its infancy. It has not become the science that real estate law became many hundreds of years ago, and has scarcely kept pace with the rapid strides which corporations have made during the last century and the development of trusts during the last decade.

As in medical jurisprudence, the lawyers have frequent occasion to consult the medical profession; so in corporation law the accountants will often be called into conference.

It is a comparatively easy matter to lay down a series of rules governing a subject like dividends, but it is the application of those rules which requires constant vigilance and labor; and this is the accountant's duty, for which he is specially adapted and trained.

Profession of Public Accountant

BY J. F. CALDERWOOD.

It belonged to the latter half of the Nineteenth Century to produce the modern profession of public accountant. It remains for the Twentieth Century to develop and give this profession the standing to which it is entitled.

An age of commercial and industrial expansion, an era of joint-stock companies and industrial corporations makes the profession of public accountant as necessary to the public weal as that of law, medicine, teaching or engineering. The duties of public accountant call for a high order of intellect, integrity and technical skill, second to that of no other profession; and certainly no other profession calls for heavier responsibilities.

It was in 1856 that the profession received its first public recognition, that being the date of the royal charter to the Scottish Institute of Accountants. It was not until 1880 that a similar charter was granted to the Institute of Chartered Accountants in England and Wales. Conditions for admission to these institutions were severe and strict, but the growth of the profession has been, nevertheless, rapid, until the membership and list of associates and fellows of the two societies has spread world-wide. Following the British example, the United States has such well-known institutions as the New York Society of Certified Public Accountants, the Incorporated Accountants of Massachusetts, the Illinois Association of Public Accountants, the American Association of Public Accountants, and other societies representing special industrial and commercial interests, of which the Street Railway Accountants' Association of America is an example. The laws of New York, Pennsylvania, California and Maryland recognize the profession by providing for examinations for the degree of "Certified Public Accountants." In the University of New York a School of Commerce and Accounts has been organized to prepare applicants for the degree, the course including bookkeeping and accounts, law and economics. The time will come when every well-equipped university will place accountancy in its course.

Probably the greatest step in the establishment of the profession of public accountant is the act of Parliament, Jan. 1, 1900, the first day of the Twentieth Century, providing not only the forms of the report and certificate by auditors, but furthermore that the accounts of every corporation must be examined and certified by an independent auditor appointed by the stockholders. This act at once stamps the profession of public accountant with legal standing. Every British corporation henceforth must submit its books to the examination of an independent accountant, and no corporation accounts in Great Britain can pass muster without the certificate of such independent accountant. This accountant is not an employee of the corporation, not a subordinate of the manager, but an independent official selected by and responsible to the stockholders. He is the watchdog who safeguards the investor. Consequently, wherever there is a British corporation, or a stockholder of a British corporation, or investment in British corporation securities, there is legal necessity for the duties of an independent accountant, and this profession has standing in law.

Without doubt, American law will soon follow English practice in this respect. Already British investors in American securities are demanding, and in many cases securing, the same protection of an independent audit directed by the investors. A number of prominent American corporations have anticipated legislation by already inaugurating the custom of an independent audit. The United States Steel Corporation is a notable example which is bound to be followed by others. Thus the profession of independent, disinterested, skilled public accountancy is assured of a wide and steadily enlarging field of usefulness, with high standing and responsibility.

The duties of public accountant are so patent as scarcely to require capitulation. Briefly summarized, these duties include:

1. The audit of accounts, which may be continuous, daily or weekly or monthly, or quarterly, half-early or annually, according to the necessities of the case and the nature and size of the business.

2. The preparation of a balance sheet and profit and loss account, based on the facts of the business.

3. The investigation of suspected frauds and the provision of bookkeeping checks against fraudulent manipulation.

4. The establishment of systems of bookkeeping based on the nature of the business, with a view not only to saving of labor, but clearness and thoroughness of account keeping.

5. The inauguration of a system of cost accounts, covering first cost and the various stages of cost through the manufacturing, mercantile or other business processes.

6. To provide for a corps of trained assistants equal to the special demands of widely varied business enterprises.

7. The investigation of the accounts and likewise of the detailed business facts for the purposes of sale, or of incorporation, or of bond and stock issues.

8. The preparation of a case in bankruptcy for the assignee, that the latter, as well as the creditor and the debtor, may begin to settle their affairs by the best system.

9. The similar handling of a trust estate for the executors.

10. Special investigation into the subject of personal injury cases, in a measure acting as a referee.

11. Expert calculation of interest installments to provide for sinking funds, bond redemptions and the arrangement of payments over a series of years.

12. Expert advice in a thousand of business lines for the investor, the promoter, the manager, where special training is required to unearth the earning probabilities of a given enterprise or investment.

The paper presented elsewhere in this department on "Corporation Dividends" was prepared by Charles Colby Reckitt, C. P. A., for the information of street railway investors, managers and accountants. It is an elaboration of the features relating to this special work that were embodied in the author's address before the Illinois Association of Public Accountants, which attracted so much favorable comment.

Ebenezer Carr, the well-known Scottish accountant, in a very able article on "The Duties and Responsibilities of Auditors," published in a recent issue of the Commerce Accounts and Finance, has this to say regarding reserve fund: "A real, as distinguished from a more or less fictitious, reserve must be invested outside the business for which it is created, and the auditor should have the nature of such investment set forth on the balance sheet."

Beginning with an early issue, we will publish a series of articles on important practical subjects, under the headings: First, "A Successful Manager and What He Requires;" second, "How to Analyze a Street Railway Proposition from an Investor's Point of View."

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Fewer horses and stables are now maintained in New York than formerly, and the number is decreasing every year. The Department of Health has just completed a census of the horses and stables in the city, and the result shows a surprising decrease in the last five years, the number of horses reported this year being only 65,086, against 73,746 five years ago, showing a falling off of 8660. There are now 3326 stables in New York, whereas five years ago there were 4640. This condition is attributed principally to the substitution of electricity upon street railway lines, although the introduction of the automobile has contributed somewhat to this result. In view of the increase in population in the periods mentioned and the consequent increase in the city's haulage requirements, this decrease in the number of horses is convincing evidence of the important part that electric traction is playing in every large and prosperous community.

Street railway companies and contractors who build public works will be interested in the opinion submitted by Corporation Counsel Rives, of New York, upon the question of the validity of municipalities inserting clauses in public contracts restricting contractors to the employment of union labor. The labor unions of New York have been trying to get the City Council to insert a clause in contracts and specifications for work and supplies providing that only union labor and union-made material shall be used. The corporation counsel holds that such action would constitute discrimination and prevent competition, and therefore would be illegal. In support of this position he cites a case in Chicago in which the Illinois courts pronounced legislation of this character unconstitutional.

In the controversy over the misdeeds of automobile operators the disputants seem to be inclined to lose sight of a very important fact, which, however, cannot be overlooked in the final settlement, namely, that streets are dedicated to the use of the people, and cannot be converted into racetracks. The automobile of to-day is built for higher speeds than is safe under ordinary conditions upon the public thoroughfares of any large city, and the tendency of the operators is to send them along at the top notch, without regard for the safety, convenience and comfort of those who cling to the old-fashioned carriages drawn by horses, thus positively endangering the lives of pedestrians, especially children. The daily newspapers have been printing a lot of rubbish in the form of communications from owners of these vehicles, who attempt to defend their practices. They emphasize the advancement that has been made in the development of these equipments, and the mechanical perfection attained which will enable an expert operator to attain a wonderful control over the machine. But all this is foreign to the subject. The numerous accidents recorded show that there is a wide difference between theory and practice in automobile operation. Objection is not made against the machine itself, but against the practice of driving it along at a dangerous speed.

A satisfactory explanation is sought for the falling off in the new mileage which is added from year to year to the country's steam railroads. So marked has been this decline that it has come to be regarded as a serious problem by the builder, the engineer and the investor interested in properties of this class. Statistics have been compiled which show that, while this diminution is general, it is particularly noticeable throughout this country and Canada, the growth in the whole of North America between 1890 and 1900 being only 40 per cent of that reported between 1880 and 1890. This condition is viewed with apprehension by many, although some capitalists console themselves with the reflection that their investments will increase in value in keeping with the decline in building opertions, but they must realize that this will be true only within certain well defined limits. It is but natural to offer in explanation of the constant decrease in new mileage the fact that during the period of greatest activity more roads were built than were really needed and that many years of industrial development must elapse before the capacity of the great systems of transportation already established will be reached. There is unquestionably considerable merit in this explanation, but it is a significant fact that the threatened stagnation in steam railroad building does not extend to the electrical field. On the contrary, in this new department there is now greater activity than ever before in its history, and the magnitude of the undertakings of to-day surpass anything seriously considered a few years ago. Besides, it is recognized and admitted that electricity is supplanting steam in much of the new work and in service that was formerly considered safe from invasion. The real significance of the tendency to adopt electricity upon interurban and suburban lines and employ it in operating feeders and branches of important steam lines is that it points to the inevitable extension of the electric equipment to the working of the entire system. The suburban and interurban field is being given over gradually, but surely, to electrical operation, just as the street railways have been, and in many districts this has naturally resulted in the development of freight and express service in connection with the passenger traffic. Of course, these changes involve radical departures from street railway methods of construction and operation. New conditions have to be met and the special requirements of the new field must be carefully studied. How sucessfully the problems have been solved is shown by the equipments of numerous roads for heavy service in various parts of the country. The development of this department is now uppermost in the minds of electrical engineers, and while it may be said that the progress thus far made has been mostly in timid, faltering steps, the experience gained has indicated such vast possibilities that we may confidently expect to see further advancement made in sturdy strides. This may result in a still greater diminution in new mileage of steam roads, and in the transformation of many of the present lines into complete electrical systems. Of course, this is not the task of a day, but its ultimate accomplishment is confidently expected by every electrical engineer.

Steam and Electric Suburban Service

The suburban passenger business of steam roads is just now at a critical point, and the same might be said regarding local passenger business where it is of sufficient volume to be of any importance. It has been evident to observers of the passenger traffic situation throughout the country that the electric railway is gradually developing to a point where it is securing a larger and larger proportion of the local passenger business, and that instead of meeting the issue and providing some permanent policy for relief the steam roads are relying upon an impracticable and unpopular plan of opposition to all advancement.

The first electric railways for city or interurban service were comparatively short and made slow time, according to the present standards. Therefore they affected steam road business only between a few points, and these were located only short distances apart. But the length of electric interurban roads is increasing, as is also their schedule speed. They are, it is true, creating new business to a large extent, but they are also taking away profitable business from steam roads, as is clearly shown by the changes in the suburban train time-tables in many localities. We do not presume to say that steam railroad companies have been entirely to blame in allowing their suburban and local traffic to go to electric suburban and interurban lines; that is a question for them to decide. It is for them to say, also, whether their through freight and passenger business is of such importance, and their track and terminal facilities are so limited, that it is impossible to cater to local and suburban passenger and express business. The steam railroad companies have, to be sure, obstructed efforts to build parallel electric lines in many cases, and it is manifest that at best such efforts can only afford them temporary relief. It is too evident to require further argument that the only way in which local and suburban passenger and express business can be retained by the steam railroads is by giving the public as good service, if not better, than can any electric road operating in the same territory. In the present state of the art this can only be done by the adoption of electricity for handling such business and by introducing radical changes in methods of operation.

Steam roads do not seem to have made any serious effort to get out of the rut of steam operation, and the building of high-speed electric roads goes merrily on, invading more and more sacred steam territory every year. In Chicago, the Aurora, Elgin & Chicago Railway is about to offer a suburban service superior in every way to that of the established steam railroads with which it competes, and these roads, too, have been noted for the excellence of their suburban service. In New York the New York & Port Chester Railway is preparing to put up a similar competition against established steam roads, and the result will doubtless be the same. These are only the two latest and most notable instances of the electric railway entering steam suburban fields. The day is surely coming when the present so-called competition between electric railways giving a local service and roads adapted to high-speed service with infrequent stops will be changed into a co-operation which will be beneficial to all parties concerned. Both classes of service are absolutely necessary, and unless the steam roads meet the exigencies of the situation soon they are lost.

When a passenger patronizes a high-speed line with infrequent stops and then consumes a large amount of time in walking from a station to his ultimate destination there is a waste of time which is as unjustifiable as if he had boarded a car on a line giving local service and stayed on that car until such time as it arrived at a distant point. In other words, there is room in every populous community for two classes of service, a high-speed express service and the local service, whether these be given on the same tracks or whether they be given by two distinct companies. It does not require any great reasoning power to recognize the fact that the passenger traffic can only be developed to its highest perfection when the local and through services are operated in harmony. We have in mind a certain magnificent suburban territory through which an electric line operates side by side with an excellent steam road. Such an arrangement would be almost ideal were the two roads to co-operate. The suburban territory in question, like many others, is scattered along the entire length of the line rather than concentrated at particular points. The electric road being built to land passengers at any street crossing is a great convenience to those living at a distance from the stations of the steam road, while the location of the electric line alongside the right of way of the railroad is very satisfactory from a suburban property-holder's standpoint who does not like to have his village cut up with many railway lines. In the case under consideration, the unfortunate thing about the arrangement for the steam road is that when passengers once board the electric car near their respective homes they are inclined to remain on the car until it has proceeded a considerable distance toward the city before changing to the steam railroad, and no small numbers escape to other lines of transportation, although many take the steam trains at some of the more important stations where the fastest steam trains stop. If the two roads were worked more in harmony as to timetables and rates of fare it would profit both, provided, however, the service on the high-speed or steam railroad was as frequent as that on the local lines. In other words, in order to make such a plan most profitable and best suited to the needs of the public the steam road should adopt electric traction, which would allow it to give a more frequent service at a profit. The only obstacle at present in the way of profitable co-operation between electric and steam railways which are parallel is the lack of frequent service on the steam roads and the lack of terminal facilities acceptable to suburban passengers in the largest cities. To overcome this latter difficulty, co-operation with the local surface and elevated lines should prevail at the downtown terminus as well as out in the suburban territory; and this, too, would be feasible with electricity, but not with steam.

Whether steam roads will awaken to the situation soon and save their suburban and local traffic by adopting electricity for that purpose is a matter of speculation. From their conservatism in this respect in the past, and the willingness of capital to go into the building of new electric interurban roads for such traffic, it is reasonable to assume that before steam roads make the necessary radical changes parallel electric lines will have covered the field. It is but natural that steam railroads should place their through freight and passenger business above anything else. They would be foolish to jeopard it for the sake of local business, if one would have to be sacrificed. The steam roads, however, should realize that they must either prepare to adopt a frequent service for local traffic, such as electric traction makes possible, or step aside and let others handle it. We have a firm belief that such a supplementary electric service could advantageously be given in connection with through steam service in very many cases in spite of the present indications that it will not be done.

Electric Railroading Before the Institute

This year's convention of the Institute at Great Barrington will be remembered because of the prominence given the subject of electric railroading and the special interest attached to the papers in this field. A day was devoted to consideration of these contributions, and it is not too much to claim for it the distinction of being the most interesting and instructive session of the entire meeting. Mr. Arnold's paper upon the New York Central work has already received attention, as has also his announcement of the completion of his preliminary experiments in the development of a system of heavy electric railroading employing a single-phase motor. Two other papers of great practical value and scientific merit were contributed by Messrs. Arnold and Potter and Mr. Mailloux.

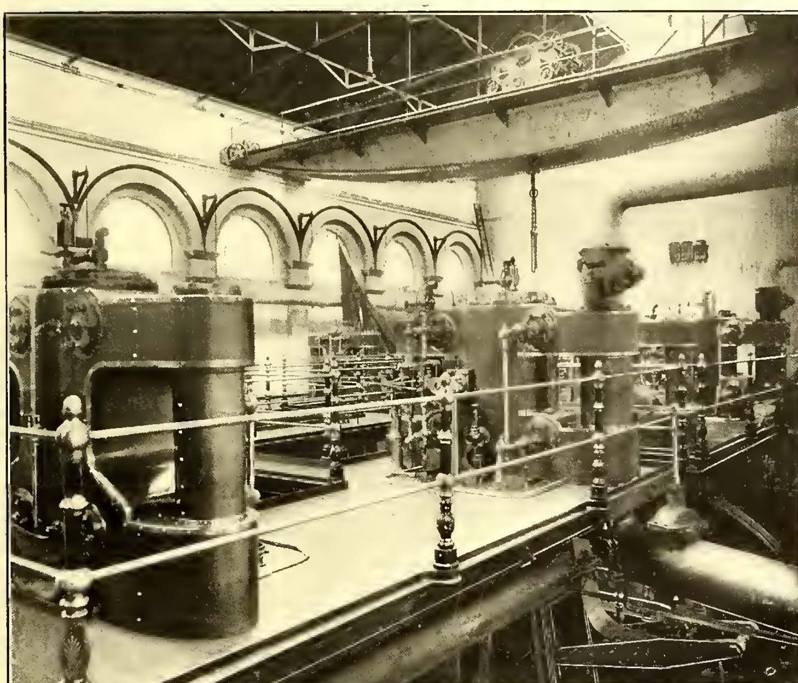
The paper by Messrs. Arnold and Potter should really be read in conjunction with Mr. Arnold's paper on the New York Central plans, as the investigations which it records were primarily made to secure special data upon which to base recommendations in connection with the Central's plans. In this paper a careful study is made of the relative merits of steam locomotives and electric motor cars for acceleration in fast suburban service, and what might properly be called heavy trunk line traffic. The comparison was made with a powerful consolidated engine designed especially for this work, and the results are consequently of greater value than they would be had the test been made with an ordinary locomotive not especially selected because of its adaptability to this work. The result was entirely satisfactory from the standpoint of the electrical engineer. The electric cars were equipped with motors of ample power, and their weight was concentrated upon the driving wheels. They made a much better showing than the locomotive in accelerating trains of equal weight, giving a greater maximum draw-bar pull, keeping up the work and giving quicker acceleration and lower maximum speed for the same schedule than in the case of the locomotive. Some very interesting data is presented upon the energy consumed, and the cost of steam locomotive service is included in this paper. Not the least important feature is the fact that the locomotive showed a marked tendency to lose steam pressure rapidly under continued effort. Every result of the investigation in this particular is favorable to electric traction, although the conditions under which the investigation was conducted were far from ideal. Under the circumstances, this showing is, of course, particularly gratifying, as it justifies electrical engineers in anticipating greater victories under conditions better suited to electric service.

Mr. Mailloux, in his paper on "Plotting Speed—Time Curves," called attention to the fact that the advent of electrical engineers in this department was marked by a substitution of rational for empiracal methods and standards. The author's purpose is to facilitate the use of speed-time curves as a method of precision by simplifying their application to practical work, and he has gone into a very careful and comprehensive investigation of the subject. It is shown in the course of the discussion that any force concerned in the movement of a train may be expressed in terms of an equivalent acceleration, and the theorem is developed that the effective acceleration in any concrete case is equal to the algebraical sum of the accelerations which will be produced by each of the forces acting independently and alone, and is consequently equal to the algebraical sum of the differential co-efficients due to these forces. The first subdivision of the subject in the body of the paper is on the analysis of train motion, followed by the specific analysis of the different forms of variable motion, including positive acceleration, and the two forms of negative acceleration, corresponding to the motion of trains while drifting and braking. The second subdivision of the subject is on the plotting of speed-time curves, beginning with certain preliminary considerations, and then discussing separately the plotting of acceleration curves, drifting curves and braking curves. In this portion of the paper the author, after briefly referring to two other methods of plotting these curves, describes a new simple graphical method of plotting speed-time curves of all kinds, based upon the theorem referred to, and also upon a formula for the time values corresponding to speed values. The first installment of this paper is presented in this issue, and the brief outline here given of the salient features will show that it is really a very valuable contribution to the literature of the subject, and is worthy of careful study.

The Cardiff Corporation Tramways

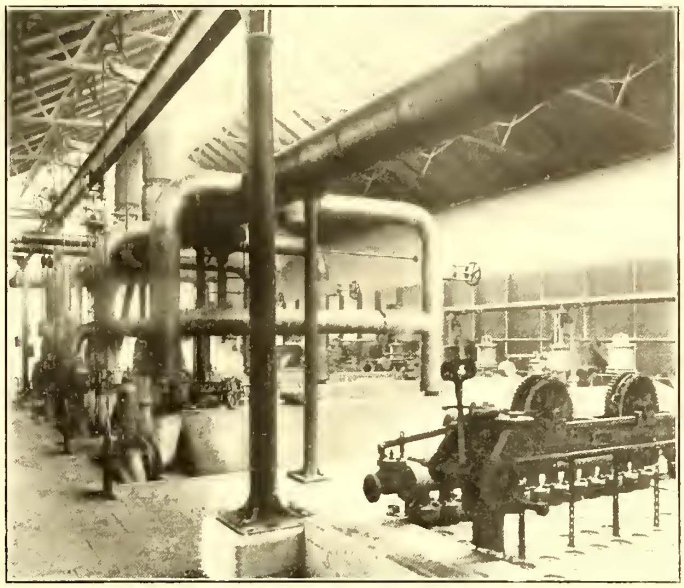
The county borough of Cardiff, the metropolis of the Principality of Wales, had a population at the last census of 164,315. The value of taxable property is about $5,000,000, and the area of the municipal borough is 8408 acres or 13.13 square miles. That Cardiff is a growing town is shown by the fact that during the last twenty years the population has just doubled, the population in 1881 being 82,671, while at the same time the taxable values have nearly trebled.

The corporation in 1898 promoted a bill in Parliament seeking powers to borrow money for various purposes, including the purchase of Cathays Park, consisting of 60 acres of land from the Marquis of Bute, the erection of a new town hall and law courts, street improvements and the construction of tramways, and the purchase of land for buildings in connection therewith. This bill in due course received the royal assent, which enabled the corporation to proceed with the various works. The amount of money sanctioned in the bill to be borrowed by the corporation for tramway purposes was about $800,000 for permanent way construction and for the purchase of lands for power station and car houses. The period for repayment was fixed by the act at sixty years for lands and thirty years for buildings.



All other monies to be borrowed for tramway purposes, such as plant and equipment, care, etc., was to be such as might be sanctioned by the Board of Trade. W. Harpur, Esq., M. I. C. E., the borough engineer of Cardiff, acted as engineer to the scheme during this important period.

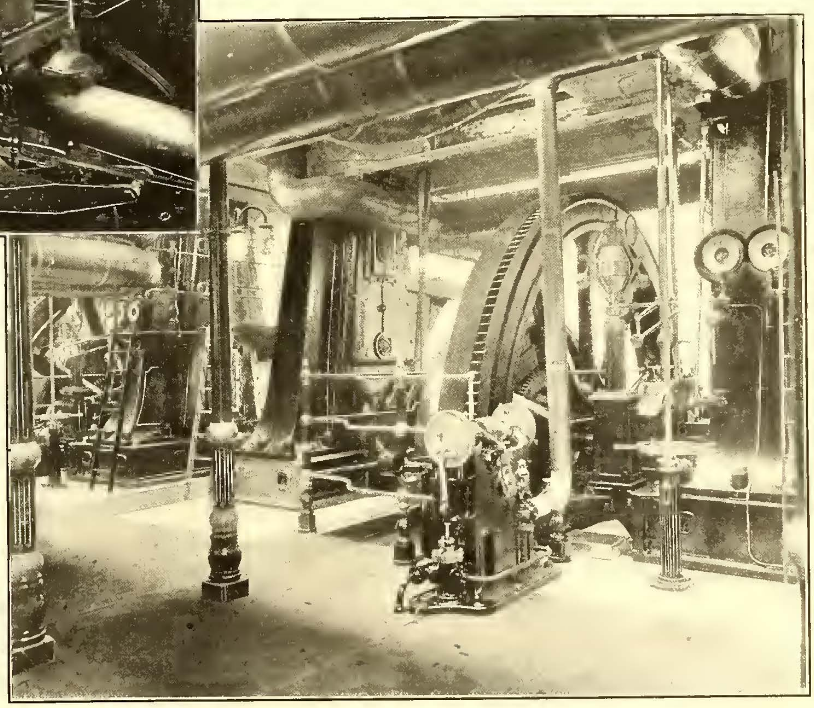
During 1899 the chairman and deputy chairman of the tramways committee and the borough engineer, acting on instructions from the Council, visited all the important tramway systems in the kingdom, and presented a lengthy and detailed report thereon, with the result that the Council finally decided to adopt the overhead system of electrical traction in preference to any other, although at one time the conduit system was suggested, and, in fact, the estimates placed before Parliament in the corporation bill were based on this system. The first important matter to be dealt with by the corporation was the purchase of lands for power station and car houses. Four sites were purchased for these



STEAM PIPING OVER BOILERS

purposes. Two are at the eastern end of the borough and are occupied by the power station and main car house, one is at the western end, and used by the district car house already constructed there, and the fourth at the southern part is held for the building, when needed, of another district house.

In June, 1900, Arthur Ellis was appointed electrical engineer to the tramways department, and took up his duties in September of the same year. In the month of December following he was appointed borough electrical engineer and manager of the electric lighting and tramways undertakings of the corporation. Immediately after taking up his duties in connection with



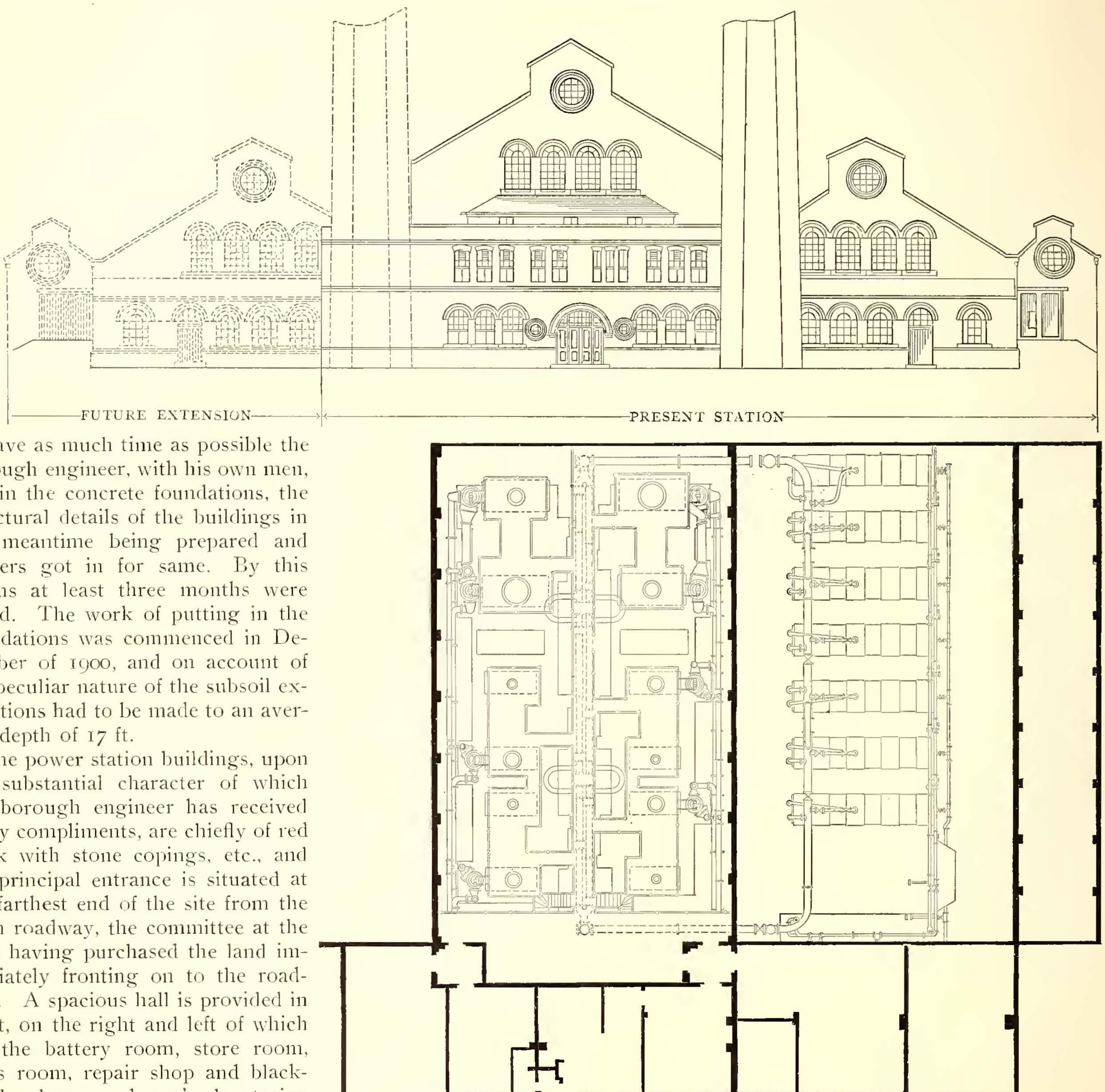
THE ENGINE ROOM ABOVE AND BELOW

the tramways he prepared details of his requirements in connection with the power station, in order that the work might be proceeded with without delay, this being the most important matter to be dealt with. Upon receiving these details of requirements Mr. Harpur, the borough engineer, who has acted as architect for all buildings in connection with the undertaking, immediately proceeded to prepare the plans of the building, Mr. Irwin acting as clerk of the works.

As soon as the foundation plans were ready and in order to save as much time as possible the borough engineer, with his own men, put in the concrete foundations, the structural details of the buildings in the meantime being prepared and tenders got in for same. By this means at least three months were saved. The work of putting in the foundations was commenced in December of 1900, and on account of the peculiar nature of the subsoil excavations had to be made to an average depth of 17 ft.

The power station buildings, upon the substantial character of which the borough engineer has received many compliments, are chiefly of red brick with stone copings, etc., and the principal entrance is situated at the farthest end of the site from the main roadway, the committee at the time having purchased the land immediately fronting on to the roadway. A spacious hall is provided in front, on the right and left of which are the battery room, store room, mess room, repair shop and blacksmith shop, workmen's lavatories, etc. Immediately over these rooms are the offices of the station staff, comprising in all five large rooms complete with lavatories, a bath room, etc. The offices are reached by means of a staircase leading from the main entrance hall, as well as from the switchboard gallery in the engine room.

