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Of this issue of the Street Railway Journal 8200 *copies are printed. Total circulation for* 1905, *to date,* 74,950 *copies—an average of* 8328 *copies per week.*

The Power Station of the London Underground Electric Railways Company

We devote considerable space in this issue to an extended description of the new power station which has recently been completed in London by the Underground Electric Railways Company, Limited, of that city. It is the largest railway power station in Europe and one of the largest in the world, being exceeded only by the mammoth plants in New York City. The station is interesting, however, for reasons other than mere size. For instance, it is the first large railway power station in Europe or America to be designed for and equipped with turbo-alternators, and the fact that the units are in 5500-kw sizes makes the installation of the generating machinery and steam auxiliaries of especial interest. In other particulars the station will also attract attention, especially in its coal-handling apparatus, its lubrication system and in its switchboard arrangements. Mr. Fortenbaugh draws an interesting comparison between the latter equipment and the switchboard in the Fifty-Ninth Street station of the Interborough Rapid Transit Company, of New York, which was designed along similar lines. He has also presented a very interesting description of the system of distribution and types of cables used, which differ in a number of features from the standards which have heretofore been followed in English installations.

We shall not attempt in this place to do more than to refer briefly to the article in question, as the descriptions of the different portions of the installation are so lucid and so complete that the reader will naturally prefer to obtain his information directly from them. We cannot refrain, however, from calling especial attention to the features outside the power station which will certainly attract comment, notably the third-rail system, in which a rectangular conductor is used, the automatic block-signal system and the design of rolling stock. As will be seen from the portion of the article devoted to the latter subject, the cars are provided with side doors somewhat similar to those used in Boston, but with a different arrangement of seats, and with the doors opened and closed by compressed air. Those for the District Railway—the subway portion of the route—are of wood, while the cars for the tube lines are of steel throughout. We feel confident that our readers will appreciate the action of Mr. Fortenbaugh in thus making public in so complete a way the details of this important installation, which can be compared in extent only to the immense systems of similar character in the metropolis of this country. They will also, we believe, appreciate the international character of this journal and its enterprise in securing and presenting to its readers the first official descriptions of all the important installations in the rapid transit field which have been made public. Thus, the first complete description of the Manhattan Elevated Railway and that of the New York Subway, not to mention other instances, first appeared in the columns of this paper.

Model Electric Car Wiring

Car wiring has long been considered as one of the vulnerable points in rolling-stock equipment. Rubber and braid, as usually applied in the insulation of wires, serve as a very inefficient protection when located in a position where they are subject to abrasion or other mechanical injury, and, if required to cope with the extreme conditions which are sometimes encountered in electric railway work, are liable to fail in emergencies.

While the measures which have been adopted in ordinary car construction have proved satisfactory for that purpose, the engineers of the Interborough Rapid Transit Company have for some time believed that their steel cars require a different treatment. Every precaution has been adopted against fire in any part of the equipment, and even against any slight electrical disturbance which would be of little consequence on a surface line, but which might be followed with panic and disastrous results in a subway. For this reason, most careful study was given to car wiring, with the result that the improvements which have been introduced eclipse anything that has been devised up to this time. The use of all-steel cars on the subway introduced a number of questions of novel character, as nothing was available beneath the car for supporting the wiring but the steel underframing members, so that a radical treatment of the question was required. The scheme finally adopted is described in an article by L. B. Stillwell in this issue, and is of the greatest interest as describing an important and commendable development in methods of wiring for electric cars. In brief, it consists in the adoption of the most improved principles of interior building wiring, inasmuch as each individual wire is not only protected from all possible mechanical injury, but also is so located that if accidentally grounded a dead short-circuit will occur at once, which will cause no other harm than that of blowing a fuse or opening a circuit breaker. Unlike interior conduit wiring for buildings, however, the wires have been given an additional protection against mechanical injury through vibration within the conduits, with the resultant chafing of insulation; the means adopted for securing this end provide also for keeping moisture out of the conduit tubes. Finally, arrangements for supporting the conduits have been carefully designed, and result in maintaining the system absolutely rigid. The methods described by Mr. Stillwell are of the greatest engineering value, and their accomplishment will go far to guide future development in the electrical equipment of motor cars.

Two-Motor vs. Four-Motor Equipments

The above title formed the subject matter of a paper read by N. McD. Crawford before the American Institute of Electrical Engineers. While the tests tabulated in the paper applied perhaps more especially to the local conditions governing street car traffic in Hartford, the general discussion of the paper brought out the relative merits of two and four-motor equipments in a broader light. A fair basis of comparison is, of course, to consider equipments of approximately the same total horse-power per car in each case. It is proper to assume that the manufacturers follow the same general lines in designing large and small motors, and that two 100-hp motors will perform the same service as four 50-hp motors with approximately the same temperature rise. On the basis of the same temperature rise, the two-motor equipment would benefit by the smaller number of motors and cost less for repairs. Given the cost of keeping a two-motor equipment in repair as, say, ½ cent per car-mile, the four-motor equipment, aggregating the same total horse-power, may run this expense up to 6-10 cents or even 7-10 cents per car-mile. The item of repairs, in fact, constitutes the only objection to the four-motor equipment, as the first cost is practically the same as that of a two-motor equipment.