The engine room and boiler house are situated immediately behind the offices. The former is a fine, large room, provided with excellent ventilation. It is 104 ft. long, 60 ft. wide and 56 ft. high and is lined throughout with cream-colored glazed brick. At intervals along the side walls substantial piers with semi-circular arches are provided, upon which the rails for the traveling crane are fixed. On one side is the boiler house, of the same length as the engine room, and 46 ft. wide and 48 ft. high. The walls of the boiler house fronting the boilers are lined with cream-colored glazed bricks, which give a very clean appearance. The front portions of the boiler settings are also lined with glazed bricks. Immediately to the side of and adjoining the boiler house is provided a building running its full length, into which the coal trucks are brought directly from the railroad siding. From this building the coal can be tipped either into the bunkers above the boilers or into the coal storage below the level of the tracks.



PLAN AND ELEVATION OF POWER STATION

The roofs throughout are supported by mild steel principals and framing of neat design, composed of angles and flat tie-bars. The buildings have been erected by W. Symonds & Co., the whole of the steel work being provided by A. D. Dawnay & Sons, Ltd., of Cardiff, as sub-contractors. The stack is situated at the front end of the building, and is 160 ft. high, it is built of red brick and is octagonal in shape. It is surmounted by a very heavy granite capping, made up of eight stones, each weighing a ton and a half, and the hoisting and fixing of these heavy stones was a matter of great difficulty. The stack was erected by Clark & Co., of Cardiff.

Mr. Ellis, in arranging these buildings, fixed their position in such a way as to leave room on the other side of the engine room for an exact duplicate of the boiler house and coal bunkers. When this addition is completed, therefore, the engine room will be between two boiler houses. These extensions he expects will be required at an early date, and the present buildings are all finished off with temporary brick ends, awaiting this enlargement of the capacity. The dotted lines in the accompanying engraving indicate the proposed extension. There is sufficient room also on the present site to extend the buildings a further 300 ft., with two additional stacks at the ends.

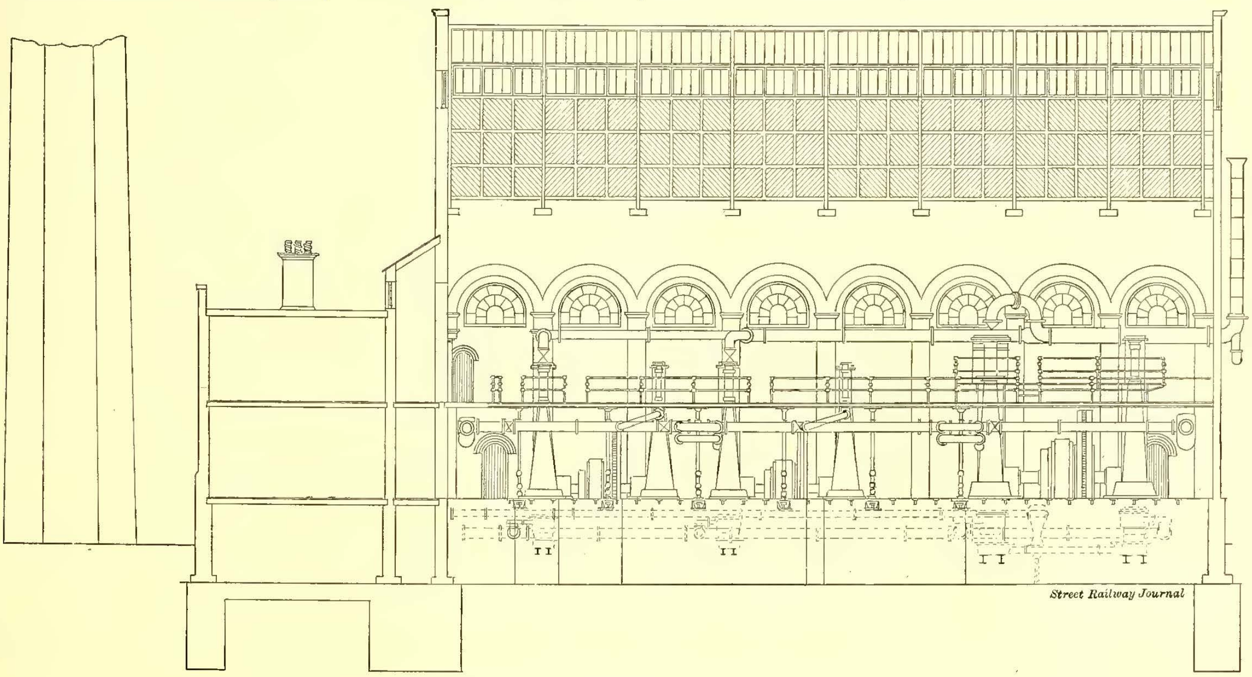
At the end of the building and in front of the offices a large cooling pond is being provided for condensing purposes. The water in the pond is drawn from a fresh water brook running along one side of the main building and dividing the power station site from that of the main car house. Mr. Ellis intends, when necessary, to erect cooling towers over the pond, which has been built with this end in view. The construction of the pond is very substantial, and has been carried out by the Department of Public Works, under the direction and supervision of the borough engineer, who prepared the detailed drawings to meet the requirements supplied to him by Mr. Ellis.

POWER STATION EQUIPMENT

The present power-station buildings, it is expected, will be fully equipped during the present year. At the present time there are in the engine room four engines each of 500 hp, and two more on order of 1600 hp each. The engines are supplied by John Musgrave & Sons, Ltd., of Bolton, Lancashire. They are all of the inverted vertical cross-compound condensing type and of heavy design. They work under a steam pressure of 140 lbs. per square inch, and run at a speed of 100 revolutions per minute. Each engine is fitted with its own condenser, driven by side levers from the crossheads. The air pumps of the smaller sets are are fitted with Corliss-valve gear on both cylinders, worked by means of eccentrics fixed to the crankshafts. Each engine is provided with Musgrave's patent automatic cut-off motion, connected direct to the governor. The engine is entirely closed, and forced lubrication is applied to the

THE POWER STATION

crank shaft necks, crank pins, crosshead pins, slide blocks and eccentrics by means of two ram pumps, fixed on each side of the engine. The governors are of the quick speed type, driven by ropes from the crankshafts. Means are also provided so that the speed can be altered by hand whilst



CROSS SECTION OF ENGINE AND DYNAMO ROOM

25 ins. in diameter, 12-in. stroke, and the condensers are all of the injector type, with suitable water regulators. On the large sets there are two air pumps, each of 30-in. diameter. The condensers are placed below the engine room floor level, and immediately at the rear of each engine.

Each engine is provided with steam-driven barring gear. They are capable of withstanding an overload of 25 per cent for two hours, and 50 per cent for short periods. They the engines are running, the governing variation from no load to full load being $2\frac{1}{2}$ per cent. The cylinders are of hard, sound metal, the high-pressure cylinder being $17\frac{1}{2}$ ins. in diameter and the low-pressure cylinder being 35 ins. in diameter, both having a stroke of 3 ft. The piston rods are 4 ins. in diameter and are fitted with United States metallic packing. The crankshafts are made of hollow Siemens-Martin steel, $12\frac{1}{2}$ ins. in diameter and 15 ins. at the wheel boss. The flywheels are 16 ft. in diameter, made in halves. They have a weight of 14 tons in the rims alone, the total weight of each wheel being 35 tons.

The larger engines, which are to come, have cylinders of 38 in. and 58 in., with a stroke of 42 ins.; piston rods 6 in. diameter and 6¼ in. diameter, and crankshafts 18 ins. in diameter and 23 ins. at wheel boss. The flywheels are 19 ft. in diameter, built up in sections, with a weight of 38 tons in the rims and total weight of 75 tons each.

SWITCHBOARD FOR BOTH LIGHTING AND TRACTION CIRCUITS

Each engine is fitted with a neat and substantial packing stage, with ornamental hand rails and pillars. Every facility is therefore furnished for getting at cylinders, valve gear, etc., and the platforms are all coupled together so that the attendants can get from one engine to any other with ease.

The four generators at present installed were supplied by the British Westinghouse Electric & Manufacturing Company, Ltd. They each have an output of 300 kw, and are capable of withstanding overloads of 25 per cent for two hours, and 50 per cent for short periods, without sparking and without movement of the brushes. The generators are of the multipolar type and mounted directly on the shafts of the engines, in between the high and low pressure sides. The armatures were forced on to the shafts under pressure of 70 tons. The generators work as compound machines on tramway loads at pressure of 500-550 volts, and as shunt machines on lighting loads at a pressure of 460-500 volts.

The two large generators on order are being supplied by Dick, Kerr & Co., Ltd., of London. They each have a capacity of 900 kw, and are being made to meet the same conditions as those already installed, and will be mounted on to shafts in a similar manner.

There is also in the engine room an 80-kw motor-generator, which works in conjunction with a battery of accumulators and serves several purposes. It receives current from the main tramway bus-bars at 500 volts, and gives out current at a pressure of 100-140 volts for charging the battery or supplying the works lighting independently. The lighting circuits can also be supplied directly from the battery when the motor generator is not working.

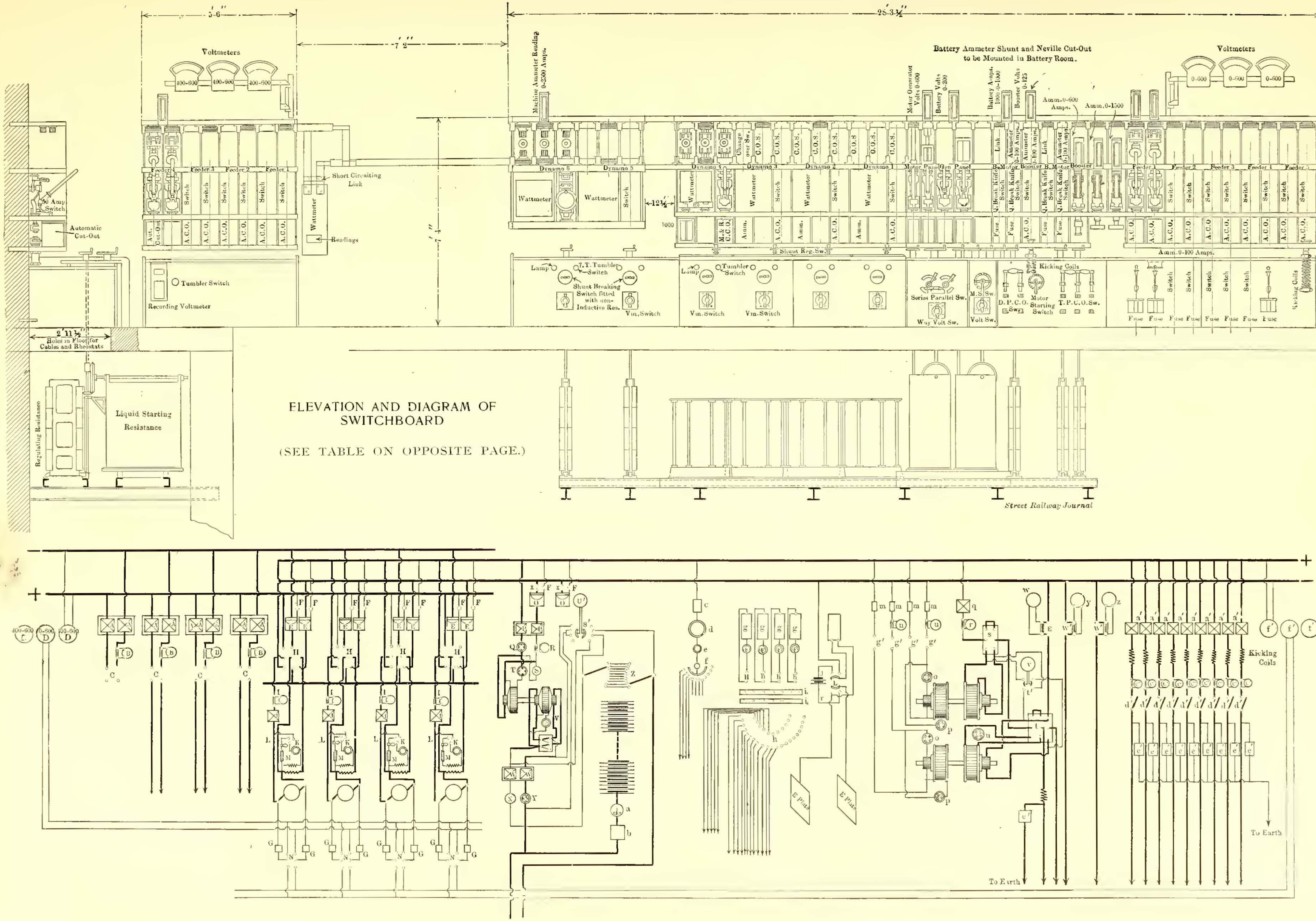
When worked in the reverse order the motor-generator can receive current directly from the battery at 100 volts, and give off current at a pressure of 500-550 volts. By this means it is possible to switch the cars in the car houses when the main plant is shut down, and to work the various motors in the power station in connection with the mechanical stokers, etc., when raising steam in the boilers previous to starting up the plant. It is also used for running any specially early cars or repair cars for night work on the overhead equipment. The motor-generator was supplied by Bruce, Peebles & Co., of Edinburgh, and consists of two generators coupled together with a flywheel weighing one ton between, and mounted on a common bedplate. The

		Amperes	Volts
A	Automatic circuit breaker	600-1,000	500
B	Ammeter (Weston type)	1,000	
C	D. P.—S. T.—Q. B. switch	1,000	
D	V meter (illuminated dial)		0 & 400 to 600
E	Watt meter (recording)	1,000	
F	Tumter switch	5	200
G	Fuse with magnetic b ow-out	5	600
H	Q. B.—D. T. switches	1,000	
I	Ammeter illuminated d al	1,000	
J	Automatic circuit breaker	1,200-800	600
K	Field switch	25	
L	8 c. p. lamp		
M	Non-inductive resistance 1,333 ohms	3	500
N	D.P.—D. T. volt meter switch	5	600
O	Recording Watt meter	400	
P	Single pole circuit breakers	200-00	600
Q	Starting resistance		
R	Ammeter	0-400	
S	Voltmeter		600
T	Shunt regulating resistance (field)		
U	Field regulating resistance		
V	Series parallel switch	1,000	100
W	Single pole. Auto circuit breakers	500-1,000	100
X	Ammeter	1,000	
Y	Starting rheostat		
Z	Charge and discharge switch (10 way.)	1,000	

		Amperes	Volts
a	Ammeter (polarized)	1,000.0 1,000	
b	Auto—cut out	1,000	
c	Magnetic blow out fuse	10	
d	Ammeter. Two scales	0-.05 0- 5	
e	H. T. switch	10	
f	12 way contact switch	10	
g	Recording volt meter		0-10
h	Plug connections	5	
i	Bus bars with plug connections	5	
j	4 volt accumulator	10	4
k	Recording ammeter	0-30	
l	Two way d. p. switch	30	
m	Magnetic blow out fuse	75-100	
n	Ammeter	0-100	
o	Starting resistance (for motor)		
p	Field regulating resistance		
q	Auto circuit breaker	600	
r	Ammeter		
s	D. P. throw over switch	600	
t	Triple pole throw over switch	600	
u	Booster field regulating resistance		
v	Voltmeter		125
w	Ammeter	800	
x	S. P. switch	400	
y	Ammeter	1,500	
z	Ammeter	1,500	

		Amperes	Volts
a'	Automatic circuit breaker	400-600	
b'	Kicking coil	600	
c'	Ammeter	600	
d'	S. P.—Q. B. switch	600	
e'	Thomson-Houston lightning arrester		
f'	Voltmeter		0-600
g'	S. P.—Q. B. switch	100	
h'	Recording voltmeter		460-540
i'	H. V.—S. P. switch	5	
j'	D. P.—Q. B. switch	200	
k'	Magnet blow out fuses	200	
l'	Magnetic blow out fuses	100	
m'	S. P.—Q. B. switch	100	
n'	Starting resistance		
o'	Field regulating resistance		
p'	Magnetic blow out fuses	25	
q'	D. P.—Q. B. switches	25	
r'	Ammeter	600	
s'	D. P.—4 way switch	5	
t'	D. P.—2 way switch	5	
u'	Voltmeter		0-200
v'	Recording voltmeter		440 to 480
w'	S. P. switch	1,500	

REFERENCES TO LETTERS ON DIAGRAM ON OPPOSITE PAGE



ELEVATION AND DIAGRAM OF SWITCHBOARD

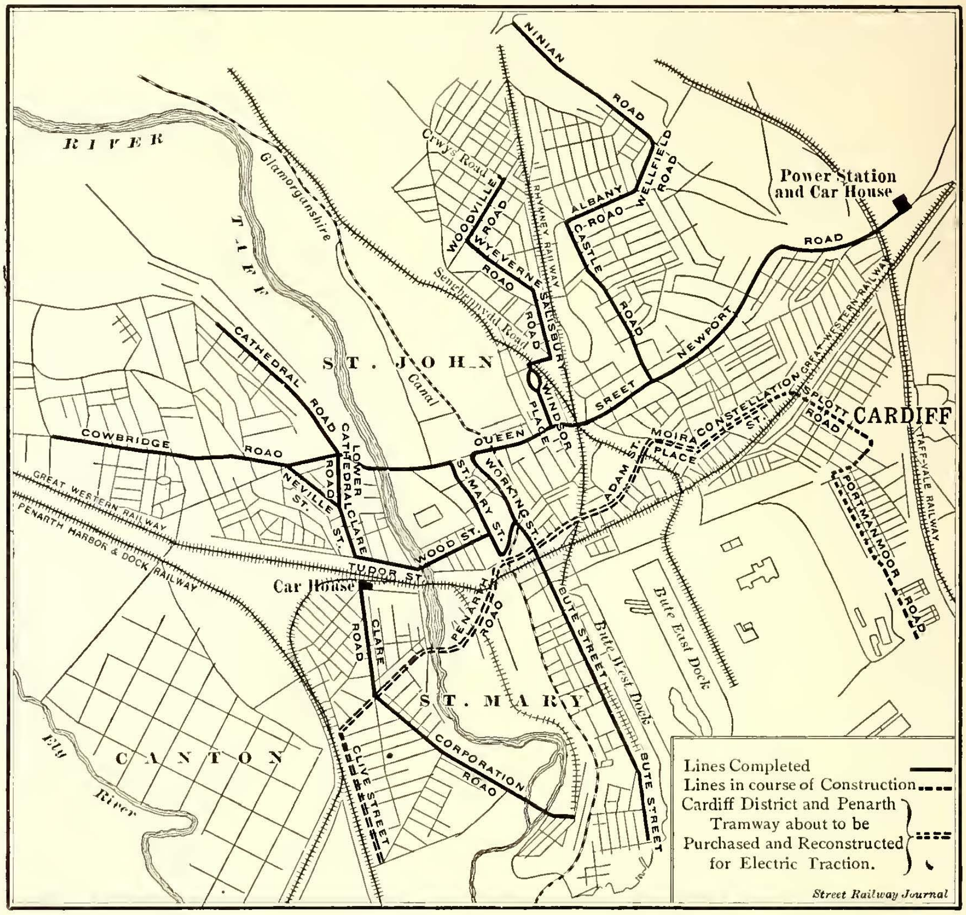
(SEE TABLE ON OPPOSITE PAGE.)

low-tension has a double-wound armature and is furnished with the commutator at each end. The reason for the double-wound armature on this side of the apparatus is to get the maximum output of the machine and to run the set at a constant speed.

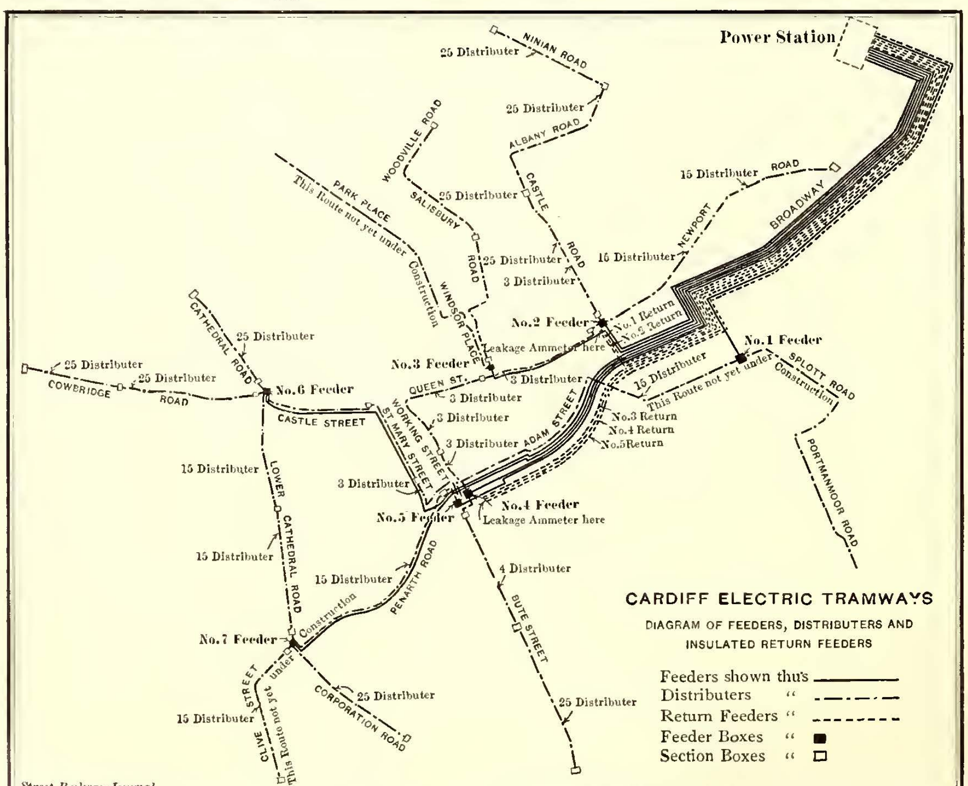
To enable the low-tension side to generate an output of 600 amps., at 140 volts or 84 kw, the high-tension side requires an output of 100 kw, at 500 volts running at 500 r. p. m. With double-wound armature and a pressure of 100 volts supplied to the low-pressure side of the two armatures in parallel the set is driven from the battery at a speed of 600 r. p. m., and the high-tension side generates its full output of 170 amps. at 500 volts or approximately 84 kw. The motor-generator can by this arrangement always be worked at its highest efficiency without any weakening of the fields except the small amount necessary to reduce the voltage on the low-tension side, as a dynamo, from 140-100 volts.

The battery of accumulators, which is placed in a room adjoining the engine room, was supplied by the Tudor Accumulator Company, and consists of fifty-six cells with thirty-one plates in each. The cells themselves consist of lead-lined wooden boxes, supported on oil insulators. The capacity of the battery, at different rates of discharge, is as follows:

2100 ampere-hours when discharged at 210 amps.
1800 ampere-hours when discharged at 360 amps.
1620 ampere-hours when discharged at 540 amps.



MAP OF CARDIFF TRAMWAY SYSTEM



ELECTRICAL DISTRIBUTION SYSTEM

The normal rate of charge is 300 amps., and the maximum rate of charge 375 amps. The duties of the battery, as previously mentioned, are the lighting of the power station and car house and the supply of current to the works generally.

In the engine room there is a 20-ton traveling crane, supplied by Joseph Booth & Bros., of Leeds, which can operate the whole length of the building. It is intended to eventually equip the crane electrically, but at present it is operated by hand. The span is 60 ft. and the lift 35 ft. The crane is fitted with platforms and hand-railing on either side, running its full length.

Down the center of the engine room, between the two rows of engines and generators, there is a gangway supported by means of ornamental columns, the gangway being 12 ft. above the engine room floor level. This gangway is coupled up to the stagings around the various engines and also leads on to the switchboard gallery at one end of the room. It is approached at the switchboard and by means of a double staircase from the engine room floor and a staircase at one side of the gangway at the opposite end of the engine room. The whole of the upper gangway is protected by means of ornamental columns and handrailing of similar design to those on the stagings of the engines mentioned above. This central gangway serves two purposes, the easy access to the cylinders and valve gear and the carrying of the main steam pipes running down the center of the room, which are supported by carriers on the underside of the gangway.

The main switchboard is built direct into the main wall at one end of the engine room, and stands back in a recess, taking up 42 ft. of the total width of the room. Immediately in front of the board there is a clear space 10 ft. in width. The gallery is carried right through into the boiler house and to the coal bunkers beyond, so that the engineers in charge can control the whole station with the smallest amount of trouble.

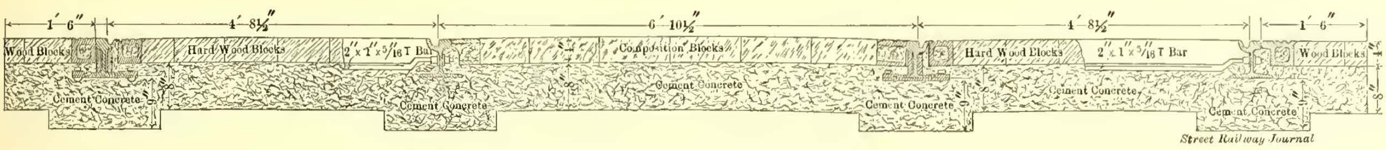
The switchboard is of the standard Ferranti pattern, and consists of ten feeder panels, each of 600 amps capacity; two return feeder panels, each 1500 amps capacity; one positive booster panel, one negative booster panel, three panels for motor generator and battery, one Board of Trade panel, four 300-kw generator panels, two 900-kw generator panels, four panels for controlling supply of current for private and public lighting and power purposes, each of these panels having a capacity of 1000 amps.

On the front there is a table standing out from the board 2 ft. 6 ins., upon which the field-regulating and motor-starting switches are placed, the resistances being below the board. There are also four panels on the front of the table for controlling the works motor, battery, regulating cells, etc. There are two independent sets of main bus bars for controlling the traction and lighting loads, each of the bars having a cross section of 6 sq. ins.

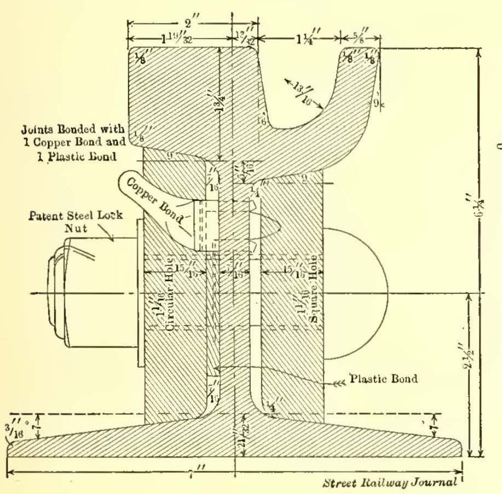
All the switches are designed for a current density of 60 amps per square inch of contact area. Each panel is fitted with an automatic circuit breaker of the Ferranti pattern, and the various indicating instruments are of the edgewise type. The recording instruments were supplied by Elliott Bros., the wattmeters being of the Thomson type. There are three Weston-type illuminated dial voltmeters at each end of the board for lighting and traction purposes. An independent switchboard has been installed for controlling the lighting circuits of the station.

In the boiler house there are at present fixed four Lancashire boilers, 30 ft. x 8 ft., with provision for three more of similar sizes, which are being erected. The boilers were supplied by John Musgrave & Sons, Ltd., and are made for a daily working pressure of 150 lbs. per square inch. Each boiler has two flues with five cross tubes in each. The fittings were supplied by Messrs. Hopkinson, and are of their latest type. At the rear end of each boiler there is a superheater of the Musgrave type, so arranged that it can be easily removed for inspection, the steam in the meantime going directly to the main steam header. At one end of the boiler house there is a Green economizer, consisting of 288 pipes, built into a by-pass from the main flue.

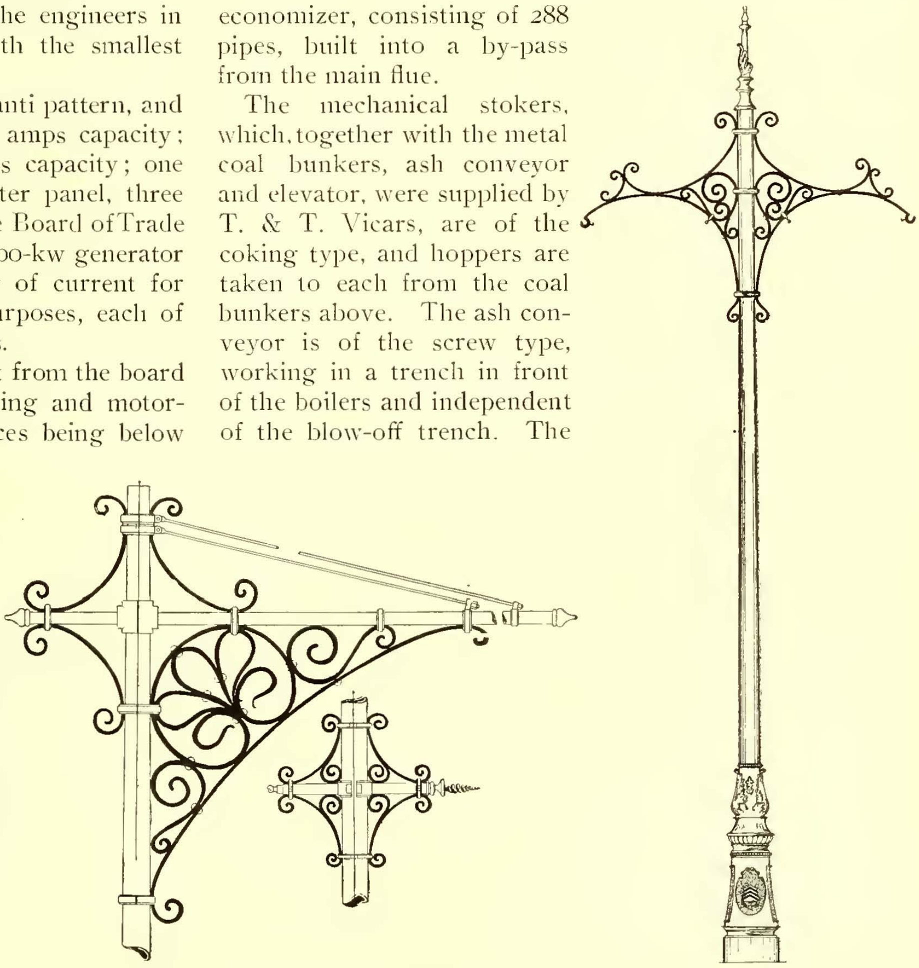
The mechanical stokers, which, together with the metal coal bunkers, ash conveyor and elevator, were supplied by T. & T. Vicars, are of the coking type, and hoppers are taken to each from the coal bunkers above. The ash conveyor is of the screw type, working in a trench in front of the boilers and independent of the blow-off trench. The elevator is fixed at one end of the boiler house. The general arrangement is such that a minimum amount of fuel handling is necessary. The coal is brought directly from the colliery and passes over the railway siding from the main line. It is weighed on a weighbridge at the entrance to the power station yard, and the trucks are delivered into the boiler room annex, where the coal is either put into the coal bunkers over the boilers or into the storage room below, which runs the full length of the building and is connected to the boiler house by sliding doors fixed opposite each boiler. The fuel is only used from this store when



CONSTRUCTION OF PERMANENT WAY



RAIL SECTION


DETAILS OF POLES, BRACKETS, ETC.

hand firing is necessary. The ashes are withdrawn from the fires, dropped through grids in the floor of the boiler house to the conveyor, and delivered into a hopper at one end, where they are taken up by the elevator and delivered either into railway trucks or carts.

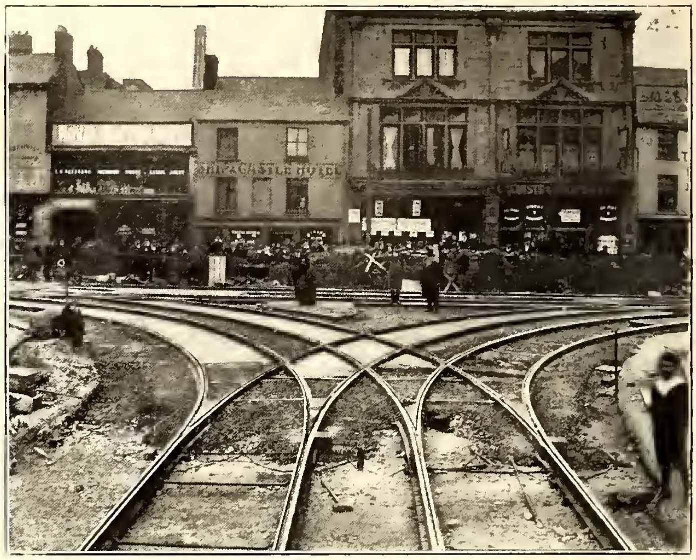
There is room for twelve feed pumps in the pump room, which is at one end of the boiler house and immediately under the repair shops. At present there are but two installed and one on order. The pumps were supplied by G. & J. Weir, of Glasgow, and are of the vertical direct-acting type, capable of delivering each 6000 gallons of water per hour against a pressure of 160 lbs. per square inch.

The whole of the steam, exhaust, injection and overflow pipes, and also the auxiliary and feed pipes, were supplied by the Sir Hiram Maxim Electrical & Engineering Company, Ltd., of London, which has also on order the pipe extensions for the two large engines and three boilers. This firm also supplied the central gangway and switchboard gallery in the engine house. The steam pipes are made of best wrought steel and other pipes of cast iron. The main steam pipes in the boiler house are 18 in. and 14-in. diameter, and are coupled to each boiler by means of a 7-in. branch, from which there is also a 7-in. by-pass to the superheaters. The main pipes are coupled up to separators at each end of the boiler house. There is a large expansion bend in the center of the boiler house, and the leaders in the engine room consist of two 14-in. pipes, supported by the central gangway.

There are separators at either end between the boiler house piping and engine room piping.

There are also expansion bends and separators in the center house. The steam branches to the engines are 6 ins. in diameter.

All of the separators are drained through Geipel steam traps and delivered into a main drain pipe, which runs back to the cooling pond. All of the valves were supplied by Messrs. Hopkinson, of Huddersfield. A duplicate system of 4-in. auxiliary steam pipes is provided for the pumps with separators and drains. The steam pipes as well as the engine cylinders are covered with non-conducting cement and finished off with planished steel with bright steel bands at the joints. The cast-iron exhaust pipes are carried the full length on each side of the engine room, and are supported by means of brackets and hangers and fixed immediately below the crane gantry. The pipes at one end of the room are 12-in. diameter, increasing to 22-in., with 12-in. branches to each engine; 18-in. branches are provided for the large engines not yet installed. There is an automatic valve between the main exhaust and each engine. The injection and overflow pipes are fixed below the engine room floor level and coupled up to the condensers, and there is a duplicate system of feed-water pipes of cast-iron,



STREETS BEFORE PAVING, SHOWING HANDSOME SPECIAL WORK

VIEWS IN CARDIFF AFTER OPENING TRAMWAY SYSTEM which deliver to the boilers either directly or through the economizers. The blow-off pipes for the boilers are fixed in a trench in front of the boilers and deliver into a tank at one end, from whence the water is pumped up into the brook, the boiler house being below water level. A complete system of drain pipes from all parts of the station is provided, and the water delivered into the cooling pond.

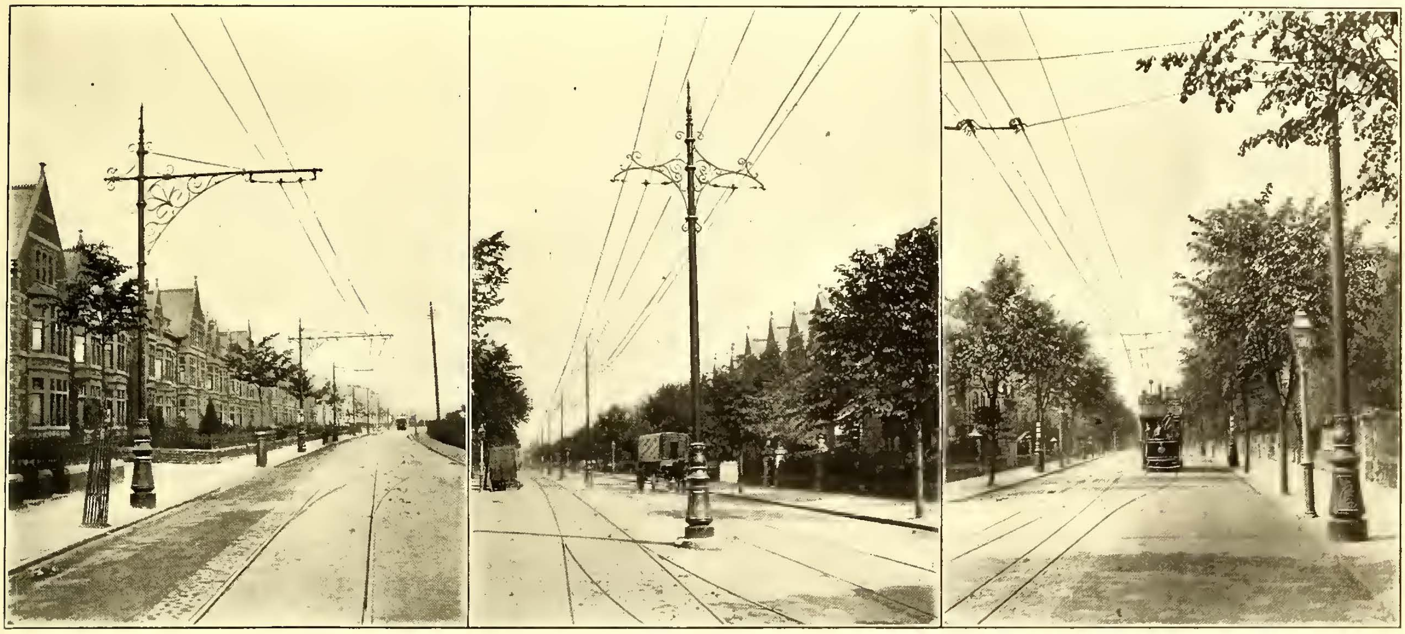
The engine room floor is chiefly constructed of cast-iron plates, which can be easily removed for getting at the pipes, etc., with mosaic work around each engine and at one end of the room. The cooling pond, mentioned above, has a capacity of over one million gallons, and is being made by the Public Works Department of the corporation, under the direction of the borough engineer. The whole construction is of concrete. The water from the condensers is delivered into a hot well at one side of the pond, and the injection water is taken from a point where the water is coolest. The pond is so constructed into two sections by means of a substantial wall that one-half can be shut off for cleaning purposes at any time. If, at some future date, cooling towers are necessary they can be built over the pond as stated.

The lighting of the power station, which has been carried out on a large scale, was done by the men of the electric lighting department, under Mr. Ellis. A complete set of engine room signalling apparatus is fixed and controlled from the switchboard gallery, there being three illuminated signal boards at different points of the room, one at each end and one below the central gangway.

MAIN CAR HOUSE

Adjoining the power station and on a site of two acres, which is divided from it by the Roath Brook, is the main car house, which, when completed, will accommodate 100 cars. The main portion of the building consists of four bays, each 320 ft. long, with three tracks in each. The total width is 136 ft. At the side of the shed there are offices for the shed foreman and timekeeper, together with men's lavatories, etc. The foreman's office is on the first floor and overlooks the interior from the large bay windows, standing out into the storage room. On this floor are also offices for clerks, engineers, etc. The whole of the shed flooring and tracks are supported on columns, leaving a clear space under the cars 4 ft. deep.

At one end there will be an electrically-driven transfer table or "traverser," operating the full width of the shed, for taking cars either from one track to another or into the repair shops beyond. The pit in which it runs is 25 ft. wide. The repair shops consist of a machine shop 120 ft. x 60 ft., painting shop 90 ft. x 33 ft., blacksmith shop 29 ft. x 25 ft., and carpenters' shop 29 ft. x 25 ft., together with rooms for the men, oil storage, sand storage, etc. The foreman in charge of this part of the shed has an office between the paint and machine shops, with glass windows on all four sides, so that he has a complete view of the whole building from his office. The contractor for this building was D. W. Davies, who also built the car house at present in use at the opposite end of the town, which has accommodations for thirty-two cars. The lighting arrangements and tool equipment of both sheds is being carried out by the staff of the tramways department under Mr. Ellis, while the borough engineer has acted as architect in both cases.



SOME TYPES OF OVERHEAD CONSTRUCTION

PERMANENT WAY

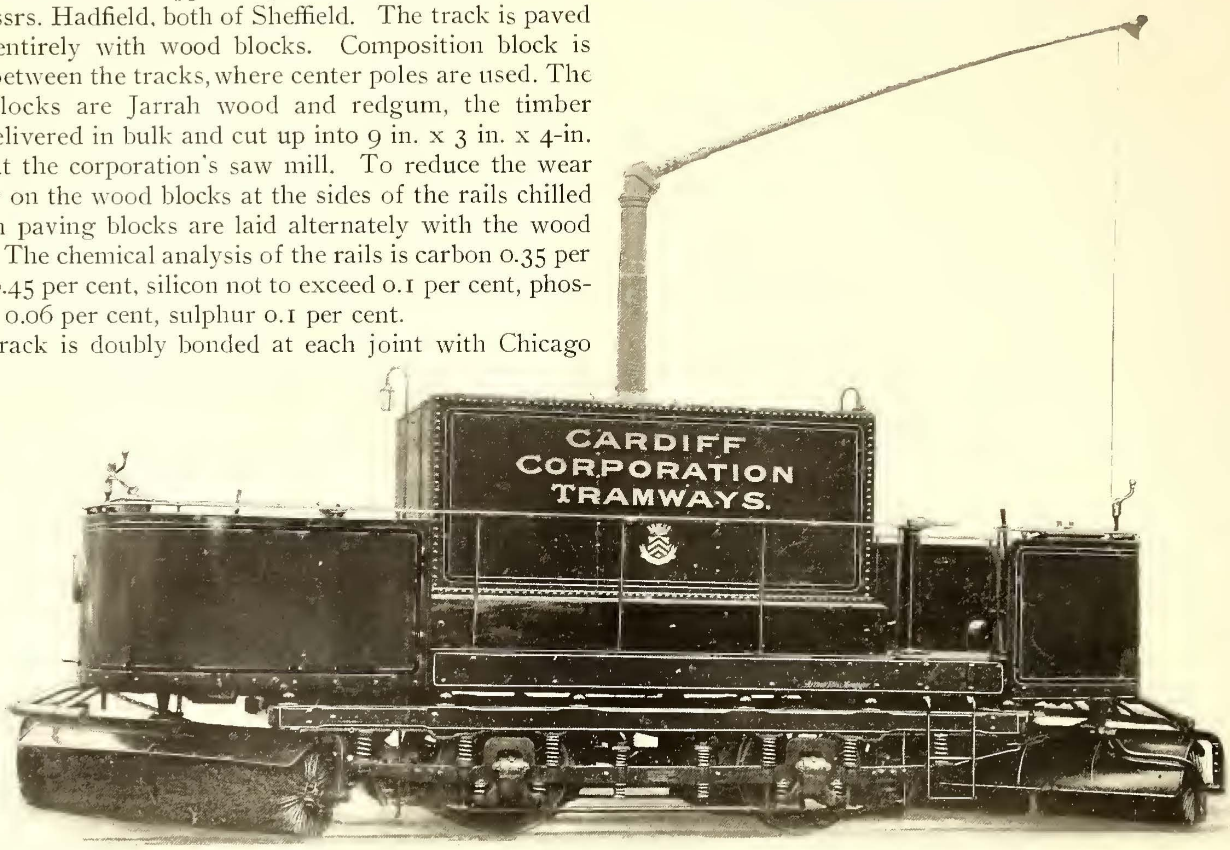
Cardiff is an ideal town for tramways, being practically flat and having only four gradients in the whole system, the worst of which is one in twenty. On the other hand the tramways are handicapped to some extent by very low railway bridges, which necessitate the reduction of headroom inside the cars, and on two routes the use of single deck cars. Fortunately on the main line, that going to the docks, where most of the cars run, it has been possible to lower the roadway 15 ins., giving sufficient headroom under the bridge on this route for the use of double deck cars. The sharpest curve on the system is of 40-ft. radius.

Girder rails have been used 45 ft. long, having a weight of 100 lbs. per yard. The rails are 6¼ in. in depth with a 7-in. flange, the groove of the rail being 1¼ ins. wide by 1¼ ins. deep. The rails are laid in a concrete bed 11 ins. deep and 1⅛ ins. wide, the depth of concrete under the other portions of the track being 8 ins. The rail joints are made by fish-plates, weighing 64 lbs. per pair, with six 1-in. bolts and patent lock nuts. The joints are further secured by sole plates, 2 ft. x 11 ins. and ⅛ in. thick, secured by four single and two double clips by ¾-in. bolts and nuts. The tie-bars used were especially designed by Mr. Harpur, the borough engineer. The rails being 6¼ ins. deep and the paving bricks only 4 ins., enables the rails to be buried in concrete to a depth of 2¼ ins. The accompanying cross section view of the track shows the various details of construction.

The rails were supplied by Dick, Kerr & Co., and Bolckow, Vaughan & Co., of Middlesborough. The points and crossings have been supplied by Askham Bros. & Wilson, and Messrs. Hadfield, both of Sheffield. The track is paved almost entirely with wood blocks. Composition block is placed between the tracks, where center poles are used. The wood blocks are Jarrah wood and redgum, the timber being delivered in bulk and cut up into 9 in. x 3 in. x 4-in. blocks at the corporation's saw mill. To reduce the wear and tear on the wood blocks at the sides of the rails chilled cast-iron paving blocks are laid alternately with the wood blocks. The chemical analysis of the rails is carbon 0.35 per cent to 0.45 per cent, silicon not to exceed 0.1 per cent, phosphorous 0.06 per cent, sulphur 0.1 per cent.

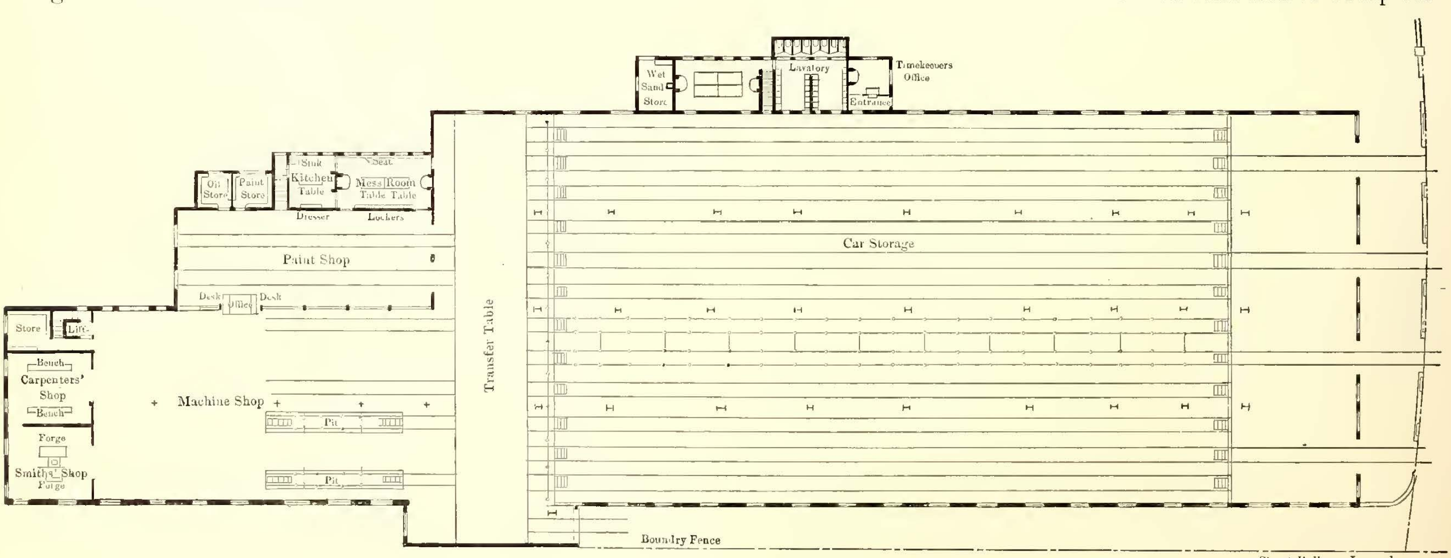
The track is doubly bonded at each joint with Chicago and plastic bonds. Neptune bonds are also used. It is cross-bonded every 80 yards.

The track construction was commenced in one of the new routes in December, 1900, and a portion opened for horse tramway traffic in June of the next year, when the Royal Agricultural Show was held in Cardiff. Several other new routes were completed during this year, the work being done for the tramways department by the public works department of the corporation. On December 12, 1901, after long negotiations with the Cardiff Tramways Company, Ltd., terms were arranged whereby the company agreed to hand over its lines to the corporation at 12 p. m. on December 31, 1901, the sum paid for the lines being £50,000. The corporation also took over fifty-two cars and 342 horses, for which it paid £15,644, and there still remains to be paid to the company the sum to be agreed upon for the purchase of three car houses.



TRACK SWEEPER AND SPRINKLER

In the meantime the borough engineer had prepared plans for the reconstruction of the whole of the company's lines, representing 12 miles of single track. Long discussions took place as to whether the work should be done by contract or by the corporation's own men. One firm offered to do the whole of the work for a stated sum and to complete the work in six months with the usual allowance for bad weather, traffic, etc. The borough engineer stated that he could not only do the work in the same length of time but for less money, and the work was taken over by the corporation. It is greatly to Mr. Harpur's credit, therefore, that on May 1 eleven out of the twelve miles were opened for traffic,



PLAN OF CAR HOUSE

whilst the rest of the twelve miles was completed on May 16, or one month less than the time guaranteed.

The cables are of the single-conductor, plain lead-covered type, drawn into Doulton's earthenware conduits. There are seven main feeding points on the system, the feeders varying in section from .6 sq. in. to .4 sq. in., there being five .6 sq. in., one .5 sq. in. and one .4 sq. in. feeders. These feeders run direct from the power station to feeder pillars and are not tapped at all between these terminals. The feeder pillars are of special design made by Mr. Ellis and contain one main feeder switch of 600 amp. capacity and four switches of 300 amp. each, as well as a lightning arrester. From these pillars cables are taken to the section pillars from which each route is fed. The section pillars contain two main switches for cutting the distributors into sections and four line switches.

The use of these feeder pillars does away with the necessity of tapping the main feeders when necessary to feed into more than one distributor. The feeders are so arranged that each one feeds a star, or, in other words, in three or four directions. There are two return points on the system from which insulated cables are taken back to the power station, and from one of these three .3-sq. in. cables are taken, and from the other two .6-sq. in. cables. These cables are coupled to the rails by means of special clamps and copper bonds. The distributors running along the several routes vary in size from .4 sq. ins. down to .15 sq. ins.

Test wires consisting of three core cables are taken to the various points of the system, one conductor being used for testing purposes and the other two for telephones. Special telephone pillars are fixed every half mile along each route and at different points in the center of the town and are in communication with the power station, central offices, depots, etc. The entire cable installation was supplied by the British Insulated Wire Company, Ltd., of Prescot, Lancashire. The conduits are laid solid in concrete, and from the power station to the center of the town there are thirty ducts. At this point the conduits radiate in all directions along the several routes. At the power station end the main line of conduits is coupled up to the power station by a subway 300 ft. x 10 ft. x 4 ft., this subway being in direct communication with the main switchboard.

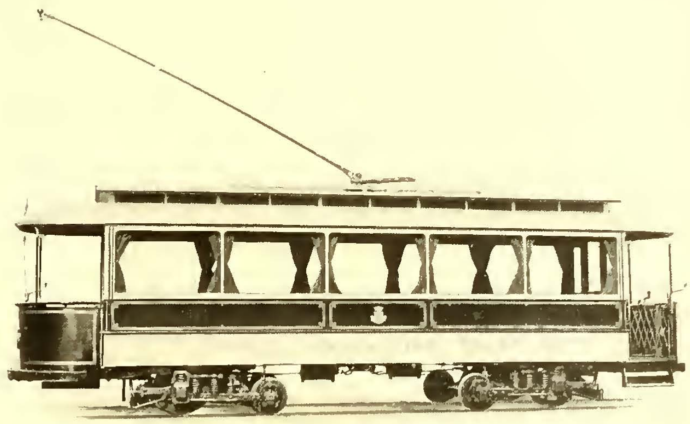
OVERHEAD EQUIPMENT

The whole of the overhead construction has been carried out by the men of the tramways department under Mr. Ellis, the poles, brackets, bases, etc., being designed by him. The equipment is very solid and substantial, flexible suspension being used throughout. Center poles are used chiefly, although side poles and bracket arms, as well as span wire constructions, are used on some of the routes where the streets are narrow and not sufficiently wide for center poles, although double track is laid. Specially heavy materials have been used, including 000 trolley wire, supplied by Back & Manson, the agents for Roebling & Sons.

The engravings give an idea of the handsomeness of the overhead work. The hangers are made of best gun metal, with ¾-in. insulated bolts. None of the ears are less than 18 ins. long, and they were specially designed by Mr. Ellis to give great strength. The ears vary in length up to 36 ins. The insulation is of the Ætna type, the line materials being supplied by R. W. Blackwell & Company, of London. The span wire consists of seven strands of No. 12 gage steel wire, galvanized, while the guard wires are of twelve No. 16 strands. Steel taper poles in one section have been used, with heavy cast-iron bases 6 ft. high. While heavy materials have been used, they do not in any way detract from the appearance of the construction, which, as can be seen, is light and elegant.

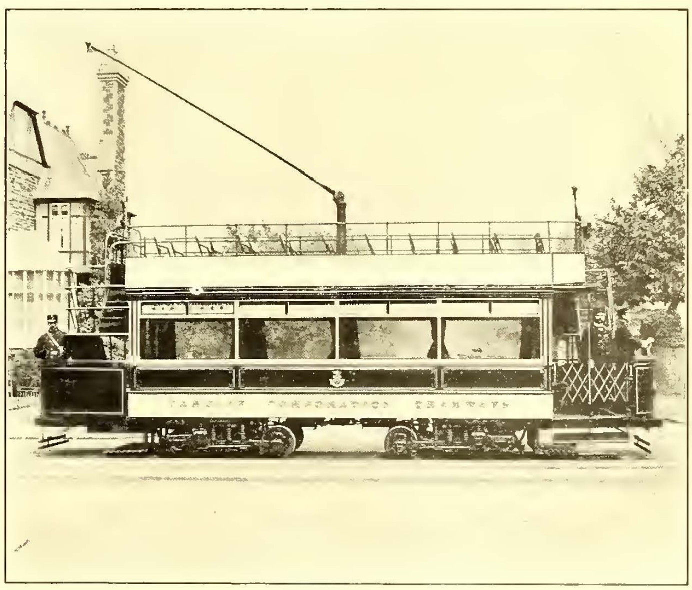
ROLLING STOCK

Three types of cars are used, all of which are extremely well built, having steel underframing and a handsome appearance. They are double-deck four-wheel cars with a fixed wheel base of 6 ft., double-deck double-truck cars with maximum traction trucks and single-deck double-truck cars with maximum traction trucks. The wheel



SINGLE-DECK CAR

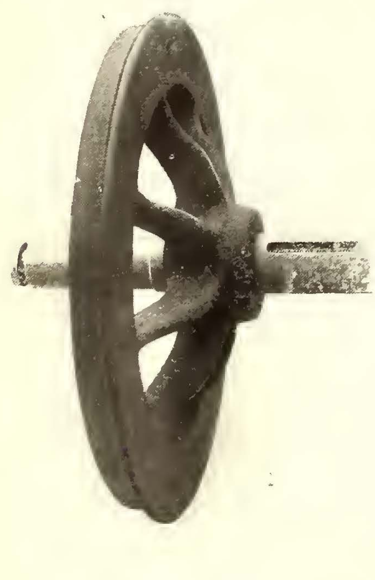
base of the maximum traction trucks is 4 ft. The four-wheel cars carry fifty-two passengers, twenty-two inside and thirty outside. The staircases are the double or broken type, with a platform half way up. The over-all length of these cars is 28 ft. 6 ins. over the bumpers, with platforms 5 ft. 9 ins. On account of low bridges the over-all height of the cars from the rails to the trolley plank is 9 ft. in order to leave 6 ft. clearance from the trolley plank or upper deck to the under side of the bridges, and on this account it has only been possible to get an internal headroom of 6 ft. The internal length of the car body is 16 ft.



DOUBLE-DECK CAR

The double-deck double-truck cars are similar in every way except in length, the length over all being 34 ft. 6 ins., and inside the car body 21 ft. 4 ins. The roof seats are in both cases of the "garden" type. The cars carry sixty-eight passengers, thirty inside and thirty-eight outside. The single-deck cars carry thirty-four passengers, and the length over bumpers is 33 ft. 6 ins. The interior length of car body is 24 ft. 4 ins., the platforms at either end being 3 ft. 9 ins. The internal finish of the three types of cars is very handsome, the double-deck cars having flat roofs, while the single-deck cars have monitor roofs. The woodwork is chiefly light and dark oak and the ceilings three-ply bird's-eye maple divided into panels by oak mouldings. All the inside seats are lathe and space, no cushions being used. The windows are draped with neat red blinds with "C. C. T." worked on each.

The larger double-deck cars have eight 16-cp lamps inside, with two roof lights and the usual dash and canopy lights, the four-wheel cars being similarly lighted with the exception of there being only six internal lights of 16 cp. The single-deck cars have eight inside lights. All the cars are provided with illuminated destination or route indicators made by the British Electric Car Company, of Manchester. Each car has also a Ruby leakage lamp at either end. It might here be added that all cars have steel underframing.



STANDARD CARWHEEL

The four-wheel trucks are the Brill No. 21-E type with 30-in. wheels. The spring base measures 14 ft. 6 ins., and the extreme length of top-plate 15 ft. 7 ins. The wheels have tires with wrought-iron centers and were made by John Baker & Company. They are forced on to the axles under a pressure of not less than 25 tons or more than 30 tons. The axles are $3\frac{1}{4}$ ins. in diameter and the journal boxes are fitted with spring caps. The brakes are the ordinary link-suspended type with Corning brake-shoes. The cars are fitted with life guards and fenders of the Tidswell type. The maximum traction trucks were also supplied by J. G. Brill & Company, of London. The diameter of the driving wheels is 30 ins. and that of the pony wheels 20 ins., and the wheels all have steel tires and wrought-iron centers. The flanges are all $\frac{5}{8}$ ins. deep and the wheel treads $1\frac{3}{4}$ ins. wide. A view of one of the wheels is given.

The cars are fitted with a controller at each end having four series and three parallel notches, as well as four notches for the electric brake. The electric braking is effected by connecting the motors as series generators in parallel with each other and in series with the same resistance as used ordinarily. Each car is fitted with an automatic circuit-breaker, main motor switch and main fuse, with magnetic blow-out, lightning arrester and kicking coil. The trolley standards are of the inclosed spring type, a single spring under compression being used. The standard is in one piece, made of malleable cast-iron. A super-elevation stop is provided to limit the vertical motion of the trolley pole. The trolley standards are fitted with hand-holes for getting at the cable connections between the car and standard. Wood's trolley-heads are used.

The motor equipment consists of two series-wound motors, each capable of a draw-bar pull of 1400 lbs. on 500 volts, propelling the car at a speed of 8 miles an hour at this load. They are capable of doing this for one hour with 100 per cent overload for short periods. The motors are of the four-pole type, with the armatures geared to the car axles by single-reduction spur gearing. The armatures are of the slot-wound drum type and so wound that only two sets of brushes are necessary. The commutators have a wearing depth of 1 in. The insulation of the armatures and field coils from the frames are tested to withstand a pressure of 3000 volts.

Each car is provided with a complete set of tools, including a traversing and lifting jack, a set of adjusted spanners, screwdrivers and cutting pliers, hammer, chisel, rubber gloves and four feet of steel rope, with a hook at each end, for hauling purposes. All of the cars have been supplied complete with equipments, etc., by Dick, Kerr & Co., Ltd., of London, whose first contract was for the supply of twenty double-deck double-truck, twenty double-deck four-wheel and fourteen single-deck bogie cars. They have recently received an extension order for twenty double-deck double-truck cars and twenty double-deck, four-wheel cars, making ninety-four cars in all. It is expected that there will be at least 150 cars required.

GENERAL REMARKS

The general arrangement of the plant, etc., at the power station, together with the cables, overhead equipment and cars has all been carried out in accordance with the plans and specifications prepared by the borough electrical engineer and manager, Arthur Ellis, M. I. M. E., M. I. E. E., who, from the commencement, has been ably assisted by his chief assistant, C. E. Davies, who is a man well versed in tramway work. The tramway system was officially opened on the first of May, and since that time has been running smoothly, no accidents of any consequence having taken place.

Mr. Ellis, in addition to his duties in connection with the electric lighting and tramways department, has, since January, had to manage the horse tramways system as taken over from the old tramways company. This consisted of fifty-two cars and 342 horses, together with the various depots. The horse tramways will, of course, be gradually done away with as the electric cars put into service increase.

Since the opening, the traffic on the electric cars has been enormous, and they have already become very popular in the district, the public realizing the greater facilities offered by them for getting about. Cheap fares have been adopted with a quick service and stopping places have been fixed along the various routes. It is interesting to note that from the new power station, which is now in operation, it is intended to supply current for electric lighting purposes in addition to the supply of power other than that for tramways, and it is mainly for this reason that the two large generator sets of 900 kw are being installed. It is expected that by next winter there will be a demand in motors alone amounting to nearly 1500 hp, the corporation having recently entered into a contract with one of the largest shipbuilding and repairing firms in Cardiff for the supply of current for the driving of the whole of its machinery, which eventually will mean 500 hp for this customer alone. In addition to this company there are applications in from several other very large firms for large amounts of power.

The whole of the current for lighting and power purposes generated at the main power station will be transmitted to a large sub-station in the basement of the electric lighting and tramways department's central offices, and it is intended to put in a main switchboard at this point, together with balancers, boosters, battery, etc., and to transmit the current from this central sub-station to the various sub-stations in the district. For a commencement, 2-sq.-in. feeders are being laid from the power station to the sub-station, and for the docks district alone two .5-in. triple concentric cables are being laid. It is intended to change over the central area to continuous current during the present summer, as the existing lighting station is practically working up to its fullest capacity. It is also intended to light up the whole of the tramway routes electrically, which will be done from the trolley poles, but the lamps will not be supplied from the tramway feeders or trolley wires, independent cables being laid for the purpose.

In closing, a few words should be said about the handsome Ferranti switchboard. It consists of a number of massive slates fixed in a horizontal position and grouted into the station wall. These slates are divided off by vertical partition slates and insulating material into a number of separate compartments. Each of these compartments contains, separately, the apparatus making up the board. There are in all about twenty panels, occupying a wall space of some 40 ft. Of these panels, commencing at the left hand facing the board, there are four lighting feeders, each feeder containing a quick carbon-brake switch and automatic device to release same on maximum current. The edgewise ammeter placed on the top of the slate reads the current passing through the circuit. The bus-bar voltmeters are mounted on a swivel bracket so that they can be seen from any position on the switchboard platform. Next to these lighting feeders, continuing toward the left of the board, is a wattmeter, arranged in the bus-bars to read the total energy distributed to the feeders.

Each dynamo panel consists of double set of bus-bars, one for traction the other for lighting, and a change-over switch by which the machine can be used on either system. The other parts comprising the dynamo panel are the quick-break switch with automatic reverse-current release, edgewise ammeter, field regulating resistance and the usual field and voltmeter switches. Two of these dynamo panels are suitable for dealing with a maximum current of 2000 amps., and the remaining four are rated at 750 amps. In order of arrangement come the panels required for motor generators and boosters containing the switches and instruments for these panels, designed so as to be in conformity with the remainder of the gear. To the extreme right are the traction and feeder panels, comprising chopper switches, quick-break switches with automatic maximum release, ammeters, kicking coils, lightning arresters, etc. A set of illuminated dial voltmeters is arranged for these panels to correspond with those fitted over the lighting feeders. The regulating table has been extended under the traction feeder-panels and contains small fuses and switches required for the station power circuits. The design is very efficient and substantial, and great care has been taken with the workmanship and finish. A striking advantage of this system is the simplicity in the general arrangement of parts which render it possible to read the connections from the front of the board without the aid of a diagram, thus reducing the responsibility of the attendant and the possibilities of mistakes.

Boston Subway Legislation

The Massachusetts Legislature, in its closing days, enacted a bill providing for the construction in Boston of a subway through the business center and along the general line of Washington Street, and this was signed by Governor Crane. As a result of long negotiations between the Governor, the Mayor of Boston, representatives of the mercantile organizations and the Boston Elevated Railway Company, the bill was drafted and was referred to the committee on metropolitan affairs of the Legislature a week ago, and was reported unanimously to the Legislature by that committee, but with certain amendments, two of which were eventually struck out.

The compromise bill agreed to by the representative of the interested parties provided that the Boston Transit Commission may construct a tunnel for elevated trains and later a subway for surface cars extending from a point near the junction of Broadway and Washington Street and a point near Adams Square, Haymarket Square, or Causeway Street, and follow the general line of Washington Street. Much latitude is allowed in the fixing of the precise route, since the tunnel may be built anywhere between the existing subway and a line 750 ft. easterly from Washington Street.

This tunnel will contain two tracks, and will be adapted to elevated cars or trains, and its construction will begin immediately after the acceptance of the act by a majority of the voters of the city. A further provision is made for the construction of another two-track subway for the use of the surface cars along the same general line, any time after one year after the completion of the tunnel just mentioned. This second subway will be built if the Transit Commission and the Elevated Railway Company agree that it is necessary, or, in case of disagreement, if the Board of Railroad Commissioners decide that it is necessary.

The Transit Commission shall, within ninety days after the passage of the act, execute a lease of the tunnel and subway for a period of twenty-five years from the beginning of the use of the tunnel, at an annual rental of $4\frac{1}{2}$ per cent of the net cost of construction. The Elevated Road is authorized to connect its elevated lines with the tunnel in such manner as the Board of Railroad Commissioners may approve.

Upon the completion of the tunnel the company must remove its elevated trains from the existing Tremont Street Subway and readapt that subway to the use of surface cars, as formerly. At any time after one year from the completion of the second subway the Railroad Commissioners may order the removal of surface tracks from Washington Street between Broadway and Adams Square, and such order shall be deemed a revocation of all locations and rights to occupy the street.

The cost of construction is to be met by an issue of fifty-year bonds by the city of Boston, and the rental derived from the use of the subway will be used for the purpose of paying the interest and providing a sinking fund for the retirement of these bonds. The act will not become operative unless approved by a majority vote in the next municipal election, or some special election called for the purpose, except, of course, the provisions that apply to preliminary work take effect at once.

The provisions of the act become a part of the terms of the contract between the city and the company, and likewise constitute a contract between the Commonwealth and the city, under which the city will own in its private and proprietary capacity as an irrevocable grant from the Commonwealth, all subways heretofore authorized, as well as those authorized in the bill.

The committee having the bill in charge made several changes, two of which were not approved. One of them provided that Pleasant Street should be widened for surface cars to provide a connection between the Tremont Street Subway and South Boston. This amendment, however, was rejected by the House, and is not now a part of the bill. The second change was the insertion of a section providing that none but American citizens should be employed as laborers or mechanics in the work of construction, and that such laborers shall be paid not less than the rate of wages paid to laborers employed by the city of

Comparative Acceleration Tests with Steam Locomotive and Electric Motor Cars*

BY B. J. ARNOLD AND W. B. POTTER.

In connection with the preparation of a report on the use of electricity for the propulsion of trains of the New York Central Railroad in the tunnel entrance and terminal in New York City, an invitation was extended by the General Electric Company to W. J. Wilgus, chief engineer of the railroad company, to use its experimental track (Fig. 1) and apparatus at Schenectady, and a series of tests were accordingly carried out under the direction of the authors of this paper. The tests were principally for the purpose of determining the comparison between steam and electric traction on short-haul suburban passenger service. Owing to the short curves in the connecting tracks the General Electric Company's track could not be used for the steam locomotive tests.

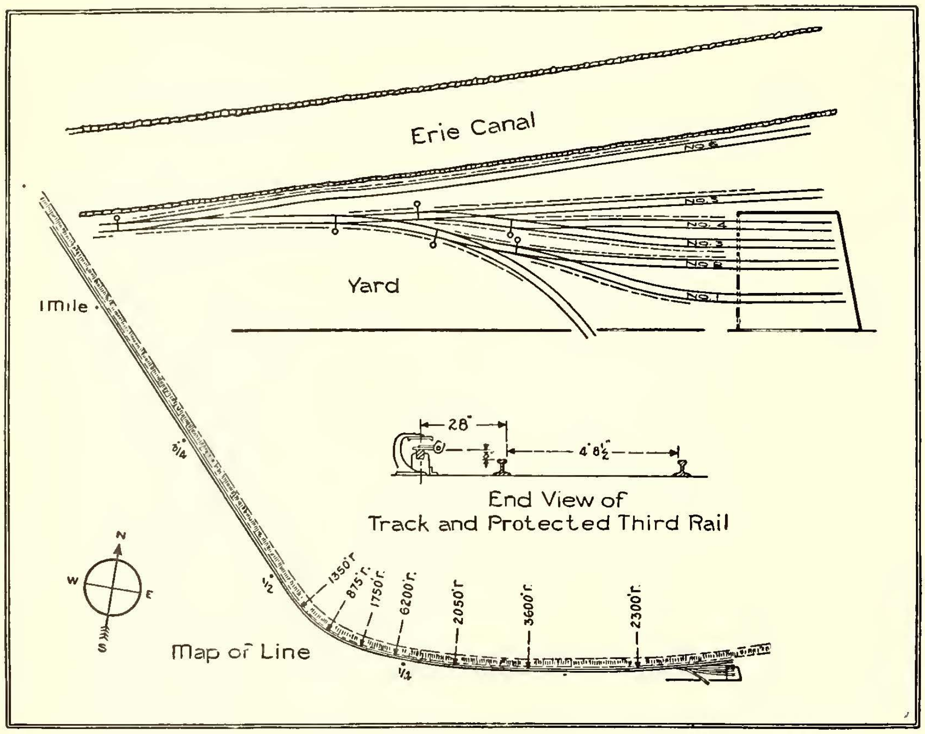


FIG. 1.—MAP OF GENERAL ELECTRIC RAILROAD

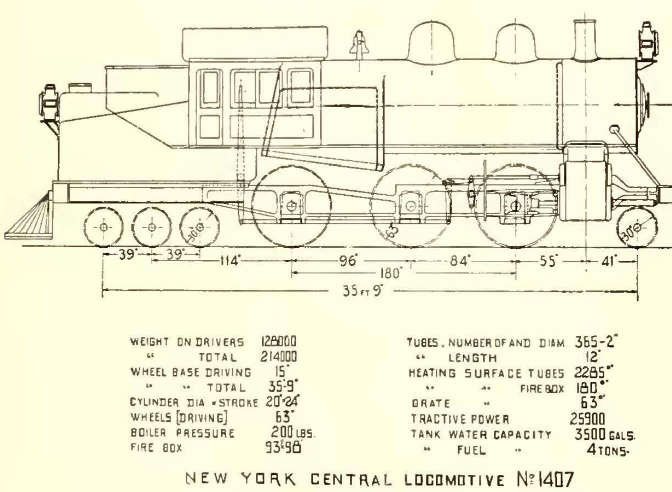


FIG. 2.—OUTLINE OF STEAM LOCOMOTIVE NO. 1407

The steam tests were therefore made on the New York Central main line tracks west of Schenectady.

The steam locomotive shown in Fig. 2 was built from the specifications of A. M. Waite, superintendent of motive power and rolling stock of the New York Central, by the Schenectady Locomotive Works. It was designed especially for the rapid acceleration work required in suburban service, being provided with large grate area and heating surface and a very large proportion of weight on its driving wheels.

The two electric motor cars were similar in form, 54 ft. over all, each weighing about thirty-five tons, including the electrical equipment, which consisted of four G. E.-55 motors and type M control. All axles being equipped with motors, the two cars together gave approximately the same weight upon the drivers as the steam locomotive. The acceleration was therefore directly comparable for trains of equal net weight, and to secure this comparison the same trail cars, arranged in the same order, were used in both steam and electric tests.

In the steam runs the draw-bar pull, speed and time were recorded by an Illinois Central dynamometer car, and the same car was used with the electric motor cars to determine the relation between current input and draw-bar pull. The dynamometer car had to be returned before the electric runs were completed, but not before a large number of readings were taken, from which curves were plotted showing the relation between amperes and draw-bar pull with different weights of train behind the motor cars. The draw-bar pull thus determined has been plotted on the attached electric motor car curves, which were taken subsequent to the return of the Illinois Central car.

The order of the tests, both steam and electric, was as follows:

A train of six cars, including five standard passenger coaches loaned by the New York Central Railroad, and the dynamometer car, was started and run over a mile of track, acceleration being made as rapidly as possible. These same runs were repeated, dropping off one car at a time, until only the dynamometer car remained. Automatic records were kept of the draw-bar pull, speed, time, distance and the strength and direction of the wind. The condition of rail and temperature were also noted. The same runs were repeated, using the two motor cars in place of the steam locomotive, the dynamometer car being used in some of the runs and a box car loaded to equal weight in subsequent runs. In the electric runs additional records were kept of voltage, ampere and wattmeter readings. The wattmeter was not carried on the car, but was placed stationary at the point of feeding the third rail, thus avoiding any inaccuracy due to jarring. The voltage leads of the wattmeter were connected to the extreme end of the third rail and track, thus receiving at all times the exact voltage at the train, so that the energy delivered to the motor cars represented the net input and did not include losses in the feeder system.

The cars used in this test and the weights are given below:

	Number	Pounds
New York Central locomotive	1407	214,000
General Electric motor car	4	73,000
General Electric motor car	5	70,000
Illinois Central dynamometer car	17	45,640
New York Central coach	1885	48 200
New York Central coach	545	60,250
New York Central coach	1709	53,700
New York Central coach	508	51,450
New York Central coach	1798	54,600

During the tests many runs were made, but for the illustration of this paper representative and average runs only are given.

ELECTRIC MOTOR CARS NO. 4 AND 5.

The electric runs were made upon the General Electric experimental track against a head wind of 15 m. p. h. The rail was dry, the temperature of 8 degs. C., and the grade practically level. In

No. of Run	Character of Load	Weight of Load, Tons	Total Weight Train, Tons	Maximum Speed	Average Speed	Watt Hours Per Ton Mile	
						From volt Amperes	From Wattmeter
1	6 trailers	157.	228.5	36.4	27.2	75.9	79.4
3	5 "	130.	201.5	37.9	28.6	78.4	82.0
5	4 "	104.	175.5	39.1	29.8	84.3	86.9
7	3 "	77.	148.5	41.0	30.6	84.7	93.4
9	2 "	47.	118.5	42.8	32.0	98.5	99.4
11	1 "	23.	94.5	44.7	33.1	115.0	114.0
13	No "		71.5	46.7	34.6	132.3	129.0

* Read at the nineteenth annual convention of the American Institute of Electrical Engineers, Great Barrington, Mass., June 19, 1902.

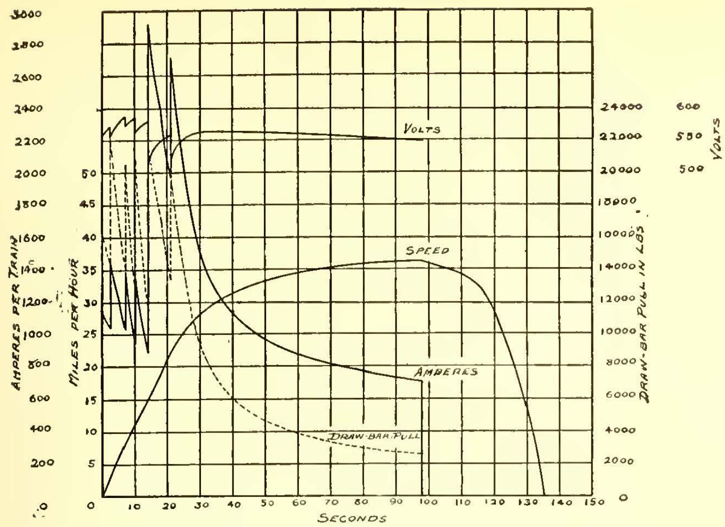


FIG. 3.—ELECTRIC RUN NO. 1. 6 TRAIL CARS—WEIGHT, 157 TONS. INCLUDING MOTOR CARS, 228.5 TONS. POWER ON, 4170 FT. DISTANCE RUN, 5380 FT. WATT HOURS PER TON MILE, 79.4

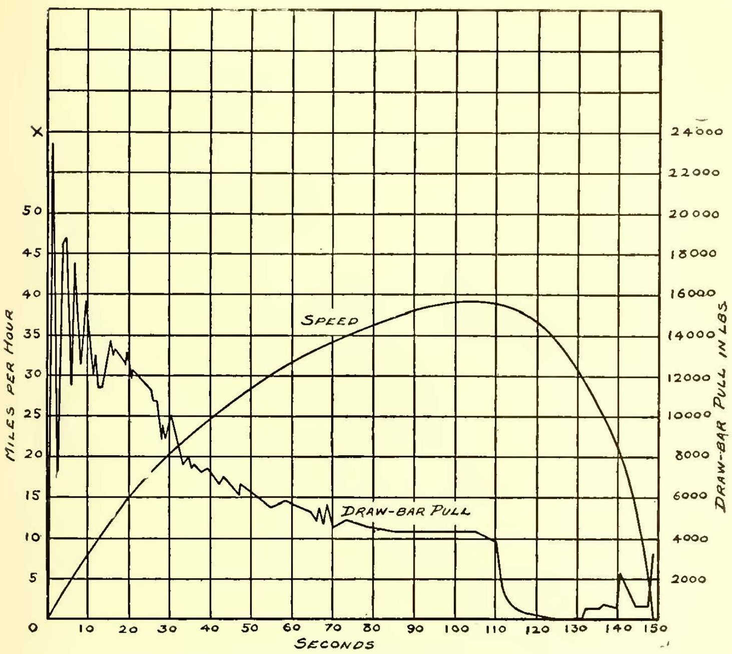


FIG. 4.—STEAM RUN NO. 2. 6 TRAIL CARS—WEIGHT, 157 TONS. INCLUDING LOCOMOTIVE, 264 TONS. POWER ON, 4035 FT. DISTANCE RUN, 6150 FT.

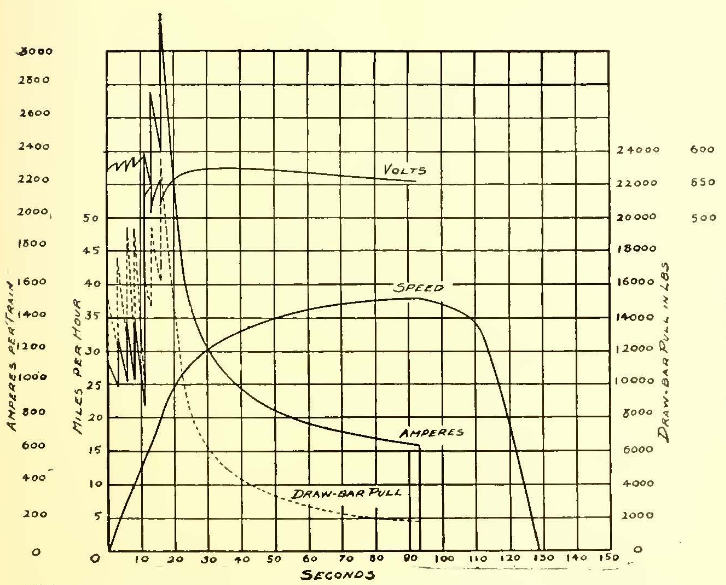


FIG. 5.—ELECTRIC RUN NO. 3. 5 TRAIL CARS—WEIGHT, 130 TONS. INCLUDING MOTOR CARS, 201.5 TONS. POWER ON, 4170 FT. DISTANCE RUN, 5380 FT. WATT HOURS PER TON MILE, 82

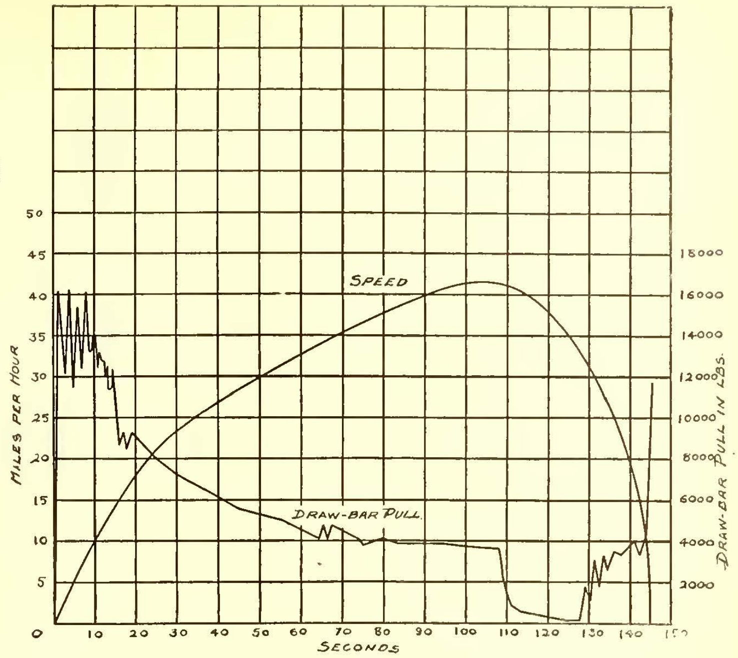


FIG. 6.—STEAM RUN NO. 4. 5 TRAIL CARS—WEIGHT, 130 TONS. INCLUDING LOCOMOTIVE, 237 TONS. POWER ON, 4270 FT. DISTANCE RUN, 6050 FT.

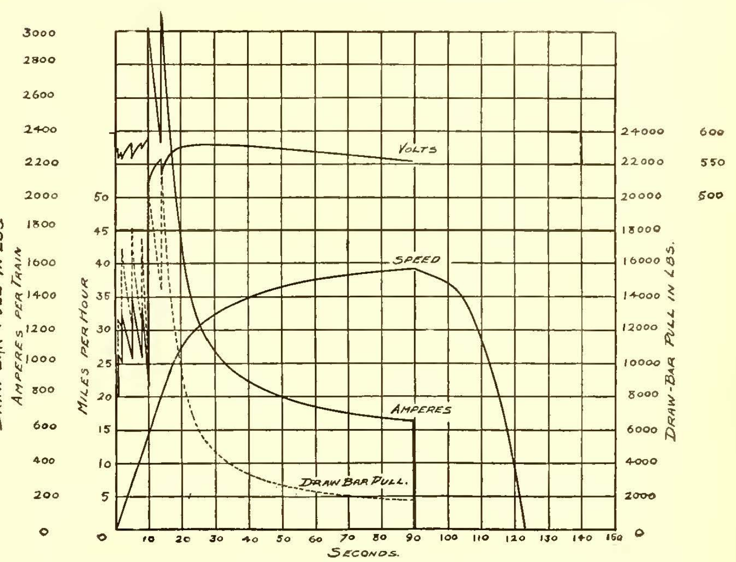


FIG. 7.—ELECTRIC RUN NO. 5. 4 TRAIL CARS—WEIGHT, 104 TONS. INCLUDING MOTOR CARS, 175.5 TONS. POWER ON, 4135 FT. DISTANCE RUN, 5380 FT. WATT HOURS PER TON MILE, 86.9

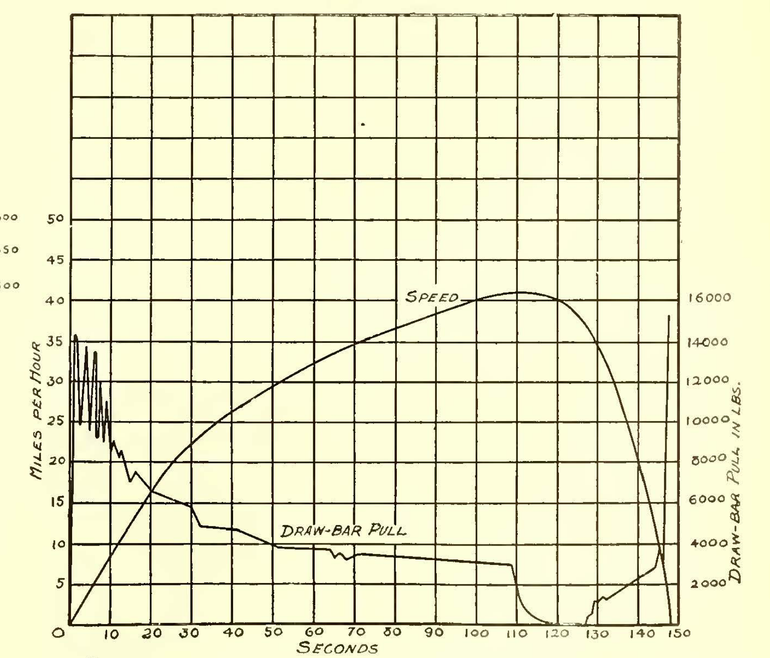


FIG. 8.—STEAM RUN NO. 6. 4 TRAIL CARS—WEIGHT, 104 TONS. INCLUDING LOCOMOTIVE, 211 TONS. POWER ON, 4490 FT. DISTANCE RUN, 5943 FT.

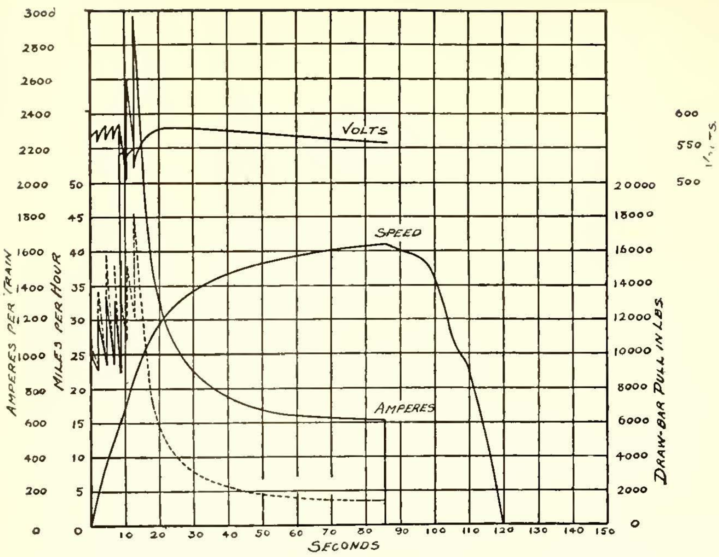


FIG. 9.—ELECTRIC RUN NO. 7. 3 TRAIL CARS—WEIGHT, 77 TONS. INCLUDING MOTOR CARS, 148.5 TONS. POWER ON, 1470 FT. DISTANCE RUN, 5370 FT. WATT HOURS PER TON MILE, 93.4

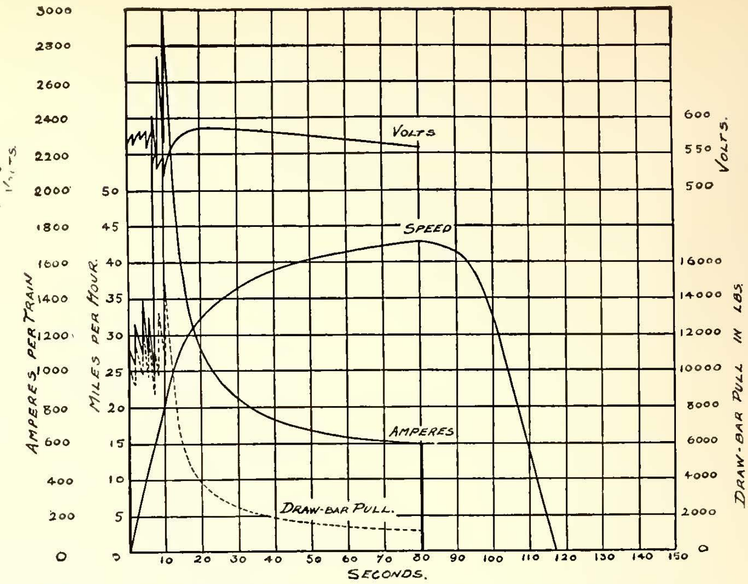


FIG. 11.—ELECTRIC RUN NO. 9. 2 TRAIL CARS—WEIGHT, 47 TONS. INCLUDING MOTOR CARS, 118.5 TONS POWER ON, 4100 FT. DISTANCE RUN, 5490 FT. WATT HOURS PER TON MILE, 99.4

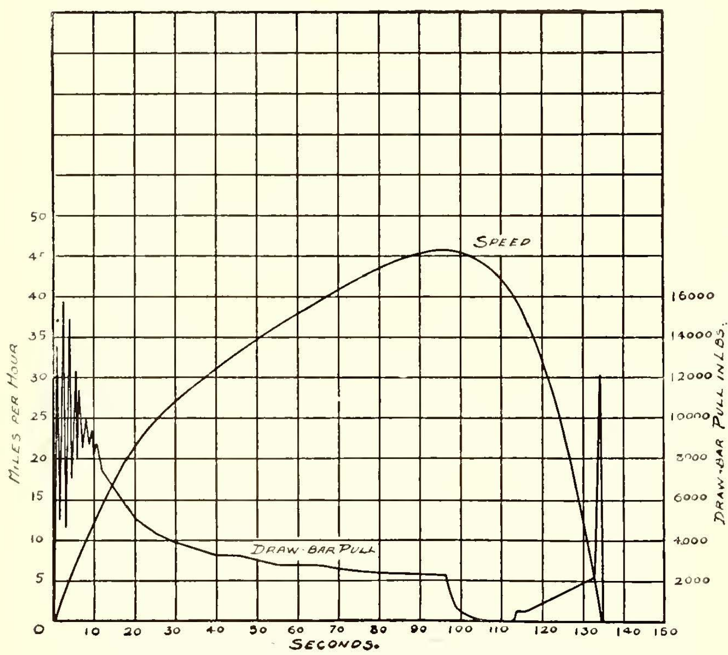


FIG. 10.—STEAM RUN NO. 8. 3 TRAIL CARS—WEIGHT, 77 TONS. INCLUDING LOCOMOTIVE, 184 TONS. POWER ON, 4520 FT DISTANCE RUN, 5930 FT.

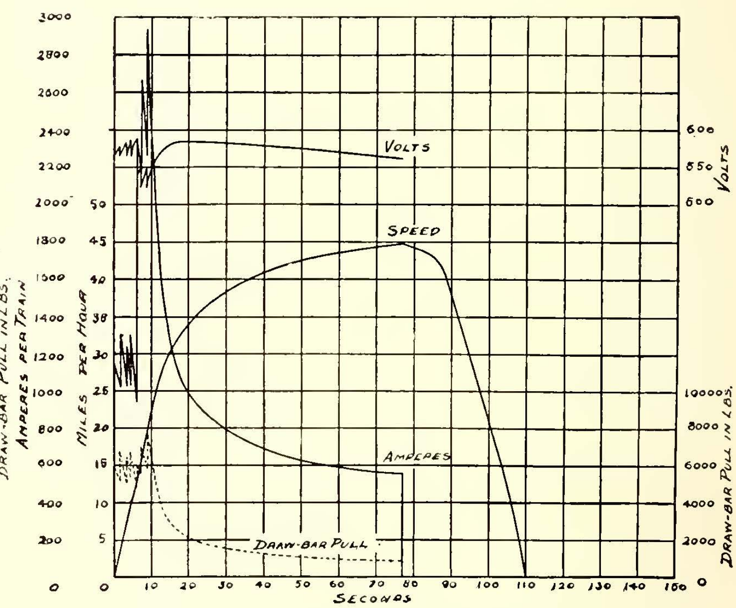


FIG. 13.—ELECTRIC RUN NO. 11. 1 TRAIL CAR—WEIGHT, 23 TONS. INCLUDING MOTOR CARS, 94.5 TONS. POWER ON, 4060 FT. DISTANCE RUN, 5350 FT. WATT HOURS PER TON MILE, 114

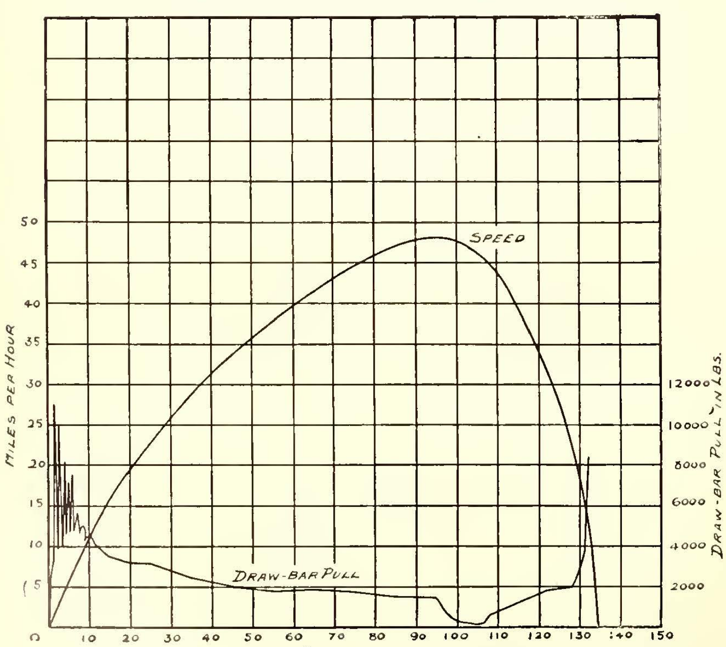


FIG. 12.—STEAM RUN NO. 10. 2 TRAIL CARS—WEIGHT, 47 TONS. INCLUDING LOCOMOTIVE, 154 TONS. POWER ON 4455 FT. DISTANCE RUN, 5927 FT.

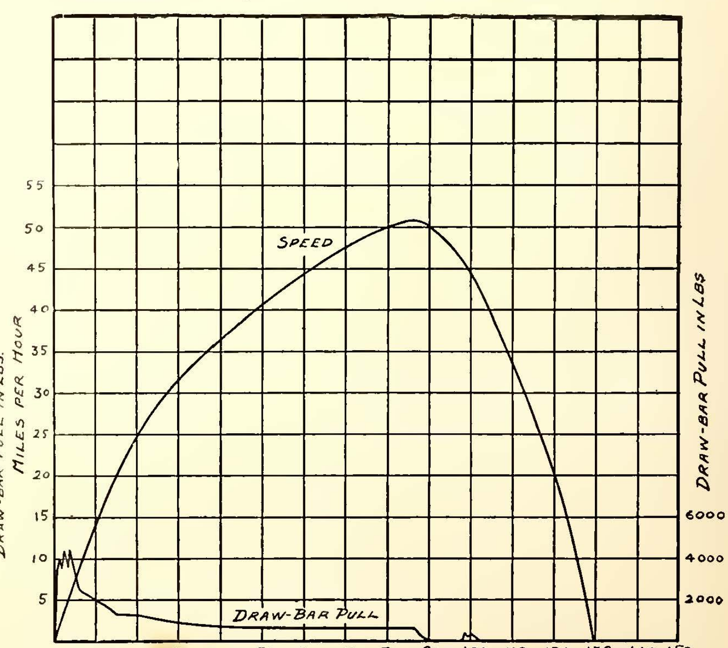


FIG. 14.—STEAM RUN NO. 12. 1 TRAIL CAR—WEIGHT, 23 TONS. INCLUDING LOCOMOTIVE, 130 TONS. POWER ON, 4460 FT. DISTANCE RUN, 6260 FT.

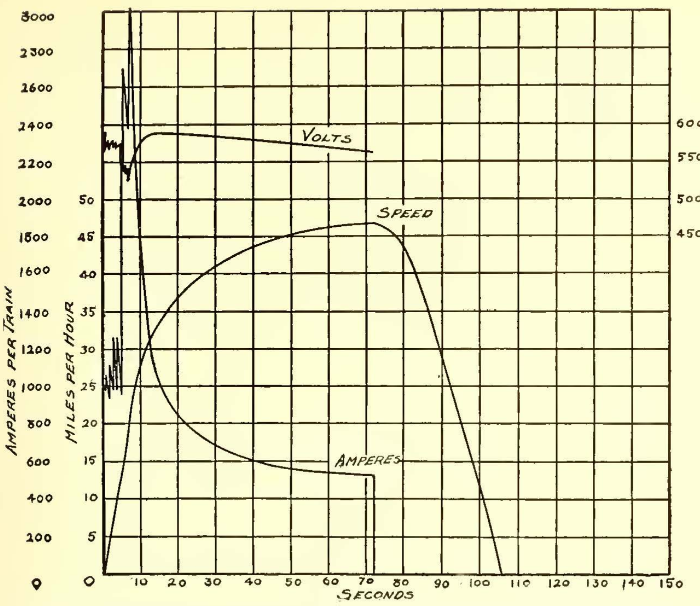


FIG. 15.—ELECTRIC RUN NO. 13. NO TRAILERS—MOTOR CARS, 71.5 TONS. POWER ON, 4080 FT. DISTANCE RUN, 5360 FT. WATT HOURS PER TON MILE, 129

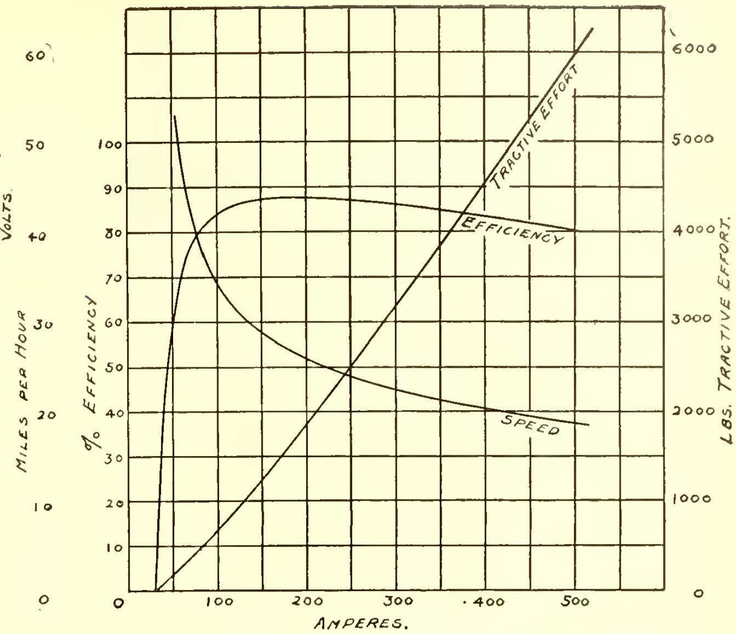


FIG. 16.—SPEED TORQUE CURVE OF G. E. 55 MOTOR

the middle of the run there was a curve having a minimum radius of 875 seconds, equivalent to about 6½ degs. curve, the effect of which may be assumed as approximately equivalent to the 1 per cent up-grade of the steam runs.

NEW YORK CENTRAL STEAM LOCOMOTIVE NO. 1407.

All steam locomotive runs were made upon the New York Central main line track west of Schenectady against an up grade of 1 per cent and a head wind of 15 m. p. h. The temperaturs was 4 degs. C. and the rail wet with a very light falling snow.

No. of Run	Character of Load	Weight of Load, Tons	Total Weight of Train, Tons	Maximum Speed. m. p. h.	Average Speed. m. p. h.
2	6 trailers	157.	264.	39.0	28.2
4	5 "	130.	237.	41.3	28.4
6	4 "	104.	211.	40.9	27.4
8	3 "	77.	184.	45.7	27.3
10	2 "	47.	154.	48.0	30.1
12	1 "	23.	130.	50.9	33.0

Although this locomotive was especially built for suburban or acceleration work, and was provided with a large fire box, giving it facilities for rapid steaming, the pressure dropped from 200 lbs. to less than 185 lbs. during the first part of acceleration. In starting, the throttle was opened wide and steam used full stroke, the engine being hooked up as acceleration proceeded. Curves showing details of these runs are given in Figs. 3 to 15 inclusive.

While the electric runs had the advantage of dryer rails than the steam runs the driving wheels were not slipped in either instance. Although the steam locomotive was able to give a maximum tractive effort at starting equal to that obtained electrically, this high tractive effort was not maintained, but immediately fell off with increased speed, even with the most expert handling.

As the acceleration curves produced by the steam locomotive and electric motor cars have different shapes, and as in the two tests there was about the same weight upon the drivers, it is interesting to note how well this driver weight was utilized. This is shown by the following tables, giving the speed reached in ten, twenty and thirty seconds with equal trailing load for both electric and steam trains:

MILES PER HOUR ATTAINED IN 10 SECONDS

No. of trailers	1	2	3	4	5	6
Motor cars No. 4 and 5	22.5	20.7	17.3	14.4	12.6	11
Locomotive No. 1407	14.	13.	12.5	12.	10.	9.7

MILES PER HOUR ATTAINED IN 20 SECONDS

No. of trailers	1	2	3	4	5	6
Motor cars No. 4 and 5	34.	32.3	29.4	27.4	24.5	21.2
Locomotive No. 1407	25.	21.2	21.5	19.5	18.	16.3

MILES PER HOUR ATTAINED IN 30 SECONDS

No. of trailers	1	2	3	4	5	6
Motor cars No. 4 and 5	38.2	36.4	34.2	32.	30.3	28.1
Locomotive No. 1407	31.7	26.2	27.	24.7	23.2	20.8

An inspection of the tables brings out clearly the fact that the electric motors during acceleration can more effectively utilize the weight upon their drivers than a steam locomotive. As rapid acceleration is especially important when stops are a mile or so apart the electric motor has an advantage in being able to cover the same distance in the same time with less energy expended and at less maximum speed than with the steam locomotive, owing to its being able to maintain its maximum accelerating rate for a longer period.

FIG. 17.—ELECTRIC MOTOR CAR NO. 4

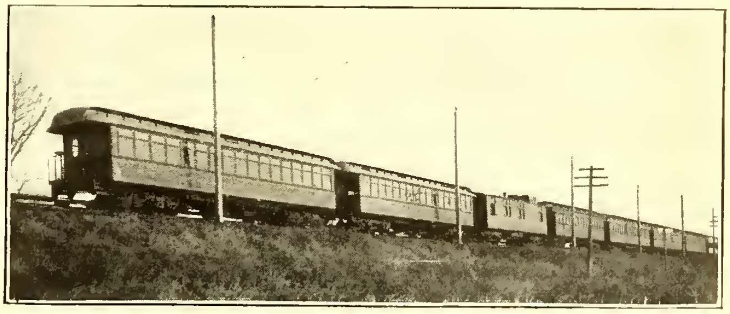


FIG. 18.—TRAIN USED IN ELECTRIC TESTS

The average speed given in both steam and electric tables is the average speed of the train while it is in motion, and does not include time of any stop at the end of the run. Starting from rest, the power was kept full on to the three-quarter mile post, where the power was shut off and the brakes applied in such a manner as to bring the train to rest as near the mile post as practicable. In the tests the steam train ran from 5 per cent to 15 per cent over a mile before the train was brought to rest, and the electric trains from 2 per cent to 4 per cent, but even with the longer distance the average speed of the steam runs only approaches that attained in the electric runs made over the shorter distance. A comparison of the two sets of runs on the basis of average speed is, therefore, not quite fair to the electric motor car, as its average speed would have been considerably higher if the length of the run had been the same as that made with the steam locomotive. An inspection of the tables will show, however, that even with the short-distance run the electric motor cars were able to make higher average speeds than the steam locomotive over its longer distance, and these higher average speeds were obtained also with a lesser maximum speed.

The maximum speed of a train making a given run in a given time serves as an indication of its energy consumption. A train, therefore, which is so handled as to make a given run in a given time, with lowest maximum speed, will consume less energy for the run. The electric runs tabulated all show a lower maximum speed and a higher average speed than those runs made with the steam locomotive, and the energy consumption of the electric runs should therefore be less for the same service performed than with the steam locomotive.

The motors of an electrically equipped train may be placed upon the trucks of ordinary passenger coaches, each carrying its full complement of passengers, and thus lessen the gross weight by elimination of the locomotive. The true measure of comparison between steam and electrically propelled trains should be the energy per seat mile rather than per ton mile, as the latter value is based upon the total train weight and includes a considerable proportion of dead weight embodied in locomotive and tender. The weight of the electric motors is much less than the weight of a steam locomotive capable of performing the same service, as the latter, in addition to its tender, must be heavy enough upon its drivers to provide a draw-bar pull sufficient to accelerate the train.

As an illustration, the following table has been prepared from these tests showing the number of cars in the train, the number of passengers carried (each car seating sixty-four people) and the energy, which for convenience we have given in watt-hours, required per passenger for both steam and electric runs:

NET ENERGY PER PASSENGER CARRIED

Number of Cars	Number of Passengers	Watt Hours per Passenger Steam	Watt Hours per Passenger Electricity
6	384	43.9	29.7
5	320	52.2	32.1
4	256	57.5	33.5
3	192	77.4	37.5
2	128	103.0	45.2
1	64	187.8	45.2

This table is based upon the actual net energy delivered to the wheels of the train and does not include the losses inherent to any system of operation. The results tabulated may therefore be considered as fundamental and typical of the two systems of operation —the steam locomotive and the electric motor car.

The following table gives the efficiencies for the seven electric runs, the efficiency being the ratio between net energy output to the wheels and total volt ampere input:

EFFICIENCY OF ELECTRIC RUNS

Trailers	Average m. p. h.	Watt Hours per Ton Mile Output	Watt Hours per Ton Mile Input	Efficiency of Run
6	27.2	59.1	79.8	74. %
5	28.6	61.0	82.0	74.3%
4	29.8	63.8	84 9	75.3%
3	30.6	68.0	90.2	75.3%
2	32.	69 6	99.6	69.9%
1	33 1	75.3	112.8	66.7%
0	34.6	79.8	130.0	61.5%

An accurate comparison of the relative efficiency or coal consumption of steam and electric power for similar service would require an extensive series of tests with indicator and dynamometer on the performance of the steam locomotive.

As a matter of interest, we have secured an approximate comparison from a single test by weighing the coal and water taken by steam locomotive No. 1407 for a period of twenty-four hours, covering four trips between North White Plains and Grand Central Station, a distance of 24.75 miles, on the Harlem division of the New York Central Railroad. The trips occupied about four hours, the yard movement about one hour and the locomotive was idle for nineteen hours.

Following is a detailed record of the service covering the twenty-four hours:

NORTH WHITE PLAINS TO GRAND CENTRAL STATION

Time	Number of Cars	Number of Stops	Total Weight	Weight of Cars	Effective h. p. h.
63.5 min.	3	21	204 tons	97 tons	129
Lay-over		6 hours			

GRAND CENTRAL STATION TO NORTH WHITE PLAINS

Time	Number of Cars	Number of Stops	Total Weight	Weight of Cars	Effective h. p. h.
66.25 min.	5	17	278 tons	171 tons	255
Lay-over		12 hours			

NORTH WHITE PLAINS TO GRAND CENTRAL STATION

Time	Number of Cars	Number of Stops	Total Weight	Weight of Cars	Effective h. p. h.
60 3 min.	7	13	387 tons	280 tons	231
Lay-over		¾ hour			

GRAND CENTRAL STATION TO NORTH WHITE PLAINS

Time	Number of Cars	Number of Stops	Total Weight	Weight of Cars	Effective h. p. h.
59.75 min.	4	20	256 tons	149 tons	246
Lay-over		1¼ hours			

Total effective horse-power hours, hauling coaehes	861
Coal consumed	13,412 lbs.
Coal per effective horse-power hour	15.6 "

The effective hp-hours given is the energy required for movement of the cars only, exclusive of the locomotive, and was determined from the draw-bar pull taken by the dynamometer ear in previous tests over the same route.

The coal consumption covers all coal burned during the period of twenty-four hours, not only for movement of cars, but also movement in the yard and the banking of fires during lay-overs.

The effective hp-hours to move the cars serves as a basis of comparison with electric service, the coal consumed by the locomotive for whatever purpose being properly chargeable to the net work done by the locomotive during the period.

The efficiency of an electrical system, as an average under variable load, may reasonably be assumed as follows:

Engine	90%	Efficiency	
Alternator	92%	"	
High Potential transmission	98%	"	
Transformers	97%	"	
Converters	92%	"	
Third rail	95%	"	
Motors, including control	75%	"	51.33%

This percentage of effective horse-power output of motors to ihp of engine will vary somewhat, depending on the load faetor. As an even figure we will assume an efficiency of 50 per cent.

Coal consumption per ihp-hour from actual records of electric power stations is in some cases less than 2 lbs., the average being about 2½ lbs. At the latter figure the coal per effective hp-hour output of electric motors would be 5 lbs. Assuming the head-end air resistance as 10 per cent, and as the electrieal equipment would increase the weight of the cars about 20 per cent, the actual comparison of coal consumption would be approximately in the ratio of 6.6 for electric and 15.6 for steam.

Assuming that coal for a power station can be purchased for 80 per cent of the cost per ton of that used in the locomotives and that the cost of coal for electrical power is about one-third of the total cost, including maintenance and interest on investment, it is probable that the actual gross cost of electrical power would closely approximate the coal consumption of a steam locomotive in this class of service, the maintenance of the electrical equipment and attendance required being, however, considerably in favor of the electric power.

We wish to express our thanks to E. C. Schmidt, professor of railway and mechanical engineering, University of Illinois, for his able management of the dynamometer car, assisted by J. F. Snodgrass and R. W. Lohmann; also to A. H. Armstrong and E. F. Gould, of the General Electric Company, for their careful supervision and calculations of the electric test.

A Serious Accident in Massachusetts

A head-on collision between two heavily loaded cars on the Hudson Division of the Marlboro Street Railway, June 28, resulted in the death of the motorman of one of the cars and injuries to thirty-five passengers, several of them being seriously injured. The accident took place about two miles from Marlboro, and the cars came together with such force that they were almost completely demolished. Both ears were going fast and came in sight of each other as they were rounding a curve at the foot of a heavy grade. The motormen were unable to reverse in time to prevent a collision. Several passengers jumped from the ears before the collision occurred.

Plotting Speed-Time Curves *

BY C. O. MAILLOUX

PART I.

The most practical way at present known of studying and analyzing electric railway problems is by means of curves depicting the relation between the various factors or quantities which influence the conditions or effect the results, and showing how these factors and quantities vary with respect to each other or with respect to the time, the speed, the electric energy or some other determining feature or circumstance of the case.

The precise determination of most of the important factors entering into the problem in any specific case, for instance the electric power input, energy consumption, capacity and characteristics of motor equipment, station equipment required, heating of motors, line losses, etc., for a given electric railway service involves the general problem of not only determining what actually does take place, but also of predetermining what may, should and must take place at every successive interval of the total time consumed in an average run between two successive stations or stopping points, or, what is still better, at every instant of time during the entire trip with each kind of car or train to be used for and in the service.

The speed-time curve is the key to the solution of this general problem. It is the important connecting link whereby the relationship between the various factors and quantities is established and verified. It constitutes, in most cases, an important and essential—one may say indispensable—preliminary step in the study and solution of new and complex electric railroad problems, for the reason that many of the factors involved can be determined with precision only by its assistance and could scarcely be determined at all without it.

The use of a curve substantially equivalent to a speed-time curve was suggested in connection with certain problems of steam locomotive propulsion as early as 1890 in Godwin's Railroad Engineers' Field Book. This suggestion was commented upon favorably in an article published in the Railroad Gazette at the time (Vol. XXII., 1890, pp. 731-732). It does not appear, however, that much if any practical use was made of this idea in subsequent discussions of railway problems. It is only within the last five or six years, and entirely owing to the efforts of electrical engineers to substitute rational for empirical methods in electric railroad engineering, that the speed-time curve has been thought of seriously or used practically in connection with electric railroad problems. The idea of thus using the speed-time curve seems to have suggested itself to and to have been utilized by several individuals independently at about the same time. It was used in January, 1898, by S. T. Dodd and the writer, who collaborated in the preparation of certain estimates, charts, data, etc., forming part of a report on an electrical equipment for the Manhattan Elevated Railroad, of New York. The importance and the value of the curve were not generally understood or appreciated by electric railway engineers, however, until A. H. Armstrong read his able and interesting paper on some phases of rapid transit problems at the Omaha meeting of the Institute in June, 1898. In that paper the utility of the speed-time curve in the study of railway problems was demonstrated by Mr. Armstrong in a brilliant and convincing manner, and the curve has since become recognized as a very useful means of analysis in dealing with such problems.

Speed-time curves have been used in two different ways: First, as a method of approximation or generalization for the determination of rules and data pertaining to and useful in abstract or general cases; second, as a method of precision for the exact determination of rules and data in individual or concrete cases, and also as a criterion or test of their fitness for and applicability to such cases.

The process of plotting these curves is much less difficult and tedious in the first case than in the second. The reason is that in generalizing or in dealing with abstract cases the use of certain hypotheses or assumptions capable of simplifying methods is admissible, whereas in dealing with an individual case all hypotheses or assumptions not strictly consistent with the actual facts of the case should be eliminated in order that the method may lead to correct and reliable results.

As might be expected, the speed-time curve is influenced and complicated by certain features and conditions characteristic of each individual case, which ought to be taken into account in order to attain accurate, reliable results. When properly plotted so as to represent truly all the factors which influence it the curve becomes a valuable instrument of precision by means of which the practical results to be anticipated in the particular case under consideration may be analyzed, checked, criticised and corrected with accuracy and confidence. These factors include the constituents or components of that complex resultant called "train resistance," also the track gradients, track curvatures, train inertia (linear and rotational), capacity and gearing of motors, current limit, voltage, etc. In dealing with a general case, however, the engineer may greatly simplify the task of assorting these influencing factors and of assigning the proper value to each by making assumptions regarding some of them. The usual process of simplification is to make one or all of the following assumptions: That the line is absolutely level and tangent (straight); that the train resistance is constant at all speeds, and that all runs between stopping points are of the same length. It is needless to say that these idealized conditions are never all realized conjointly in any practical case. Consequently the more the conditions of the actual case depart from these idealized conditions the less reliance should be placed upon conclusions and data obtained by methods involving these assumptions. It is unfortunately not always easy to determine the point at which the simplified method should no longer be trusted in dealing with a practical case. The assumptions made usually lead to incorrect instantaneous speed values at certain points of the acceleration curve, and these errors tend to vitiate the subsidiary curves derived from the speed-curves, such as, for instance, the energy input curve, whose ordinate values depend upon the speed values. These errors in the energy input curve and in the energy consumption calculated therefrom are likely to affect the motor equipment and the generating station equipment provided for a given service, since the calculations and conclusions regarding them are based upon these subsidiary curves. A relatively small discrepancy between the idealized and the actual conditions may lead to radically different conclusions and results in these respects, thereby influencing greatly the total cost of equipment and reacting seriously upon the capital investment and the fixed charges involved in the project. Such cases have actually happened.

The "second way," or the use of the speed-time curve as a "method of precision" in concrete practical cases, while a trifle more troublesome, will, in the majority of cases, undoubtedly prove more satisfactory and less expensive in the end. The truth is, that the practicing engineer is very seldom called upon to deal with abstract or general cases. It might be said that every individual case becomes a specific concrete case very soon after the engineer begins the process of analyzing and studying it.

The object of this paper is to facilitate the use of the speed-time curve as a method of precision by contributing certain notes of theoretical and practical observations bearing upon its analysis or the study of its characteristics and upon its synthesis or the principles involved in plotting it.

Technical Definitions.—The generic term "speed-time curves," as used in this paper, is understood to denote any curve showing the velocity of a car or train at successive intervals of time. Figs. 1, 2 and 3 show three different kinds of speed-time curves. In plotting these curves the horizontal distances, or abscissæ, are generally used to represent time values (in seconds), and the vertical distances (ordinates) are used to represent speeds (usually measured in miles per hour in this country and in kilometers per hour wherever the metric system is used.)

The curve in each case not only shows the speed attained at any given interval of time, but it also shows the variations in speed occurring at various intervals of time. The slope of the curve at any time point is an indication and a measure of the time rate of change of speed at the corresponding instant of time; and it shows whether the speed is constant or increasing or decreasing.

A horizontal speed line indicates constant or uniform speed. An upward slope in the speed line indicates increasing speed, or acceleration; a downward slope indicates decreasing speed, or retardation. These characteristics serve to distinguish the different kinds of speed-time curves.

The term acceleration curve is usually restricted to curves or portions of curves in which the speed is increasing, or, at least, remaining constant or nearly constant. Such curves correspond to the portions of time during which power is being applied to the train so as to increase the speed or to keep it constant (Fig. 1).

The retardation curves are of two kinds, corresponding to different rates of retardation.

The term coasting curve or drifting curve is used to designate speed-time curves, or portions thereof, corresponding to intervals of time when the car or train is moving by its own momentum only and when the rate of retardation is relatively small (Fig. 2).

The term braking curve is applied to speed-time curves, or portions thereof, corresponding to intervals of time when the speed

* Read before the American Institute of Electrical Engineers, Great Barrington, Mass., June 19, 1902. (The second part of this paper is being revised by the author, and will appear in an early issue.)

is being purposely reduced by means of brakes and when the decline or decrease in velocity is relatively rapid (Fig. 3).

The term run curve is often used to denote a speed-time curve, showing all the changes in the speed of a car or train from the time it starts until it stops at the next station or stopping point (Fig. 4).

The first portion of every run curve, or the portion during which the train is gaining speed, is an acceleration curve. The run curve usually, but not always, contains a portion which is a coasting or drifting curve, and it also generally contains a portion which is a braking curve.

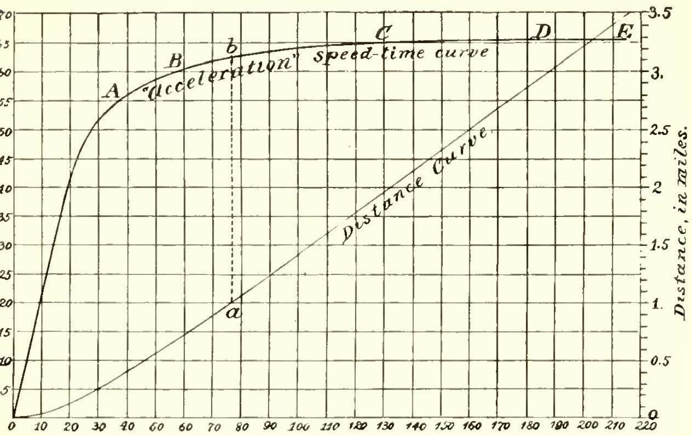


FIG. 1.—ACCELERATION CURVE

The terms velocity and speed are used as synonymous terms in this paper.

Analytical Definitions.—A certain knowledge of the physical nature and mathematical properties of the various time-function curves mentioned in the previous section is essential for the proper, intelligent use of these curves and is presumed to be possessed by those who make practical use of them. The precise definitions of these various curves and the analysis of their properties involve the analytical study of motion, more especially rectilinear motion. For the convenience and benefit of those who may wish to refresh their memories, or who may wish to go more deeply into the subject (no general treatment of the subject having as yet been published), a brief summarized analytical study of time-function curves, more especially the distance-time and speed-time curves, is given separately at the end of this paper in Appendix A.

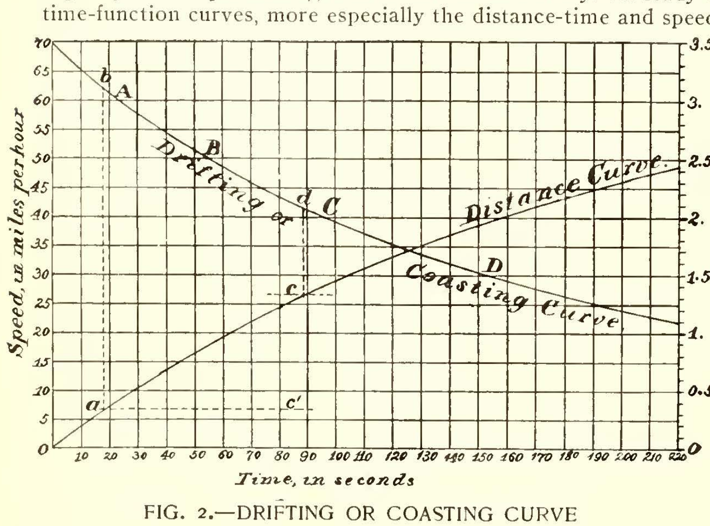


FIG. 2.—DRIFTING OR COASTING CURVE

The derivation of the fundamental formulæ relating to train acceleration constituting the extension of this analytical study is given in Appendix B.

Appendix C and Appendix D contain the derivation of certain formulæ which are of use and convenience in plotting the run curves. These formulæ are not generally known. *

I.—ANALYSIS OF TRAIN MOTION.

The motion of a car or train under actual or assumed service conditions constitutes an aggregation of different forms or phases of motion.

* These appendixes will be published in an early issue.—[EDS.]

The run-curve, which graphically depicts the train motion, is, therefore, a resultant curve. The analysis of the motion involves the separate determination and segregation of the elementary or fundamental forms of motion which constitutes the components of which the resultant motion is made up.

A glance at a run-curve shows three distinct characteristic kinds of lines which correspond to distinctive phases or kinds of motion, namely, the motions characteristic of acceleration, coasting or drifting and braking, respectively.

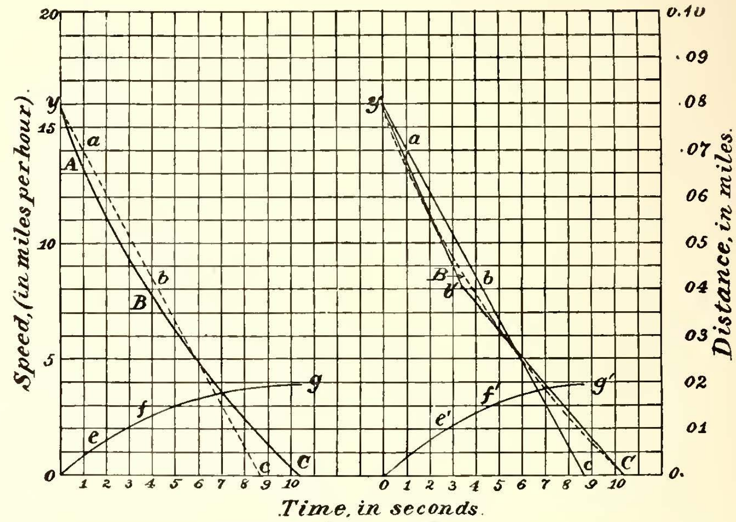


FIG. 3.—BRAKING CURVES

In Fig. 4 the curve *O b d* is a run curve of the simplest character. The first portion (*A*) is a simple acceleration curve. The second portion (*B*) is a drifting or coasting curve and the final portion (*C*) is a braking curve. The acceleration portion (*A*) is the same as the corresponding portion of the acceleration curve in Fig. 1, from which it was taken. The vertical dotted line (*a-b*) indicates the point at which the acceleration line was cut off. In like manner, the drifting portion of the run curve in Fig. 4 was taken from Fig. 2 between the points corresponding to the same letters (*b-d*). The vertical dotted lines (*a-b, c-d*) indicate the points at which this line was cut off. The braking portion (*C*) of the curve in Fig. 4 was calculated.

This particular run curve corresponds to a case in which the power

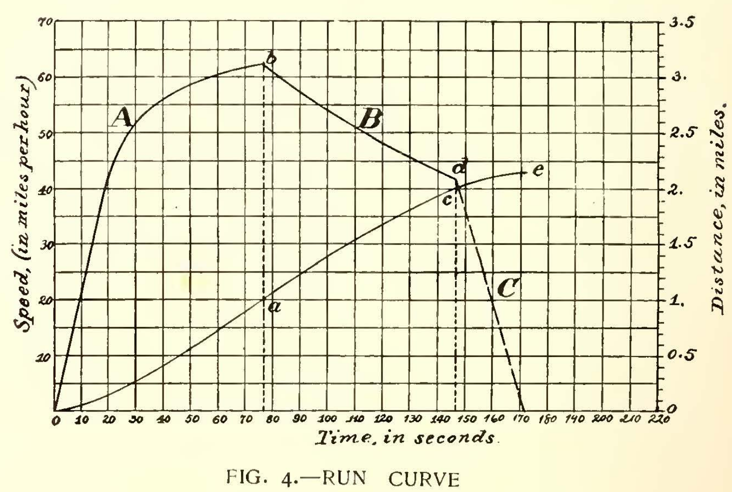


FIG. 4.—RUN CURVE

is applied to the car only once, or during the early portion of the run. In actual practice, however, it is often found necessary to allow, or purposely to cause, the speed to diminish and subsequently to cause it to increase again at intermediate points of the run. In such case the run curve will show notches or humps (Fig. 5). These notches or humps are almost always due to the occurrence of track curves having a relatively high degree of curvature at points intermediate between stopping points. These curves impose a limit on the speed which it is safe to maintain at such points of the line. When such curves occur at or near the stations they have less influence on the form of the run curve, because the speeds are lower, owing to the starting and stopping of trains. In such cases they do not cause humps or notches in the run curve, although they do affect the "angle" of the acceleration or of the retardation (braking) curve. The notch or hump in the run curve indicates the fact that acceleration again takes place after the speed has been reduced to the proper or desired limit. This acceleration is followed by drifting and braking, and, in some cases, the run curve may contain several such notches, each of which, as will be readily understood, corresponds to what might be called an "acceleration cycle."

Acceleration.—Each acceleration cycle of a service run corresponds to the time during which energy from some source is applied to the car or train so as to cause the speed to increase.

(The physical and mathematical characteristics of acceleration are discussed summarily in Appendix A and in Appendix B.)

The energy imparted to a train during an acceleration cycle is absorbed and disposed of by the train in two ways: First, a portion of it is immediately converted into heat, which represents the energy required and expended in overcoming the various frictional resistances making up what is called "train resistance;" second, a portion is stored as mechanical energy in the "mass" of the train. This storage energy is the energy required either (*a*) to produce acceleration, in which case it is stored as kinetic energy, or (*b*) to lift the train on an up-grade; in the latter case it is stored as potential energy. The two forms of stored energy often occur simultaneously. When accelerating on a down-grade the stored energy at any instant would evidently be equal to the difference between these two kinds of energy at that instant.

The energy concerned in acceleration may be classified under three general heads, namely:

1. The energy required for overcoming the actual mechanical resistance to the motion of the car. This energy is immediately dissipated as heat.

2. The energy required to overcome grades. This energy is stored as potential energy.

3. The energy required to overcome the inertia of the car and give it momentum. This energy is stored as kinetic energy.

The third form of energy, namely, kinetic energy, is the only form usually recognized as being concerned in producing and entering into acceleration. It can be shown, however, that in any case in which acceleration occurs all other forces than that of kinetic energy may also be estimated in terms of an acceleration, which may be termed "equivalent" acceleration. This has been done in Appendix B in equations (24) to (29), by means of which an important theorem is deduced, to the effect that the total acceleration in a moving mass is the algebraical sum of the individual accelerations corresponding to each of the forces acting to produce or prevent the motion of the body. This theorem is doubtless well known in kinematics, although its application to the speed-time curve appears to be new. It is one of those principles which, though not at first readily apparent, and somewhat difficult to work out, proves to be really very simple to understand and to apply. According to this theorem, the second form of energy, or the energy required to overcome grades, may be estimated in terms of equivalent acceleration. It is known, as a matter of fact, that the potential energy, or energy of position, in a car which is on a down-grade can produce the same acceleration that could be produced by an equivalent tractive effort in pounds per ton applied to the car in any other way. Conversely, the motion of the car in the contrary direction would produce a contrary effect, or a reduction of acceleration, which could be expressed in terms of equivalent loss of acceleration.

Energy of the first kind cannot, strictly speaking, be said to be capable of producing an acceleration. It may, nevertheless, be expressed in terms of equivalent acceleration, since, as in the case of a car going up-grade, it may be considered as equivalent to a force occasioning a loss of acceleration.

In the same manner, and by analogy, we might consider the kinetic energy absorbed in pure acceleration as an energy required to overcome an apparent increase in the train resistance due to the inertia of the train, and in like manner the energy required to overcome grades might be also ascribed to an apparent increase in the train resistance. From this standpoint the three forms of energy may be considered as having the same kinemetical character. The energy corresponding to an actual resistance represents energy necessarily lost, or which is not recoverable, while the energy corresponding to a spurious resistance (analogous to reactance in electro-kinetics) represents energy which is not primarily or necessarily lost, but which is really stored and which is recoverable wholly in theory and partially in practice. The former is analogous to the electrical energy dissipated by an ohmic resistance, and the latter to the wattless energy absorbed provisionally by a reactance, the analogy being so obvious as to require no further explanation.

An acceleration curve is, as pointed out in Appendix A, a speed-time curve, or velocity curve, having a positive differential coefficient. This differential coefficient, as shown in Appendix B, in equation (28) is equal to the algebraical sum of the differential coefficients corresponding to the various forces concerned and active in producing the acceleration.

Using the letter "k," with suitable affixes, to designate the individual coefficients corresponding to the individual forces concerned in each case, and using the letter A' to designate the resultant acceleration, we have, from equations (28) and (29) in Appendix B,

$$\frac{dv}{dt} = k \pm k' \pm k'' \pm \text{etc.} = A' \qquad (I)$$

Some of these individual coefficients may be positive, while others may be negative, but the algebraical sum, according to the above definition of an acceleration curve, must be a positive number.

When weights (W) are expressed in tons of 2000 lbs., and when p = the equivalent gross tractive effort or pull corresponding to each of the individual forces concerned in the resultant motion, we have, by analogy to equation (21*a*) in Appendix B,

$$k = \frac{dv}{dt} = .01098 \left(\frac{p}{W}\right) \qquad (II)$$

and, reconstructing equation (I) accordingly, we have

$$A' = .01098 \left(\frac{p}{W}\right) \pm .01098 \left(\frac{p'}{W}\right) \pm .01098 \left(\frac{p''}{W} \pm \text{etc.,}\right)$$

of which the simplest form is

$$A' = .01098 \div W \left(\frac{p}{W} \pm \frac{p'}{W} \pm \frac{p''}{W} \pm \frac{p'''}{W} \pm \text{etc.}\right) \qquad (III)$$

The factor $.01098 \div W$ is sometimes written $1 \div 91.1\ W$.

When each term "p" is taken in pounds per ton the term "W" disappears, and we then have

$$A' = .01098 \left(\frac{p}{W} \pm \frac{p'}{W} \pm \frac{p''}{W} \pm \frac{p'''}{W} \pm \text{etc.}\right) \qquad (IV)$$

We must now determine the number and character of the force factors (p), by reference to which the resultant acceleration is to be expressed.

The force of the equivalent acceleration corresponding to train resistance could be expressed by a single symbol, but it is more convenient to express it by means of two separate symbols, one of which (f) shall correspond to and shall include all the factors of train resistance except the increase of resistance due to curvature, which latter may advantageously be considered separately, in which case its equivalent force may be expressed by the symbol c. The force corresponding to grades may be expressed by the symbol G. The force corresponding to kinetic energy may be expressed by the symbol I. In this case, however, the effect is complicated by the fact that in a moving train there is inertia of two kinds, namely, linear inertia, or the inertia due to the entire mass of the car moving in a straight line, and rotational inertia, or the inertia due to the rotating parts of wheels, gears and motors. It is possible, however, to express the rotational inertia in terms of linear inertia. This fact was alluded to in the paper read before this Institute by N. W. Storer, in which it is stated that the rotational inertia has the same effect in increasing the total inertia as if the mass of the car were increased by a certain percentage. This percentage varies in different cases, but Mr. Storer recommends that it be taken at about 10 per cent. We may therefore use the same term to designate the effect of linear inertia or rotational inertia, if this term includes the proper correction for rotational inertia. It is just as simple, and it may be sometimes convenient to use a separate symbol i for the rotational inertia.

These several symbols express the forces which react upon and modify the propelling force applied to the car. The forces in each case are understood to be measured in pounds of pull per ton of train weight, this being the basis assumed in the fundamental equation (21*a*) in Appendix B. The propelling force of the motor may be expressed in terms of an equivalent gross tractive effort (P), also measured in pounds per ton. In the case of a series electric motor, this gross tractive effort depends upon the amount of current passing through the motor and also upon the gearing ratio of the motor. The amount of current itself passing through the motor is, as is well known, a function of speed, consequently the gross tractive effort of the motor is itself a function of the speed of the car.

Tabulating these symbols, we have

W = Weight of car or train (in tons of 2000 lbs.).

T = The total or gross traction (due to the current) per motor.

$P = T \div W$ = Gross traction in pounds per ton.

f = Force expended in overcoming the friction of all kinds (including axle friction, air and wind resistance, etc., but not including curve resistance) in pounds per ton.

c = The force expended in overcoming the additional resistance due to track curvature.
G = The equivalent traction due to grades. (This factor will have + sign on down grades and — sign on up grades.)
I = The force expended in overcoming linear inertia.
i = The force expended in overcoming rotational inertia.
p = Resultant force expended in acceleration. ($= I + i$.)

The factors f, c, G, I, i are all expressed in pounds per ton of train weight.

From this it is seen that we have to consider a total of six (6) terms of the type p.

The term f expressing train friction varies, as is well known, as a function of the train speed, same as the gross traction.

The term c varies with the degree of curvature. This term only occurs in those portions of acceleration curves which correspond to points on the run at which there are track curves. It is usual to assume this resistance as equivalent to from 0.7 lb. to 0.9 lb. per ton per degree of curvature. Thus, assuming a coefficient of 0.8, a track curvature of 5 degs. would increase the train resistance by an amount equal to four pounds per ton.

The term G depends upon the percentage of grade and is constant for each percentage. For example, a grade of 1 per cent, which means a rise of 1 ft. per 100, would be equivalent to lifting the train weight (W) one-hundredth of the distance or lifting one-hundredth of the weight the entire distance. Each ton of 2000 pounds would therefore occasion an apparent increase in train resistance equivalent to twenty pounds per ton.

From the above it is seen that the value of G in any particular case will be

$$G = 20\ q,$$

in which q expresses the percentage of grade.

The terms I and i together represent, as will be understood from the preceding discussion, the net force, or the force which is expended in acceleration.

We may retain the term p to express this net force, so that

$$p = I + i.$$

If we substitute the above terms for the terms p', p'', etc., in equation (IV) we have.

$$A' = .01098\ (P - f - c \pm G) = .01098\ p. \qquad (V)$$

The signs of f and c will always be minus.

The sign of G will be + when the car is on a down grade, and it will be — when the car is on an up-grade.

We thus see from equation (V) that the differential coefficient of an acceleration curve may be simplified in expression until it is equivalent to the algebraical sum of various factors representing real or spurious train resistances, multiplied by a constant. The algebraical sum referred to is nothing more than the net pull, since, if we equate the last two terms of the equation, the coefficient .01098 disappears and we have simply

$$p = P - f - c \pm G \qquad (VI)$$

Each term, taken separately with the constant, indicates the equivalent acceleration corresponding to said term expressed in miles per hour per second. Thus, in the case of the gross traction (P) the quantity .01098 P would mean the acceleration in miles per hour per second, which would be obtained if it were not for the modifying factors f, c and G.

Retardation.—In the second portion of each cycle of train motion there is a stage of motion during which the car moves without extraneous power being employed, it being impelled by the kinetic energy previously stored in it during acceleration. The car is then said to be "drifting" or "coasting." The coasting or drifting motion would continue, with the speed in the meantime gradually diminishing until the kinetic energy stored in the car or train has been entirely dissipated in overcoming the train resistances, when it will stop. When the rate of dissipation of the kinetic energy is purposely increased by friction shoes bearing against the car wheels the retardation is more rapid and the car is then said to be "braking." A braking curve is, therefore, a retardation curve showing a high rate of retardation.

A retardation curve may be defined as a velocity curve having a negative differential coefficient. (See Appendix A, last paragraph.)

In a coasting curve the coefficient is relatively small; in a braking curve it is high.

The same equations which apply to acceleration will apply to retardation. In this case, however, since power is no longer being applied to the car, the quantity P will be zero, and will consequently disappear from the equation. The only terms remaining will be f, c and G, so that the equation will now become.

$$-A' = .01098\ (-f - c \pm G) = .01098\ p \qquad (VII)$$

If there happen to be no curves or grades the equation will be simply

$$-A' = -.01098\ f = -.01098\ p \qquad (VIII)$$

whence we have

$$-f = -p$$

or the force (p) due to the kinetic energy is exactly equal to the force required to overcome the train resistance (f). The minus sign indicates that the acceleration is negative or that its rate is a decreasing one. The energy-producing acceleration comes, of course, from the kinetic energy stored in the car. The rate of decrease of the speed will be exactly such as to produce the force p ($= f$) and no more. This is in accordance with equation (22) in Appendix B. It seems strange until we stop to consider the two following circumstances: First, that the only way in which the energy of the car can be dissipated when braking does not occur is by means of the friction due to train resistance; second, if the speed variation could in any way become greater than that which corresponds to and develops a force equal to that of the train resistance (in accordance with equation 22) there would be a surplus of force, and this surplus could only be expended in producing acceleration or in the reacceleration of the car. It is evident, therefore, that the rate of retardation of the car must of necessity be exactly such as, and can be no more than can and will suffice to cause the kinetic energy stored in the car to be dissipated at precisely the rate required to overcome the train resistance and also the effect of track curve resistances and of up-grades, if there be any. It is worth while to note that the case would be different if the car were running on a down grade, for, in this case, G is not equal to zero, but has a positive value, and, consequently, represents a force which is, of itself, capable of producing acceleration. Under these circumstances, we should, therefore, expect, and we find in practice, that a higher rate of acceleration is produced.

When braking the car there is, as already stated, an additional retarding force. This retarding force, which may be designated by the symbol B, enters in the fundamental equation with the negative sign, so that we have

$$-A' = -.01098\ (-B - f - c \pm G) \qquad (IX)$$

In practice it is usual to speak of a braking force of so many pounds per ton. For high-speed work the value generally taken is $B = 150$. As pointed out in section II, in discussing the subject of plotting braking curves, it is usual, for the purpose of simplification, to assume that this figure (150) also represents and includes the values of f and c, so that the equation, as used in practice, would generally be simplified to the following form:

$$-A' = -.01098\ (150 + G) = 1.647 + (.01098\ G) \qquad (X)$$

In the coasting curve, as well as in the braking curve, the effect of a down grade, which makes the sign of G a plus sign, will be evidently to decrease the rate of retardation, while the effect of an up-grade, making the sign of G minus, will be to increase the rate of retardation.

The equation shows that the slope of the braking curve will depend not only upon the value of the braking friction (B) but also upon the train resistance, also the track curvature and percentage of grade, if any.

The term B is generally assumed constant and independent of the speed. This is not exactly true, however. The true braking curve (y, A, B, C in Fig. 3) is, like the drifting curve, more or less convex to the axis of x. The straight line (y, a, b, c) indicates the (constant) rate or retardation that would be required to bring the car to stop within the same distance. It will be seen that, with a constant rate of retardation, the car would come to a stop a little sooner than is actually the case in practice. The data available from actual tests are still so meager, and the analysis of them is so incomplete, that engineers are still obliged to assume a constant rate of retardation in dealing with the braking curve. This point is again referred to in section II.

In the foregoing equations individual acceleration coefficients which go to make up the resultant coefficients are shown by means of various terms indicating a force or pull in pounds per ton, multiplied by a constant. This has been done out of deference to the established practice among engineers of estimating the accelerating force in pounds per ton. The writer believes that a more satisfactory way would be to estimate acceleration in miles per hour per second, using equations of type shown in equation (I) rather than those of the types shown in equation (IV). The advantage of equation (I) is the fact that it gives the resultant acceleration in terms of the individual accelerations expressed in miles per hour per second. Translated into words, this equation means that the total or resultant acceleration is obtained by taking the difference between all the positive acceleration co-efficients and the negative acceleration co-efficients. The transition from one type to the other has been clearly indicated, and it is not necessary, therefore, to repeat the equations in the modified form. In plotting the curves by the method which will now be described the values used are those obtained by equations corresponding to equations (V), (VII) and (IX), but patterned after equation (I).

Interesting Turbine Work

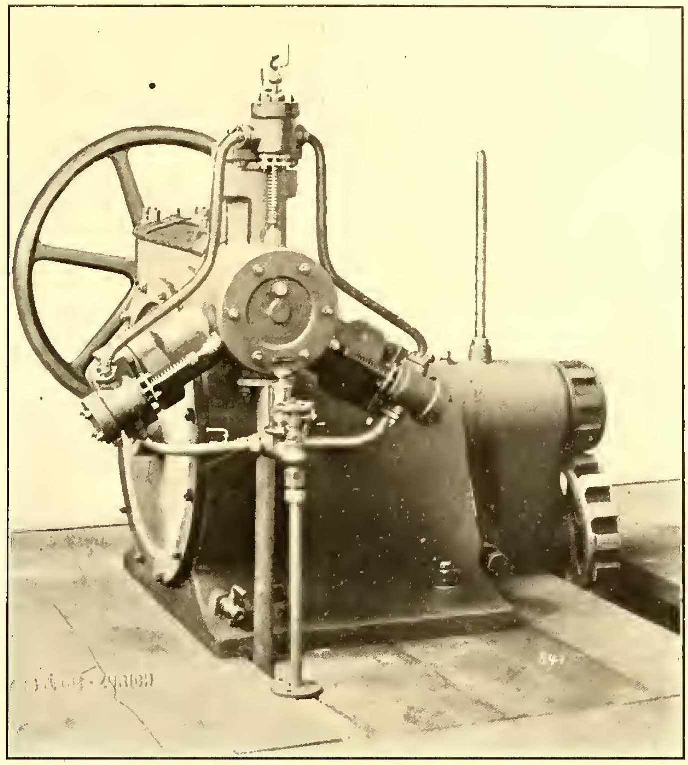
American engineers will find much to interest and instruct them in the development of the water turbine in Europe and its numerous applications under widely varying conditions. The work of Escher, Wyss & Co., of Zurich, in this line is particularly interesting. Some idea of the extent of this concern's experience may be gained from the statement that up to the first of the present year it had built and installed upward of 3200 turbines, aggregating 372,303 hp. This work, of course, has not been confined to any particular locality, but extends over the entire continent of Europe, and examples are to be found wherever water power is utilized. Some of the more notable installations are those at Bellegrade, France, comprising two turbines of 1500 hp each; Kanderwerk, Switzerland, six turbines of 1400 hp each; Glommen, Norway, one turbine of 3000 hp; Isarwerke, Munich, Bavaria, two turbines of 1000 hp each, and St. Maurice, Switzerland, five turbines of 1000 hp each.

The turbines built for medium falls are in most cases of the Francis type and have, according to the prevailing circumstances, one, two or more runners, or turbine wheels, arranged on the same shaft. One of the most interesting examples is the power plant of the Société Lyonnaise des Forces Motices du Rhône at Lyons, France, which has been supplied with double turbines. These machines were designed to produce 1500 hp each under a head of 10 m (32.81 ft.) and 1350 hp each under a head of 8 m (26.24 ft.) when operating at a speed of 120 r. p. m.

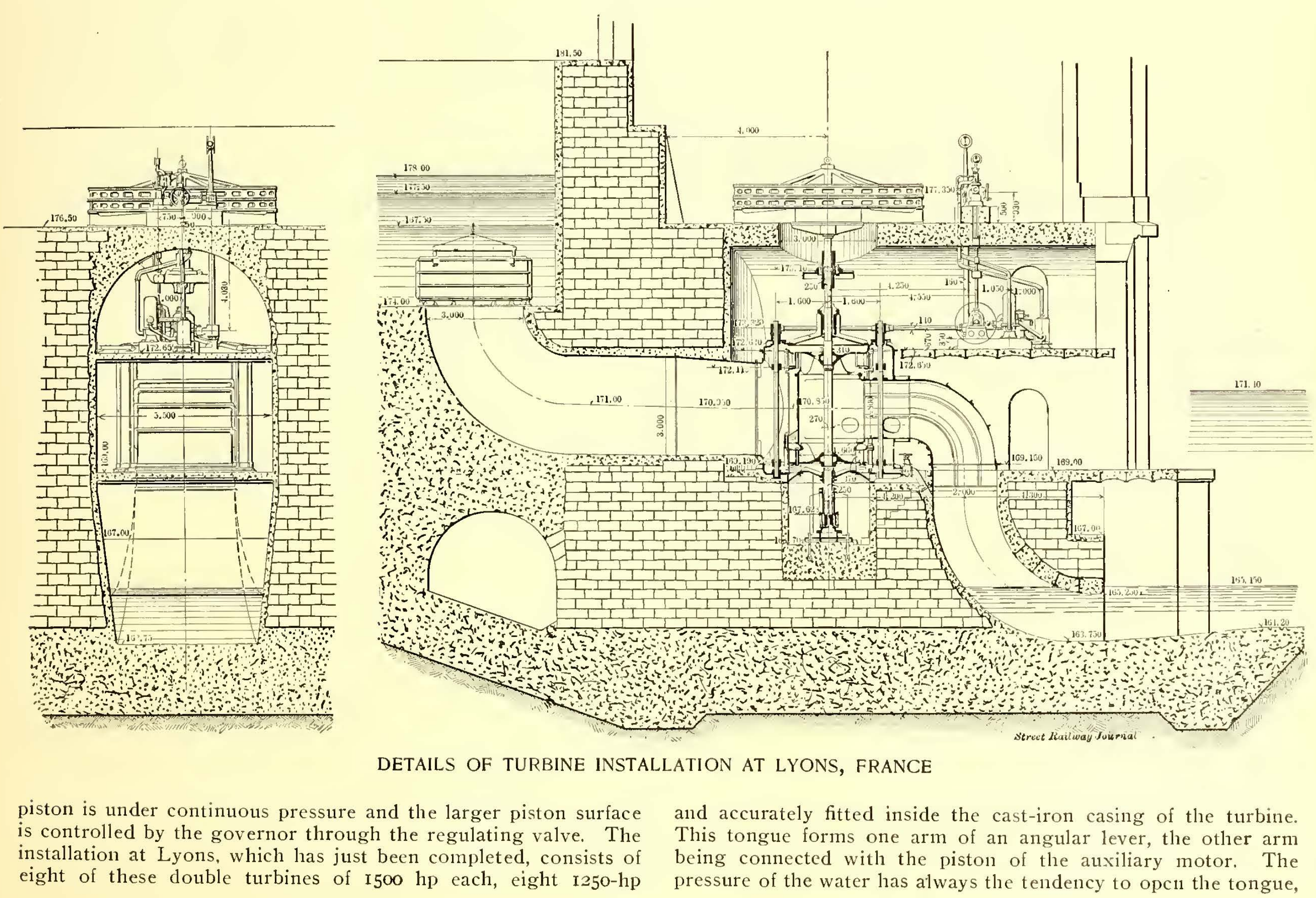
The design of this turbine and the general features of the installation may be readily understood by an examination of the accompanying plan. The turbine proper is situated in a flume of plate, which is closed at the upper and lower ends by means of split cast-iron covers. From the two turbine wheels the water flows into a common discharge dome, or draft chest, and thence through a draft tube, or suction pipe, which is constructed partly of plate and partly of concrete, into the tail-race. The vertical pressure on the shaft caused by the rotating parts of the turbine and dynamo as well as by the pressure of the water is partly provided for by a hydraulic balancing apparatus and partly by a pivot situated below the turbine. The regulation is effected by turning the adjustable guide-floats, which may be operated by means of a gearing from an auxiliary motor that works with oil pressure.

The motor is regulated by the governor through a regulator valve and is supplied with a differential piston. The small surface of the piston is under continuous pressure and the larger piston surface is controlled by the governor through the regulating valve. The installation at Lyons, which has just been completed, consists of eight of these double turbines of 1500 hp each, eight 1250-hp conical turbines with three rows of buckets each and three exciter turbines of 250 hp each. A photographic reproduction of one of these double turbines of the Francis type is presented herewith and also a view of the starting apparatus.

For installations at high falls a special type of high-pressure turbines with spoon-shaped buckets has been designed. This type is illustrated in the cut on page 56. The discharge from the usual rectangular nozzle is regulated by a tongue which is placed and accurately fitted inside the cast-iron casing of the turbine. This tongue forms one arm of an angular lever, the other arm being connected with the piston of the auxiliary motor. The pressure of the water has always the tendency to open the tongue,



STARTING ENGINE FOR TURBINE INSTALLATIONS



DETAILS OF TURBINE INSTALLATION AT LYONS, FRANCE but it is prevented from doing so by the power produced by the water pressure on the lower part of the piston of the auxiliary motor. If, however, the water is guided by the regulating valve into the upper and larger surface of the differential piston the tongue is opened, but it is shut again when the upper surface of the piston is shut off from the pressure water and connected with the discharge room.

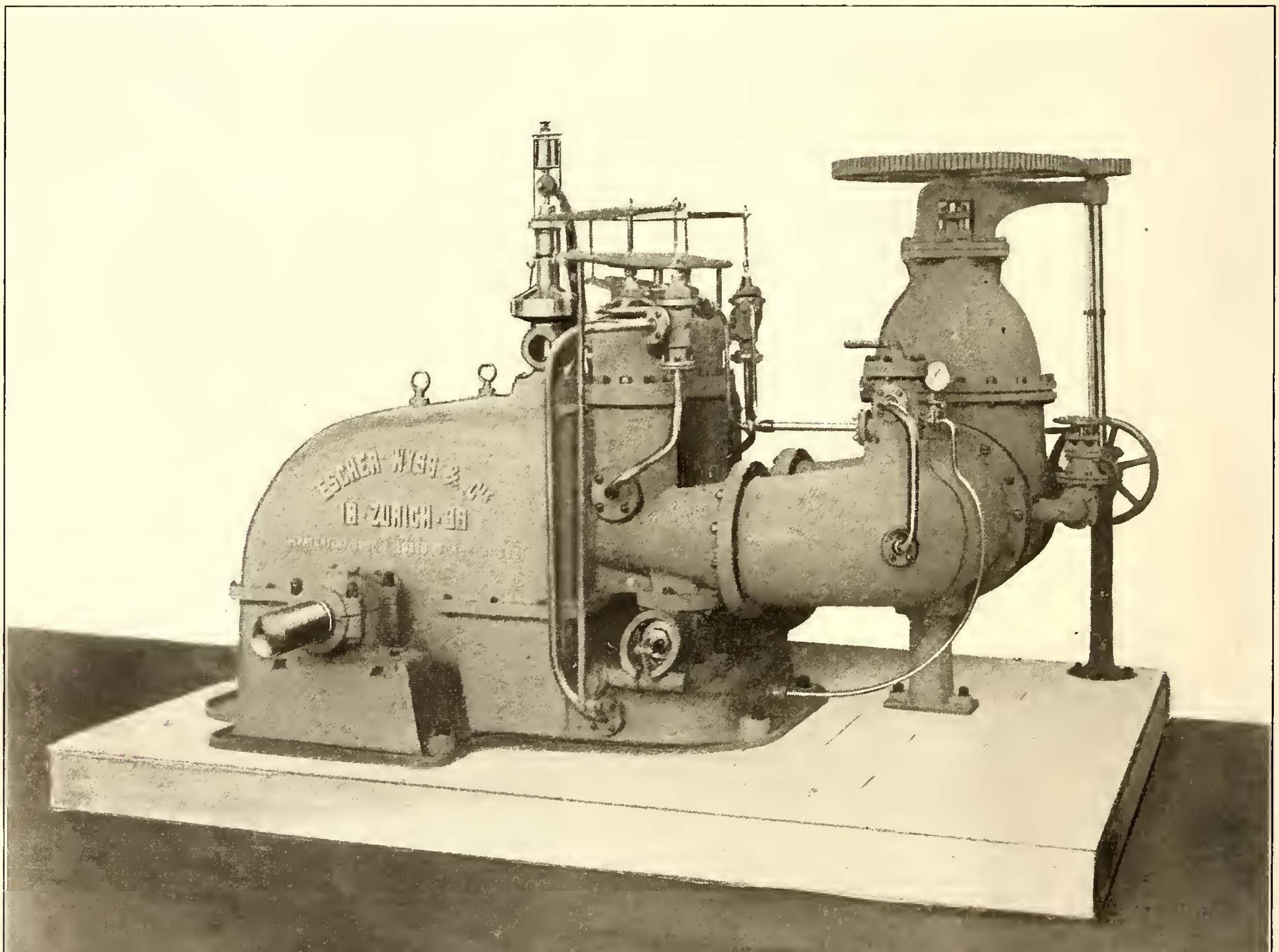
As a rule, these high-pressure turbines are provided with special pressure-regulating apparatus which is intended to avoid dangerous variations of pressure in the pipe line. These equipments permit the water, when it is cut off suddenly by the regulation on sudden changes of load, to flow out without a moment's delay through a side opening, which afterwards shuts automatically by means of an oil cataract. The tests which were made with this apparatus in several installations have shown that, even by a total discharge, the maximum variation of pressure did not exceed 2½ per cent, though there is no fly-wheel or air vessel connected with the apparatus.

Interurban Lines Projected in Scotland

Reports about the promotion of a mono-rail line between Edinburgh and Glasgow have been revived, but so far as the investing public is concerned it will probably prefer to await the result of the mono-rail experiment between Manchester and Liverpool. At present there are three lines of railway between the two chief cities of Scotland, and the construction of a fourth does not seem very inviting to investors. Commenting upon this project, the Edinburgh Dispatch says, however, that railway companies and city authorities cannot close their eyes to the signs of the times, and it calls attention to the progress of the electric railway in this country. As an example of the work that is being done here it cites the interurban service of Western Pennsylvania and reproduces some statistics from the STREET RAILWAY JOURNAL of May 7 on the development in that region, with the comment that the value of such a great network of lines in developing the country cannot be exaggerated. At the conference of charity and kindred societies held in Edinburgh reference was made to the influence of cheap and rapid traction on the improvement of the condition of the poor, and it is interesting to note, says the *Dispatch*, "that additional confirmation of the beneficial effect of these railways is given in the article to which we have referred. Whatever agreement is come to regarding our Edinburgh tramways, it is earnestly to be hoped that nothing will be done that might have the effect in future years of checking the introduction of such suburban lines as those which are working a great revolution among American cities and improving the condition of the workers in a marvelous way."

Discussion of New York Central's Plan

In discussing Mr. Arnold's paper before the Institute upon the plans of the New York Central for substituting electricity for steam in the terminal work, Frank J. Sprague, who has given the subject special attention and is familiar with the conditions that exist there to-day, said that he was glad to note that the power requirements agreed very closely, considering the changed conditions, with the result of a similar investigation made under his direction three years ago. Mr. Arnold had very wisely confined himself to the problem of train movements within the limits of New York. For the specified service, the use of continuous current motors, to be operated at a moderate pressure, was the only safe recommendation. Mr. Arnold's paper had made special comparison of steam and electric operation in the matter of economy, with the result that no special advantage had been shown in favor of one or the other. Economy, however, was in this particular case the least important consideration, and he did not doubt that Mr. Arnold believed with himself that while this comparison was a necessary thing to be presented, there was no question, not only as to the practical possibility of electric operation, but of its economy. Wisdom, and even imperative need on the score of comfort and safety, required the change; and furthermore, the financial results would also entirely justify it. On account of the special nature of the problem, if the railway company should defer the adoption of electricity until some great

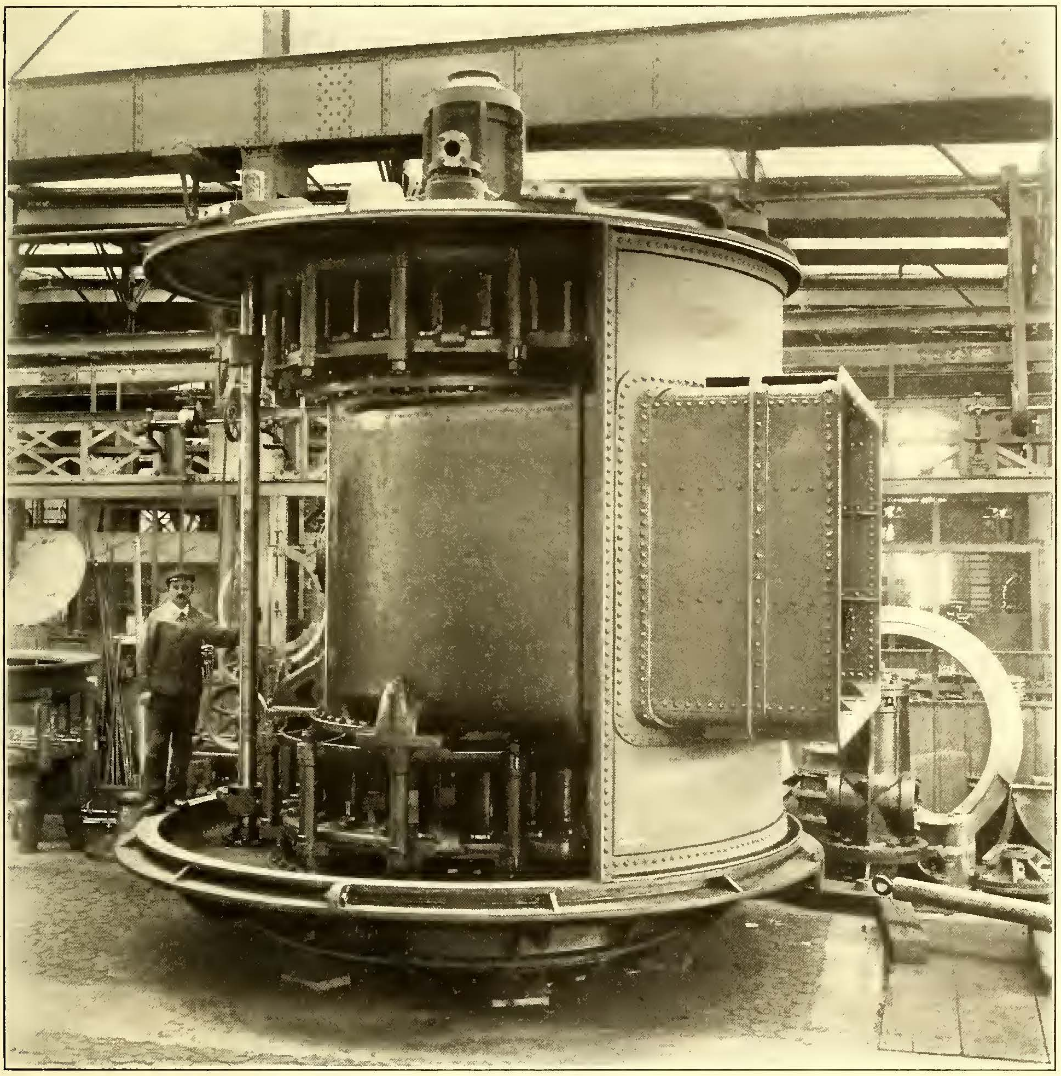


HIGH PRESSURE TURBINE FOR HIGH FALLS

saving in car-mile operation was manifest, steam would continue to be the motive power of the tunnel. Safety, cleanliness and comfort, however, being assured, increased dividends would most assuredly result from increased traffic.

The problem was a two-fold one—the replacing of the steam locotive on through trains and tne operation of the suburban service. The requirements were to be met in different ways. At present both train services were operated by steam locomotives. The through service must remain such, but the suburban could be readily changed. No less than ten or a dozen types and sizes of locomotive were now in use, and at limited speeds. Train weights varied from a hundred and fifty to six or seven hundred tons. It would seem, therefore, that in so far as locomotive service was concerned, it could best be performed by units of, say, 30 to 35 tons weight, and of 700 hp to 800 hp, these units to be so equipped and controlled that one could be used for the lighter service and two operated as a single-unit for the heavier.

This condition made imperative what has already been well settled—electrical instead of hand operation of control equipments, and the grouping and simultaneous control of units; in short, the multiple-unit system of operation. For suburban service, individual equipment of cars and like control of any required number was now beyond question. Another thing should be borne in mind, and that was that electrical equipment not only would insure greater safety of operation by clearing the tunnel of smoke and condensed steam, but the adoption of electrical control would leave the engineer free to devote himself to the safe piloting of his train, untrammelled by the distractions of other duties. Mr. Sprague concluded by saying that, so far as the possibilities of the case were concerned, he would not hesitate—and he felt sure that he voiced the conviction and readiness of others in the room—to undertake the feat of putting the heaviest train from Mott Haven to the Grand Central Station under electric power on schedule time within six months. Of course, such demonstration would be a special one, for considering the many civil engineering and railway problems involved, from two to three years would be necessary to make a general change.



DOUBLE TURBINES OF THE FRANCIS TYPE FOR LYONS, FRANCE

The accompanying tables contain the data, in convenient form, that was presented and discussed by Mr. Arnold in his paper. At the time of publication the arrangement of this data had not been completed. It is presented as an inset, in order that those who may desire to do so may bind it in the last volume with the original paper, thus making a most complete record.

Opposed to Running Cars on Sunday

The promoters of electric railways have encountered a sturdy opponent in Aberdeen in the form of the United Free Presbytery. At a recent meeting the following resolution was unanimously adopted:

"The Presbytery having learned with deep concern that a proposal to run tramway cars on the Lord's Day is to be made in the Town Council of Aberdeen, resolve as follows: Whereas, this proposal, if carried, would involve a complete reversal of the habit and custom of the city in the matter of Sunday traffic on the street, a serious increase of Sunday labor on the part of men employed by the city, whose opportunities of rest are already very few, and a still more encouragement to the increase of Sunday traffic in general; and whereas this proposal has not arisen from any desire expressed by the community for a Sunday service of cars, but is certain to awaken strong disapproval on conscientious grounds on the part of a large section of the citizens; therefore, the Presbytery, while expressing their own strong conviction that the proposal is uncalled for, and is fitted to do lasting injury to the institution of the Christian Sabbath and to the best interests of the city, respectfully appeal to the Town Council to withhold consent to the action proposed until the mind of the citizens has been ascertained."

In the discussion that followed the introduction of this resolution the Rev. W. Mackintosh Mackay said that the movement would not be confined to Sunday morning, but was bound to be projected into the afternoon, and especially into the evening. There should, at least, be a plebiscite of the community on the question.

Councillor Esslemont said he did not regard it as a sinful thing in itself that there should be means of locomotion on the Sunday, but the aspect that appealed to him was that sunday cars could not be run without causing very serious inconvenience and a very great injury, in his opinion, to the employees of the corporation. It might be said that they would get a day off during the week in lieu of the Sunday; but nothing could take the place of the Scottish Sabbath for the Scottish working man. It was on that ground he intended to oppose the motion in the Town Council. There was a feeling, however, in the community in favor of the Sunday cars.

Principal Salmond said it would need a very strong argument to make out that there was any pressing reason, any necessity, for a change like this in the case of a city like Aberdeen.

Mr. Donaldson said if this was a modified service of cars to suit people going to church, he did not see how they could object to it, without objecting to carriages, for the car was simply the poor man's carriage. It those who could, by paying for it, obtain a cab to church, he did not think they could object to the modified use of cars. It was also resolved to recommend ministers to call the attention of their congregations to the subject, and the public questions committee was empowered to approach other churches with a view to joint action.

New Cars for Philadelphia Suburbs

Some handsome cars built by the J. G. Brill Company, of Philadelphia, have recently been put in commission on the lines of the Ardmore & Llanerch Street Railway Company. They are

DOUBLE-TRUCK CAR FOR SUBURBAN SERVICE

especially interesting on account of their fine appearance, structural strength and suitability to the service required of them. The heavy traffic between these fine residential suburbs requires an equipment modern in every respect and conducive to every convenience and comfort. The cars have smoking compartments seating twelve passengers. The main compartment seats twenty-eight. The doors and windows of the dividing bulkheads and

INTERIOR OF SUBURBAN CAR

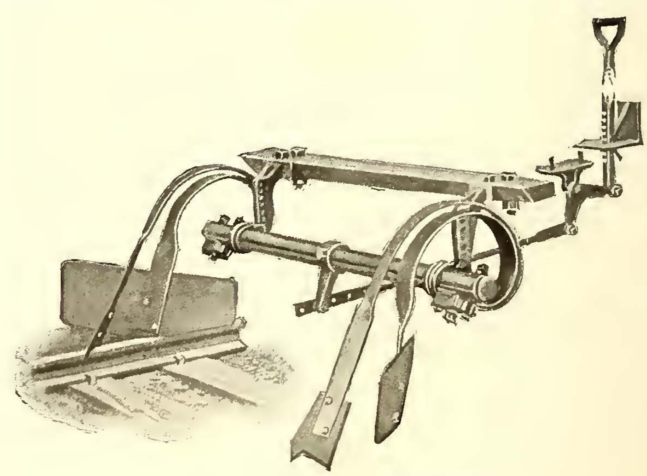
ends have drop sashes, which, together with the large windows and high and wide monitor decks, make the cars exceedingly pleasant in warm weather. The length over the bumpers is 41 ft. and the width at the belt line 8 ft. 4 ins. Heavy sill-plates, angle-iron reinforced platform timbers and Brill patented angle-iron bumpers are parts of the powerful construction. The interiors are done in natural-finished white quartered oak, and the ceilings of the same highly finished and decorated. The cars are equipped with Brill patented specialties, including sand-boxes, "Dedenda" gongs, radial draw-bars and track scrapers. The trucks are the Brill patented No. 27, which have a remarkable record for strength, ease and safety at high speed.

Automatic Block Signals

The system of signals for electric railways which has been perfected by the United States Electric Signal Company, of West Newton, Mass., was first introduced in 1898, and since that time has been installed on a large number of roads. The importance of a safety device of this kind under the conditions obtaining on high-speed interurban lines cannot be overestimated, and the expense of installation of an absolutely sure block signal system is very small when compared with the probable damage claims resulting from a single collision. The "United States" signal was conceived by some of tne most expert engineers of the Gamewell Fire Alarm Company, which is sufficient guarantee that the mechanical details of the apparatus are of exceptional merit. The system works automatically, a small switch attached to the trolley wire operating the signals. The signal boxes, which are attached to the poles, have substantial cast-iron cases containing two colored windows, one red and one green, and the lights behind these windows are controlled by operating magnets. The system can be used on third rail or surface-contact roads with a slight variation of the standard equipment furnished for overhead construction.

Track and Trolley Wire Scrapers

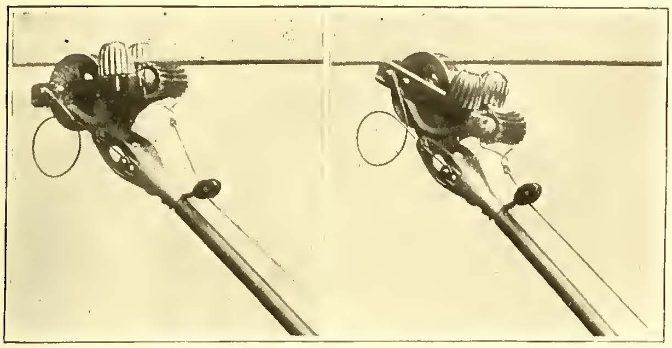
The accompanying illustrations show two ingenious devices which have recently been perfected by Fred. M. Root, of Kalamazoo, Mich. The Root track scraper is an ingenious device for cleaning the track thoroughly of all dirt and obstructions. The springs are made of oil-tempered steel, and the hand lever which is connected



TRACK SCRAPER FOR STREET CARS

to the bell crank under the front platform enables the motorman to maintain any pressure on these springs that may be desired. The shoe of the second scraper, being just the width of the rail head, is always on the track, and even should the rail be several inches below the pavement the surface is kept bright and clean under all conditions, insuring good electrical contact of the wheels with the consequent saving in power. The crank on the shaft to which the springs are attached is connected to the bell crank under the platform by a rod in the end of which are several holes to receive a set screw so that the apparatus can be perfectly adjusted to any car.

The other device is intended for cleaning trolley wires of ice and snow in a much more efficient manner than the ordinary corrugated wheels sometimes employed. The cuts show the rollers or knurls held against the wire when in operation and also removed from the wire when their use is not required. The conductor can control their position by means of the cord which runs down the trolley pole. The two side rollers are held in position close to the trolley wire by means of springs on the side and yield readily to any diameter of ice on the wires. Having three corrugated wheels in the relative positions shown, the ice is thoroughly cracked up on three portions of the wire, on each side and underneath. In this way the wire is thoroughly cleaned before the trolley wheel reaches it and the groove of the latter makes good electrical contact.

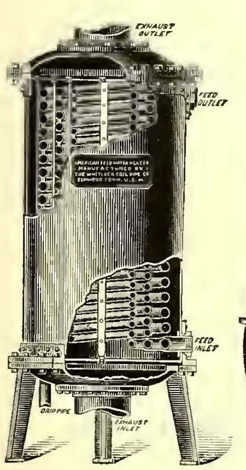


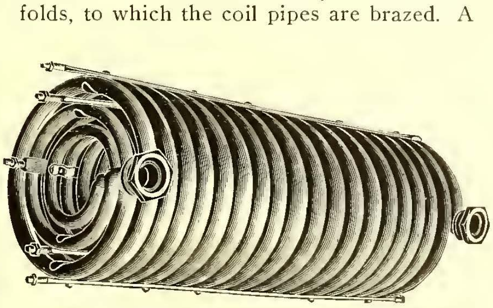
SLEET ATTACHMENT FOR TROLLEY WHEELS

By the use of the two devices described above the manufacturers claim that a large amount of power can be saved through the winter months, and with a power station equipment that is now hardly able to cope with the service at bad seasons of the year, roads may be run on schedule time without overtaxing the present facilities. Both pieces of apparatus are made by the Root Track Scraper Company, of Kalamazoo, Mich.

American Standard Feed-Water Heaters and Their Economical Arrangement

Of the accompanying illustrations Figs. 1 and 2 give an idea of the construction of a copper coil feed-water heater extensively used in electric lighting and street railway power stations, while Fig 3 shows a popular arrangement of primary and auxiliary feed-water heaters for all classes of condensing steam plants. The feed-water passes through a double coil, such as is shown by Fig. 2, the stream passing inside the shell of the heater, around the tubes, the internal area of the shell being several times that of the exhaust pipe, in order to obviate back pressure. The coils are of seamless-drawn copper tubing, brought together into a common inlet and outlet by metal manifolds, to which the coil pipes are brazed. A





FIGS. 1 AND 2.—DETAILS OF HEATER

patented form of clamp-stay permits of free expansion and contraction of the coils, at the same time holding them securely in place. In order to permit the renewal of packings without disturbing the pipe connections, an improved fitting is used, the feed pipe being screwed directly into it and not outside of it, so that the gland nut holding the coil in position may be run back on to feed-water pipe, while the asbestos packing is renewed. Each coil is tested to withstand 600 lbs. hydraulic pressure. The manufacturers direct special attention to the fact that the feed water comes in contact with no other metal than copper in passing through the heater, which takes up little room and has no removable or adjustable parts to get out of order. The arrangement of apparatus shown by Fig. 3 is one which obviates the use of a hot well, the feed water passing first through the horizontal primary heater, in which it attains a temperature depending upon the vacuum in the exhaust pipe. With a 26-in. vacuum in ordinary working the feed water should leave the primary heater at a temperature about 25 degs. above that of the hot well, say at 125 degs. From the primary heater the feed water passes to the vertical auxiliary heater, into which is discharged at atmospheric pressure all the exhaust steam from the feed, condenser and other steam pumps, small engines or any other auxiliary apparatus, the temperature of the feed water being raised nearly to boiling point. With this arrangement of heaters it is not generally economical to use a condenser driven from the engine shaft, because the exhaust steam from an independent condenser is usually required in the auxiliary heater to insure economical results, but in cases where the exhaust from the auxiliary machinery is more than sufficient to do the work, a part of such auxiliary apparatus may be exhausted into the primary heater, and thus work under vacuum with increased economy. Where the available amount of exhaust

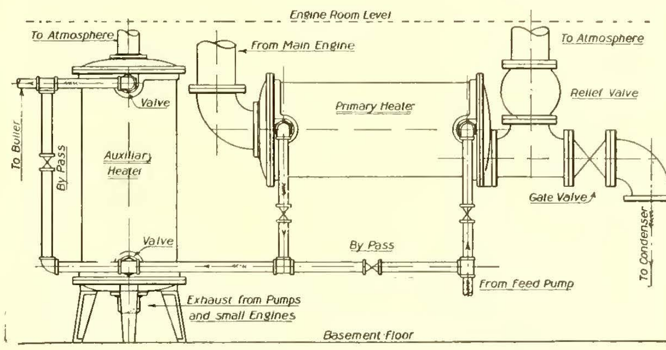


FIG. 3.—ARRANGEMENT OF FEED WATER HEATERS

steam is insufficient, however, the required amount of steam may be secured by "bleeding" the high-pressure exhaust of a compound engine or by taking steam direct from the boiler through a reducing valve. As to the relative sizes of the heaters it is considered good practice to have them of equal capacity, the work to be done being usually about the same in each. The primary heater is arranged to drip at the lower end, and the heaters are usually so by-passed as to permit either one to be used independently when necessary. As the primary heater itself acts as a partial condenser its use causes no impairment of the vacuum, while the fact that there are no threaded or expanded joints in the tubing, all connections being made by lapping and brazing, is a safeguard against any leakage that would prove detrimental to the maintenance of the vacuum. The heaters described are manufactured by the Whitlock Coil Pipe Company, Hartford, Conn.

An Efficient Ticket Destroyer

A machine has been designed for making valueless used tickets, transfers, etc., so as to leave no chance for fraud. It is known as the Patten ticket destroyer. It has frequently been found that the old method of burning is very ineffectual, and it is evidently doubtful policy to intrust a man with anything to destroy that may be of value to him if saved.

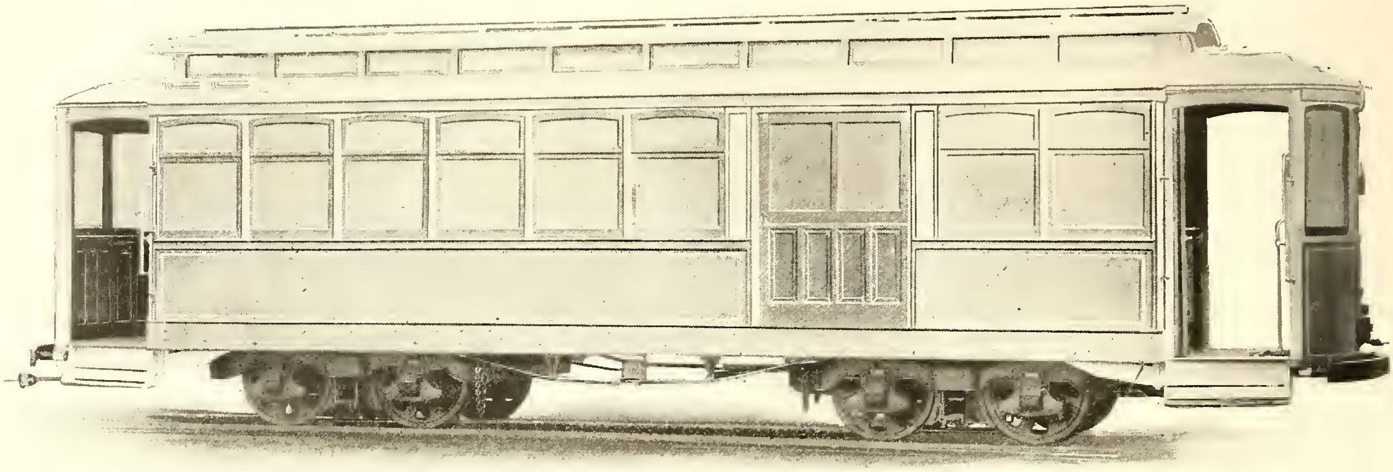
This apparatus can be set up in the auditor's department and the tickets destroyed under his immediate supervision. After passing through the machine the cuttings can be sold for paper stock or otherwise disposed of without fear of their being further presented for use. The construction of the apparatus is very simple, and, as it is strongly built, has large wearing surfaces, babbitted bearings, crucible steel cutters, etc., it is very durable. It may be run by a 1-hp motor or by hand power.

These machines are built by Paul B. Patten, of Salem, Mass., and are in practical operation on a number of street railways. Among the users may be mentioned the Boston & Northern Railroad, Old Colony Railway Company, Brockton Street Railway Company, Waterbury (Conn.) Electric Company, Bridgeport Traction Company, Buffalo Railway Company, Cincinnati Traction Company, Fitchburg & Leominster Railway Company and Youngstown & Sharon Railway.

The report of tests made with fuel oil at the plant of the Dallas Electric Light Company is attracting considerable attention among managers of power plants, although the data given out is incomplete, and consequently unsatisfactory. This test was made under a Babcock & Wilcox boiler of 317 hp rating, based on 10 square feet of heating surface on a run of eight hours. The evaporation of 212 degs. was said to be 13.77 lbs. of water to the pound of oil. At the time the test was made oil was worth 59 cents per barrel, delivered in Dallas, against $3.15 per ton for coal. As compared with an eight-hour run of coal, while evaporating 8.87 lbs. of water to the pound of coal, the actual saving was $3.66, without figuring on the fireman at $2 additional. This plant has since adopted the system used during the test, and the management estimates that it is saving approximately $2,000 per month on fuel and $26 a day on firemen.

A Light Interurban Car

The accompanying cut shows a light combination interurban car, which was part of an order recently completed by the John Stephenson Company, of Elizabeth, N. J., for the Montroseville, Bellevue & Norwalk Traction Company, of Sandusky, Ohio. The order comprised several different styles, but that shown in the engraving is the one of greatest interest. The body is 28 ft. long over the end panels and is divided into two compartments. One of these, about 8 ft. in length, is used for baggage as well as for smoking, and is provided with sliding doors on each side. The other compartment for passengers is about 20 ft. in length. The car measures 37 ft. over the dashers, with a width at sills of 8 ft. 4 ins. A straight side with the "Stephenson" double sheathing was adopted as making the best and most convenient method of constructing a car which required a sliding door in the side. As a car with such an opening requires unusual strength, on account of the side truss being interrupted, the sills are heavily plated with steel. As will be noticed in the engraving the plate is well secured by a double row of bolts, closely spaced. In addition to this there is the usual truss rod under each side sill, and two extra longitudinal sills along the center.



HANDSOME INTERBURBAN CAR WITH BAGGAGE COMPARTMENT

The vestibules are of the completely enclosed type with round ends, street car bonnets, three-dropped sash with metal stiles and channel-iron platform timbers. The metal stiles have the advantage of making a minimum obstruction to the view. The channel-iron platform timbers, with their riders of oak, make a very solid construction, and being dropped bring the platform floor so near the head of the rail that only a single step is necessary. The buffers are of the Stephenson spring type. They are of channel-iron, and are so cushioned by the springs that the framing is entirely relieved from the shock of the inevitable blows which the end of a car receives in storing cars at night and at other times. This construction materially increases the life of the car body. The bonnet is built with bows and rafters of bent ash, and as is desirable in a car of this type, the roof is unusually stiff and strong, having nine steel rafters. The projection of the upper deck, both on the sides and at the ends, is sufficient to afford the ventilators ample protection against rain. The two compartments are divided by a partition, finished in panel work. The swinging door has glass in its upper portion.

The cars are mounted upon the No. 20 Stephenson truck. The use of this truck enables the body to be brought low, and, at the same time, there is ample room for the truck to swing clean of the timbers. This is effected by the dropped ends of the truck frame and by the arrangement of its swinging bolster. The No. 20 truck not only carries the car body with great steadiness, making what is recognized as an easy riding car, but the amount of power needed for propulsion is remarkably small. This is due to the way in which the truck frame is carried by the double journal springs and to the soft swing motion. One important point is worth attention, viz.: that no matter how far the swing beam moves from its normal position, even though the links may make a sharp angle with the vertical, no part of the swing motion can ever strike the wheels. The truck frames are of great strength owing to the stiff form given to the wheel pieces and the very effective manner in which the end pieces are secured to them.

These cars are arranged for double trolley poles and are provided with powerful motors, as they are intended to operate on a fast schedule.

Automatic Signal for Block Systems and Car Spacing

The American Electric Switch Company, Pittsburgh, Pa., is placing on the market an automatic signaling device to be used on both single track roads between turnouts and on double track roads. The time is approaching when the double track roads using high-speed cars will require a block system answering the same purpose as the block system on steam roads, as the cost of one bad rear end collision will equip an entire road with a block system.

In this system there is always a light burning at each turnout, incandescent lamps being used, which are so arranged that the sunlight will not strike them and confuse the motorman. All wiring is done with No. 12 B. & S. gage insulated iron wire or cable, as desired. No trolley wire is cut or separate section required, and there is no trigger or any obstruction for the trolley wheel or pole to strike against required to operate the signal, the current being taken directly through trolley wheel so that the device will operate whether the motorman uses his power or not. The signal is operated by the trolley wheel making contact between the trolley wire and an independent circuit, and the car crew have nothing to do with setting them.

For a single track road with turnouts, diagrammatically shown

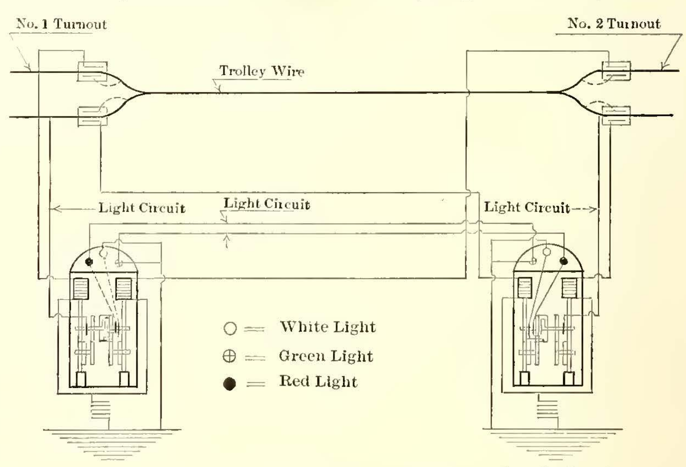


FIG. 1.—SINGLE TRACK INSTALLATION

in Fig. 1, the device works as follows: When a car crew desiring to leave the turnout runs out on the line, a white light signal being set, the trolley wheel passing over a certain point makes contact with an independent circuit operating the signal, setting a red light on the far turnout No. 2, and a green light on the near turnout No. 1. Thus the motorman, seeing a green light, knows that the signal is set at danger at the No. 2 turnout, causing any car proceeding in the opposite direction at No. 2 turnout to come to a dead stop. The car passing through the block and reaching No. 2 turnout the trolley wheel makes contact between the trolley wire and an independent circuit, throws out the red light at No. 2 turnout, and the green light at No. 1 turnout, lighting up a white light at No. 2 turnout and a white light at No. 1 turnout. Thus a white light is set at each end of the block, and a car can now enter from either end with a clear track.

This device will allow any number of cars, going in the same direction, to enter the gauntlet as follows: The first car, seeing a white light, throws up a red light at No. 2 turnout and a green at No. 1 turnout, and enters the block. The crew of the next car following, coming to No. 1 turnout, and seeing a green light, the motorman knows there is a car going in the same direction in the block, and therefore can enter, but proceeds with car under control. Three, four and five cars or more can run in the section likewise, and the white signal will not be set at No. 2 turnout until the fifth or last car has left the block. This is done automatically. The first car, passing over the point of trolley wire at No. 1 turnout, the trolley wheel makes connection with the independent circuit, energizing a magnet at No. 2 turnout which operates a drum or disc, on which are segments, throwing the drum forward one space so that a brush rests on the red light segment, lighting a red light at No. 2 turnout and a green light at No. 1 turnout. The second car, going in the same direction, seeing a green light at No. 1 turnout, runs into the block, throws the drum one space farther ahead, making the white segment two spaces from the brush. When the first car passes out of the block it throws the brush, revolving in the same direction as the drum but operated by a separate magnet, ahead one space, leaving the light still set at danger. When number two or the last car passes out of the block it throws the brush again one space ahead on to the white light segment, thus setting safety signals at each end.

On a double track system, shown in Fig. 2, as one car passes a given point, say *B*, it sets a red light signal at *B* and a green light signal at the block behind *A*. As the car runs off block *B* on to block *C*, it will extinguish red light at *B* and green light at *A*, setting red light at *C*, green light at *B* and white light at *A*. Thus any car following approaching block *A*, and seeing white light, can proceed at full or schedule speed; coming to block *B*, where a green light is set, the crew of car knows that the leader is one block ahead. Approaching block *C*, where a red light is set, the car comes to a dead stop or proceeds slowly with car under control, as the management of road desires. Any number of cars can enter a block without disarranging signals. It is evident the device can also be used as an efficient car spacer, allowing only one car in a block at the same time.

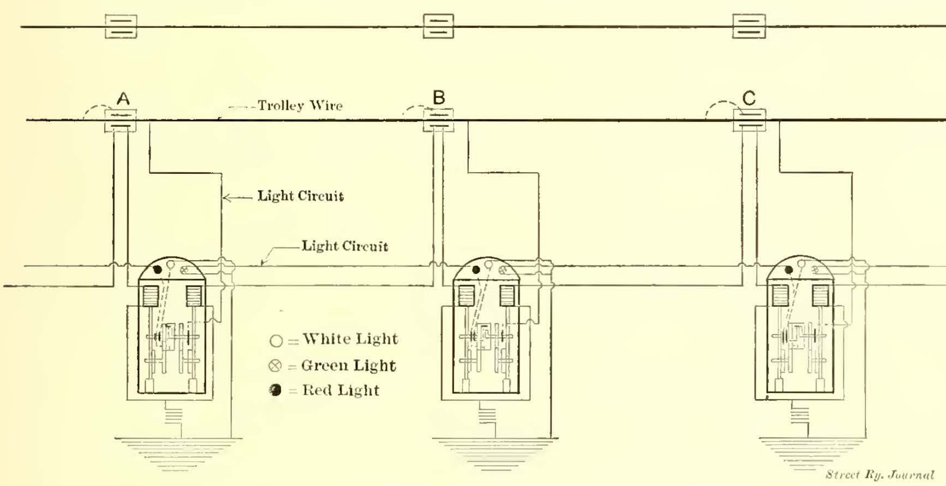


FIG. 2.—SIGNALS ON DOUBLE-TRACK SYSTEM

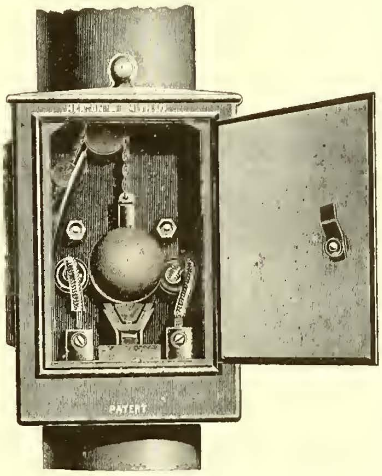
All Night on Trolley Cars

As a result of the severe storm on June 28 a number of persons camped out on electric cars between Belleville and East St. Louis all night.

At about 7 o'clock p. m., a great cottonwood tree which stood a short distance east of the Lake Bridge, between East St. Louis and the bluffs, was blown down across Rock Road, carrying all the wires with it and cutting off the current. One of the cars of the East St. Louis Suburban Railway was within a hundred yards of the tree when it fell. For three hours the car, and all the others of the system, lay motionless on the track. The wind blew a terrific gale. The car near the bridge rocked and swayed, and it seemed every minute that it would be blown over. By the time the wind died down it had become very dark, and for another two hours the people sat in the darkness. The car was then moved a short distance and stopped again. Ahead was the giant cottonwood tree across the track. Sunday morning had dawned before the tracks were cleared and the cars could proceed.

An Ingenious Safety Device

The apparatus illustrated herewith is intended for protecting property from the injurious effects which often result when the current from trolley wires escapes either by the falling of other wires across the overhead system, the breaking away of the trolley wire or other accidents. Where the conditions are such that the accident produces a bad ground of the system the circuit-breaker immediately goes out in the station; but it often happens that wires are so disarranged that they become dangerous without actually grounding the circuit, and until word can be sent to the station or some auxiliary cut-out box along the road there is some liability of injury to life and property. The device consists of a cast-iron box arranged to be fastened to the trolley pole and containing a spring switch. One side of this switch is connected to the trolley line and the other to ground, and unless held open the contact-maker will ground or earth the section of trolley wire which it controls. The contact-maker is held in an off position by a cord which passes over an insulated pulley and is fastened to a knob which passes through a pane of glass in the side of the box. In the event of accident, all that is required is to break this glass, thus releasing the cord, and the section is immediately grounded, throwing out the circuit-breaker at the station and making that part of the line dead, and therefore safe. On the front of the box is an inscription indicating what to do in case of wires falling, and it is of course possible for anyone to cut out the section in case of emergency. As soon as the glass is broken the engineers in the power station can tell immediately by the circuit-breaker that opens which section of the line is in trouble and a repair gang can be despatched rapidly to the desired point. While the contact-maker in the grounding device is allowed to make connection between earth and trolley wire, it will be impossible for the attendant at the switchboard to replace the breaker, or not, so that repairs can be made with perfect safety on the section.



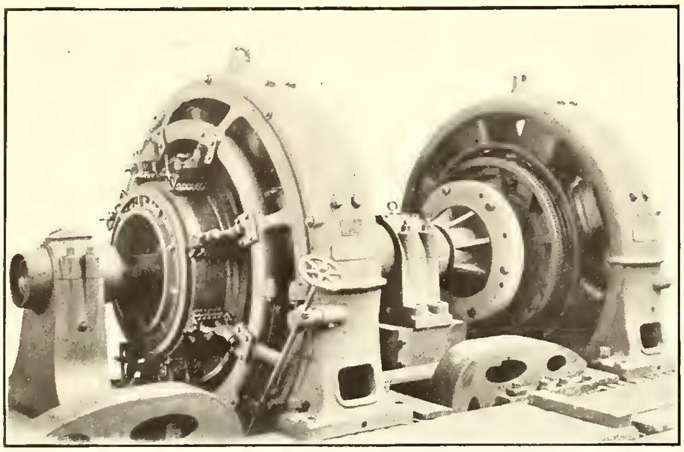
AUTOMATIC GROUNDING DEVICE

This apparatus is made by Heaton & Smith, Ltd., electrical engineers, of London, England, and has been used on a number of roads, the engineers pronouncing it very satisfactory. It has been tried in St. Helens and Oldham with equally good results, and at present there are many other towns in England considering its installation. The company has been experimenting with devices of this kind for considerable time and has tried many different arrangements for obtaining the best results, both automatically and otherwise. The manufacturers claim that they have now succeeded in making a device which not only will work well when first turned out of the factory, but which after left standing for years without being used would be just as good as on the day it left the workshop, and immediately the glass is broken will automatically render the section upon which the accident has occurred perfectly safe.

The R. D. Nuttall Company report unusual activity in the trading of trolley wheels, many roads availing themselves of the opportunity offered to replace old types or worn-out trolleys with the latest forms, the old trolleys being accepted in part payment on the new. The most notable case is that of the Cincinnati Traction Company, which traded 700 of its old-form double trolleys not long ago for 1400 of the single type. Individual roads all over the country are taking advantage of the opportunity to re-equip their systems with more modern apparatus of this kind.

Siemens Multipolar Dynamos

The generators shown in the accompanying illustration have been made by Siemens Brothers & Company, Limited, of Woolwich, England, for the Corporation of Oldham. These machines are compound wound and are arranged to be driven by Willans

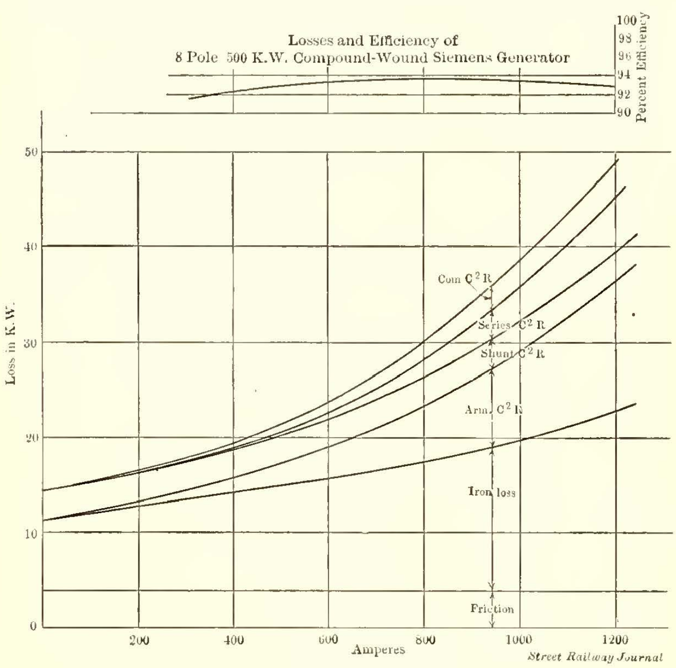


SIEMENS DYNAMOS COUPLED FOR TESTING

central valve engines, running at a speed of 300 revolutions per minute. The capacity is 500 kw each.

The field magnets consist of a ring of special quality cast iron, made in two parts and strongly bolted together, carrying eight poles of laminated steel. The core of the armature consists of discs of annealed mild steel accurately stamped and keyed to a cast iron body. The core is slotted and the bars securely held in the slots by means of hornbeam strips. The strips can be readily withdrawn to allow a coil to be replaced in the event of injury.

The commutator is built up of hard drawn copper segments, and



EFFICIENCY CURVES OF SIEMENS DYNAMOS

is insulated throughout with mica. The brush gear is mounted on a cast-iron ring, which is fixed concentrically with the armature, and which can be rotated so that the position of the brushes can be easily and simultaneously adjusted. The brush holders are neat and compact in design and are fitted with adjustable springs.

The two dynamos were erected for a Hopkinson test in Siemens Brothers & Company's test house at Woolwich, and a copy of the curve showing the efficiencies at various loads is reproduced. The voltage at no load is 500 volts. and at full load 550 volts.

New Publications

How to Become a Competent Motorman, by Virgil B. Livermore and James Williams, 232 pages. Illustrated. Price $1.00. Published by the Authors, 1902.

This book is a practical treatise on the proper method of operating an electric street car. The authors are both experienced, practical men in the handling of street railway apparatus, Mr. Livermore being chief instructor of the Brooklyn Rapid Transit Company and Mr. Williams shop foreman of the same company. They are, therefore, not only competent to give instructions as to the best method of keeping a car in good condition, but are familiar with every ordinary defect that is likely to occur upon the road and with its temporary repair. The value of such knowledge to the motorman cannot be overestimated, as the ability to repair his own car is the greatest safeguard that he has against being late at the end of his run. The book contains a great number of diagrams of controllers, etc., showing cross-connections that can be made to temporarily cut out different portions of the equipment and prevent a car from being stalled. This class of diagram is given very completely, but it is to be regretted that there has not been included in the volume a few diagrams showing the entire car equipment and connections, so that new men who are entirely ignorant of the electrical details would obtain a more tangible idea of the different parts described than can possibly be given in the text. As, however, the book is primarily intended for men who are actually in contact with the apparatus itself, this is not of very great importance. A catechism consisting of a series of questions and answers relative to the operation of electric cars is added, which will prove of great assistance to the ambitious motorman in fixing the knowledge obtained from the previous pages, and much of the information given will be of considerable benefit to the average inspector. The authors have been assisted in the preparation of this manual by Messrs. Kane and Geiss, instructors of motormen for the Metropolitan Street Railway Company, of New York. who have furnished data upon the underground conduit system. The subject of multiple unit control and storage battery operation is not touched upon. In other respects the exceptional facilities afforded by the equipments of the Brooklyn Rapid Transit Company, which from its consolidation of numerous individual lines has upon its cars a most varied assortment of controllers, motors, etc., has enabled the authors to speak authoritatively, from personal experience, upon nearly every type of apparatus employed at the present day.

The Electrical Catechism. Compiled from the regular issues of "Power," 216 pages. Illustrated. Price $2.00. Published by Hill Publishing Company, New York, 1902.

To a large majority of practical men, especially those who have not had the benefit of a college education, that class of books known as catechisms is of the greatest benefit. In "The Electrical Catechism," 533 plain answers are made to 533 practical questions about electrical apparatus, and the reader is given, in clear and concise language and in an entertaining manner, a great deal of valuable information regarding the construction of the apparatus and the requirements which should be expected of it. Only such branches of electrical work as come within the range of the average central station engineer are treated, and the majority of the questions relate to what the author terms in the preface as the "heavier branches of electrical engineering." Considerable space is allotted to the answering of questions devoted to strictly street railway subjects, such as car wiring, series motors, series-parallel controllers, the rotary converter, etc., as well as to such matters of dynamos, measuring instruments, alternating-current transmission, etc., which are as intimately connected with railway work as with lighting installations. The many illustrations consist mainly of diagrams and add greatly to the book's value.

Manual of Electrical Undertakings and Directory of Officials for 1901-1902. Compiled under the direction of Emil Garcke. 976 pages. Price 12s. 6d. net; delivery 6d. Publishing offices, Mowbray House, London, Eng.

This is the sixth annual volume of this manual. It contains data and general information upon British electrical undertakings both of the municipalities and of private companies. The information is classified under five sections, that pertaining to electric railways being in the first department. Lists of electric companies formed under the joint stock acts and of all electric undertakings belonging to municipalities are published in this manual. In the section devoted to "Progress of the Year" reference is made to the power bills, including those of the tramway power supply, the London underground railways and similar enterprises. A list has been added showing the electric tramways completed, under construction .and authorized, and particulars are given of all orders and bills promoted and adopted during the last Parliamentary session relating to electric tramways and light railways. There is also a map showing the present condition of the electric railways in London. The directory of officials, which is a very important feature of this manual, contains upward of 4000 names and addresses of chairmen, directors, managers, secretaries, engineers, solicitors, bankers and auditors of electrical properties. The work shows evidence of careful compilation and constant improvement.

NEWS OF THE WEEK

Must Pay for Delays in Chicago

The City Council has passed an ordinance providing that in cases of street railway breakdowns causing a delay of ten minutes or more the companies must issue to the passengers coupons good for a trip at any time in any direction or return the fares. The ordinance provides that the fares shall be returned where the delay occurs by reason of any neglect of the company, or where "the delay is at the company's fault." Where the company could show that the delay was not due to its neglect or fault the fare need not be returned. It would seem that the passenger will have to prove that whatever happens to make the delay was the fault of the company in each case.

A Cyclone in Indiana

A most terrific storm swept over central Indiana at about 9 a. m. June 25. Telephone, telegraph and electric railway wires were torn down along its trail, and at 12 m. communication with the storm-swept section was almost entirely cut off. The storm spent most of its force in the country 20 or 30 miles northeast of Indianapolis, lying between the Indianapolis & Greenfield Electric Railway on the south and the Union Traction Company's lines to Anderson on the north. Maxwell, Cleveland and Pendleton suffered most severely. Houses in all of these towns were blown down and from ten to eighteen persons are reported to have been killed. The Union Traction Company's system between McCordsville and Anderson was tied up for hours. In many cases trees were blown across the tracks of the electric railways and many hours elapsed before traffic was resumed on some of the lines.

New Low Fare Ordinance for Cleveland

Mayor Tom L. Johnson, of Cleveland, who is nothing if not persistent, says that, although he has met with a severe reversal in the recent Circuit Court decision declaring against his 3-cent fare ordinances, he is in no way dismayed and that no time will be lost in preparing plans for a new ordinance. The decision that has just been handed down is a complete reversal of that of Judge Strimple in the Common Pleas Court. As previously stated, the case was commenced some time ago by William M. Raynolds as a taxpayer. The city and Mr. Hoefgen, to whom the franchise was granted, claimed that Mr. Raynolds was simply acting for the companies now operating in the city, and the case was most bitterly fought in both Common Pleas and Circuit Courts. As soon as the case was brought a temporary injunction was granted, but after Judge Strimple had heard it he dissolved this injunction, giving a verdict for the defendant. The plaintiff immediately appealed the case and another temporary injunction was granted by Judge Caldwell. It was this injunction that has been made perpetual.

The Rhode Island Merger

Possession of the property of the Union Railroad, of Providence, the Pawtucket Street Railway and the Rhode Island Suburban Railway Company was assumed by the Rhode Island Company under a 999-year lease on June 24. The properties taken over are owned by the United Traction & Electric Company, the holders of whose $8,000,000 stock will receive under the lease dividends at the rate of 5 per cent per annum, and in addition a distribution of 25 per cent ($2,000,000) in the stock of the Rhode Island Securities Company, which will shortly be organized, with a capitalization consisting of $10,000,000 each of stock and bonds, to take over the $2,000,000 stock of the Rhode Island Company, with its lease of the street railway properties, and also the proposed lease of the gas and electric lighting properties. The $2,000,000 capital stock of the Rhode Island Company was subscribed by the United Gas Improvement Company of Philadelphia. The officers and directors of the Rhode Island Company are: Marsden J. Perry, of Providence, president; Samuel P. Colt, of Providence; Randall Morgan and Walton Clark, of Philadelphia, vice-presidents; Lewis Lillie, secretary-treasurer; Nelson W. Aldrich, William G. Roelker, J. Edward Studley, Howard O. Stuges, Walter F. Angell, Samuel M. Nicholson, of Providence, and Thomas Dolan, of Philadelphia.

The Providence Strike

There has been some cessation of violence at Providence and Pawtucket during the last week, but at times the outbreaks were renewed. Strikers armed with revolvers ambushed a car on the Pawtucket line. They lay in wait behind bushes on either side of East Avenue, near Pidge Street, and as the last car was returning to Providence opened fire upon it. There was but one passenger aboard, but he and the crew narrowly escaped being murdered. Twenty bullet holes were found in the woodwork of the car. On the same day, on the short line, the late cars were driven out of service by men who stoned the crews, one of the conductors being badly hurt. The militia were withdrawn on June 26.

On June 25 the Supreme Court rendered an opinion that the ten-hour law which was passed at the May session of the Legislature was constitutional, and that the United Traction Company cannot legally compel its employees to work eleven consecutive hours for a day. The original demand of the strikers was that not more than ten hours' work in every twelve at 22½ cents per hour be required, and recognition of the union to the extent of dictating who should be employed, but these demands have been reduced to 20 cents an hour, the strikers upon return to work to have their old places, and that the repair shop hands should have fifty-eight hours per week with sixty hours' pay and half-holiday on Saturdays until Sept 1.

The United States Circuit Court has declined to issue an injunction to restrain the Woonsocket Street Railway Company from obeying the Ten Hour Labor Law and also restraining the Attorney General from prosecuting the company if it fails to comply with the law.

Thomas Martin, of Chelsea, Mass., a large stockholder in the Woonsocket company, was the petitioner, who argued that the law, if complied with, would work injury to the interests of the stockholders. The question will be taken to the United States Supreme Court, which will also be called upon to pass upon the constitutionality of the law.

The United Traction Company raised the constitutional point when its men, refusing to accept reduced pay for reduced hours, struck. The company contends that the law is unconstitutional because its terms abridge the rights of a citizen to contract with a railway corporation for employment.

Overdoing a Boycott

The Citizens Protective League has been organized by the business men of Terre Haute, Ind., for self protection, because of the injury done to the business of the city through the boycotts growing out of the strike of the employees of the Terre Haute Electric Company. The strike has long since been a thing of the past to the company, for it was practically ineffective from the first, and all of the men who engaged in it have either returned to work or have secured other places. But the boycott that was first declared against the company by the Central Labor Union has been extended from time to time so that there are now brought under its ban merchants, manufacturers, shopkeepers and even clergymen. Without regard for anybody or anything the labor organizations have carried their high-handed practices to the point of overdoing. The Street Railway Journal has already told some of the curious results that followed the declaration of the strike. As previously stated the boycotts were first declared against the company. Next they were extended to persons patronizing the cars. They were soon extended to the business men and dry goods stores, mills and factories were one after another placed on the boycott list. It would be thought now that no more boycotts could be declared, but there still was room for more. Clergymen and school teachers next were assailed, and then a traveling salesman who patronized the cars was prevented from making a sale. One man took his children out of school because one of them was seated next to the daughter of a merchant against whom a boycott had been declared. The teacher was requested to change the seats of the children, but this she refused to do. A boycott was proposed against the school, but it was voted down. A clergyman, who frankly declared that the conditions existing in Terre Haute were a disgrace to the city, and that the law should be enforced, was threatened with bodily harm, and a boycott was declared against his church.

Disclose Your Identity

To the electric railway promoter, who, though seeking a franchise from a council or other municipal body, persists, as some promoters do, for unknown reasons, in refusing to disclose the identity of those whom he represents, there is a lesson in the action taken by the council of one of the large cities in New York State To the Tommy Dod, of Whatville, who thus seeks his franchise, this tale will bear repeating. A Mr. Blank, of New York, went to the city in question, and there, stating that he had ample financial backing, made an earnest plea for a franchise. But this council challenged the veracity of the statement of Mr. Blank and asked him to disclose his associates in the enterprise and otherwise make his identity known. Mr. Blank, however, thought that it sufficed to say that he had ample financial backing. Thereupon the councilmen, the press and the public raised their voices, and Mr. Blank was told that the franchise grant would be voted down if he did not comply with the demand. He refused to heed the warning and the grant was voted down in council. In the comments of one of the local papers on the incident there are some things of interest. Among other things are the following:

The franchise has been a thing unknown and unknowable. Its quality first and last has been that of dense mystery. Whether "a strike," aimed as a reputable form of blackmail against the present company; whether speculative, seeking merely to get control of valuable public privileges which might subsequently be sold out; or whether a project honest in intention, but incapable and irresponsible financially, are things which no man has been able to find out. On this ground solely the enterprise at every turn has met and has deserved to meet a popular and an official disapproval, auguring its certain defeat. This public opposition, let it be clearly understood, is not opposition to any business-like and legitimate and needed street railway improvement within the limits of the city. If it can be publicly shown, as has been within twenty-four hours guardedly intimated, that the project now back of this franchise is not "a strike" nor "hold-up" nor speculation by irresponsible persons, but a legitimate enterprise seeking to give to the city added street railway conveniences to the full extent that such conveniences are lacking; that capital is available and waiting for investment in the extensions the franchise covers; that this waiting capital is home capital, and that home business men who are financially as strong as any we have are going to stand sponsor to the project and see it through—then every objection of every sort that has been raised, and thus far justly raised, falls absolutely, and the enterprise straightway becomes one the general public of the city will foster as earnestly as hitherto it has opposed. The franchise is a mystery whose merits and purpose have been quite unknown even to the Mayor himself, and the franchise permitting local street railway extension that home capital shall pay for and home capitalists own and operate, are radically different propositions. With the one the city should do nothing; with the other, it could hardly do too much.

Electric Plant in Amsterdam

The City Council of Amsterdam has voted a loan of $2,613,000 and a second one of $1,165,800 for building a plant to furnish electricity for lighting and motive power and for changing the street railway to electric traction. The contract for the building of the plant has as yet not been made. The steam engines, dynamos, and the installation will be furnished by German and Dutch manufacturers. Particulars of the cables will be published on July 1; bids to be delivered September 1, 1902.

Electric Opposition for New York Central

In the denial of the application of the New York Central Railroad for an injunction to restrain the Buffalo & Williamsville Electric Railway from extending its lines to Rochester the means pursued by steam railway companies generally to throttle electric competition are again brought to public notice. Some time before the Pan-American Exposition a company was organized to build an electric railway between Niagara Falls, Buffalo and Rochester, the promoters planning to have the line completed in time to carry passengers to the fair. When the application of the new company came before the railroad commissioners the New York Central representatives were there with argument upon argument to convince the commissioners that public necessity did not require the construction of the road. Hearing after hearing was held, and the proceedings dragged so that it was long after the exposition had closed before a certificate of necessity was granted to the electric railway company. At the hearing it was shown that the New York Central's service was not satisfactory to the people along the line, and that the territory through which its lines passed did not have the service that it required. The handwriting was there upon the wall, but the New York Central evidently did not care to interpret it. The new company went on perfecting its plans, and finally, after much deliberation, awarded the contract for construction. The New York Central, however, as far as can be learned, made no efforts to improve its service, having confidence that the new road would not be built. And this confidence, it would seem, was not misplaced, for so far construction work on the line has not been begun. But a road already in operation, and for the extension of whose lines no certificate of necessity from the railroad commissioners is required, has stepped in and upset the calculations of the New York Central. Now the New York Central, it would seem, in the interval between the granting of the application of the company to build between Niagara Falls, Buffalo and Rochester, and the announcement by the Buffalo & Williamsville Electric Railway of its intention to extend its lines to Rochester, had time to meet the demands of its patrons, and, by improving its service, win them over. In this case there would have been little or no necessity for the extension of the Buffalo & Williamsville Railway. But the New York Central did nothing. It heeded not the experience of the Boston & Albany Railroad and other companies, neither did it profit by the experience of the New York, New Haven & Hartford Railroad, whose policy of opposition has resulted in the projection of a third-rail system that will parallel its lines for twenty-seven miles out of New York City and which will cut very materially into its passenger receipts.

PERSONAL MENTION

MR. HENRY A. EVERETT, accompanied by his wife and daughter, is now at Yellowstone Park, Wyoming, enjoying a much-needed rest.

MR. F. W. KINMOUTH has resigned as purchasing agent and superintendent of the Glens Falls, Sandy Hill & Fort Edward Street Railroad Company, of Glens Falls, N. Y., to become prominently identified with the Niagara, St. Catherines & Toronto Railway, of Niagara Falls, Ont.

MR. B. E. MERWIN has been appointed general superintendent of the Cincinnati & Eastern Electric Railway, of Cincinnati, Ohio, and will have charge of the operation of the road. Mr. Merwin was formerly general superintendent of the Lake Street Elevated Railroad, of Chicago, with which company he was connected eight years.

MR. C. N. DUFFY, who has occupied the position of auditor of the Chicago City Railway Company since Sept. 1, 1899, was elected secretary of the company on June 20 to succeed Mr. F. R. Greene, resigned. Mr. Greene, who was identified with the company for a number of years, has recently become president and general manager of the Chicago Street Car Advertising Company, and will devote his entire attention to that concern hereafter.

MR. JOHN DENHAM, of the Cape Government Railways, Cape Town, South Africa, who visited America last year and inspected many of the railway and lighting plants, recently read a paper on the subject of electrical engineering in Europe and America before the Cape Town Section of the Institution of Electrical Engineers. Mr. Denham was a guest of the American Institute of Electrical Engineers during its Buffalo convention, and made a great number of friends among American engineers.

MR. F. B. ROCKWELL, recently appointed general manager of the Syracuse, Lakeside & Baldwinsville Railway, of Syracuse, N. Y., although a young man, has had much experience in street railway work. Mr. Rockwell aided in the construction of the electric railway that was built at Scranton, Pa., in 1885. Prior to that time he had been engaged in the lighting of Scranton, Wilkesbarre and other Pennsylvania cities. Mr. Rockwell constructed, among other electric railways, the Middletown & Goshen Railway, the Athens, Waverly & Sayre Railway, the Staten Island & Midland Railway and the Richmond Beach Railroad. He was general manager and president of several of these roads, and retired from the last-named a few weeks ago, when it was bought by C. H. Schwab, of the United States Steel Corporation.

MR. A. H. FORD, who for several years has been general manager of the New Orleans & Carrollton Railroad, Light & Power Company, of New Orleans, La., will shortly leave the company and become confidential man in the brokerage and private banking office of Isidore Newman Mr. Ford will take the place of Mr. J. Newman, who will go to New York next winter to open a New York branch office of the firm of Isidore Newman. Mr. J. Newman, eldest son of Isidore Newman, has been the head of the office under his father since the removal of Sidney March to New York. Mr. Newman has also been president of the Carrollton Company since the Newman control reorganized the system. The sale of the Carrollton system to the Pearson syndicate left Mr. Newman in position to carry out his desire to have his oldest son establish a branch office in the great financial centre of the country. Mr. H. A. Davis, superintendent of equipment, is made acting manager of the railroad department of the company.