The chief asset of the four-motor equipment is the increased traction which it makes available. For city service, with its frequent stops and demand for high-schedule speeds, this increased traction may permit an increase in the rate of acceleration sufficient to reduce materially the energy consumption of the car. In fact, local conditions may be such that the increased acceleration of the four-motor equipment may permit the use of a greater gear ratio and lower maximum speed for the same schedule performed. It is a well-known fact that the greatest gear ratio possible for a given schedule will call for the lowest energy consumption, and the saving effected in cost of power consumed may readily amount to enough to offset the increased cost of maintaining the four-motor equipment. A 20-ton car consuming 2-kw hours per car-mile with two motors may be operating under conditions where a four-motor equipment could perform the same service for 10 per cent less energy. At 1 cent per kw-hour, this saving of 2-10 cent per car-mile in energy consumed would pay for the extra cost of maintaining four motors and still leave them all the advantages of less weight per axle, smaller wheels, one step instead of a possible two, shorter wheel base and greater clearance over city streets. We regret that operating figures were not more fully entered into, as a carefully conducted series of tests along the lines indicated would be of much more value than the general statements made in the discussion of Mr. Crawford's paper.

It is seldom that figures have been available comparing the performance of two and four-motor equipments of the same aggregate horse-power, and four-motor equipments have often performed a given service with less temperature rise than two-motors previously used, due to the fact that more horse-power per car was installed, and not owing to any ability of smaller motors to dissipate internal losses more readily. In many instances the cost of maintaining four-motor equipments has been given as less than that of maintaining two-motor equipments, but we believe that this statement has seldom been made when both equipments were operating with the same temperature rise, which can only be the case if approximately the same total horse-power per car is installed. There is no reason to doubt the statement that four motors will cost more to maintain than two motors, as the cost of labor in winding an armature is but slightly greater with a 100-hp motor than in the case of a 50-hp, although the supplies, forming the greater item of motor upkeep, will be more nearly proportional to the capacity of the motor.

While the increased traction of the four-motor equipment gives promise of a better maintenance of schedule in all conditions of weather and track, and may permit a considerable reduction in energy consumed at the car, it further provides a means of increasing the carrying capacity upon badly congested city tracks without increasing the number of moving units by the use of trail cars. This phase of the subject is more fully discussed in the following editorial, under the title, "The Use of Trailers for Rush-Hour Service."

The increased traction provided by four-motor equipments has no material effect upon the energy consumption of suburban cars, as the losses in starting form but a small proportion of the total energy consumed in such infrequent stop service. There are, however, two reasons at least which give the four-motor equipment considerable advantage over the two-motor for suburban service. Owing to the infrequency of suburban cars, the complete disabling of a car becomes a serious matter. Four-motor equipments may have one motor disabled without in any way interfering with bringing the car back to the car houses at practically schedule speed. A two-motor equipment, however, is seriously handicapped if operated with a single motor, and if the suburban road contains grades of any extent, or if the tracks are in poor condition, it is probable that such a car would be completely stalled, an incident most strenuously to be avoided in the operation of suburban systems. Furthermore, if a car becomes disabled on a system employing two motors on double-truck cars, the limited tractive effort provided by the succeeding car may be insufficient under certain conditions to bring both cars to the car house without a considerable loss of time.

The high-schedule speed and comforts demanded by patrons of our suburban electric railway systems have made necessary the introduction of very heavy cars, running at speeds approaching in some cases 60 m.p.h. The motive power per car may total 500-hp, making the adoption of four-motor equipments absolutely necessary, as this horse-power capacity could not be introduced in two motors without an impossible diameter of wheel and length of wheel base. The very general adoption of four motors for suburban service seems well justified.

The field of the two-motor equipment seems to be more especially on lines employing trains of several motor cars succeeding each other at short time intervals and operating over tracks free from the congestion of city streets. As the train consists of several units, it becomes possible to cut out a disabled car without fatally reducing the rate of acceleration available. Furthermore, such roads operate trains at very frequent intervals, leaving little time for the accumulation of snow or sleet on the tracks, and hence track conditions may be assumed to be of the best at all times. Large diameter wheels, calling for two or more steps, offer no objections in such service, as platforms are generally used, and the capacity of motor per axle can be kept within the limits of reasonable weight and length of wheel base. For such service the two-motor equipment offers some slight advantage in lower first cost and lower cost of maintenance over a four-motor equipment of equal capacity, unless the service be of such a competitive character as to require extremely high rate of acceleration, calling for a tractive effort in excess of that available with the limited axles per train equipped.

The Use of Trailers for Rush-Hour Traffic

Closely associated with the problem of the two-motor vs. four-motor equipment for city service is the question of the operation of trail cars for rush-hour service. In the early days of electric railroading, long before double-truck cars came into use, the trailer was a regular part of the equipment of most roads. Even the old light motor equipments were made thus to do double duty, often to their misfortune. After a little while came the long car and steadily increasing demands for more power and speed, and it was found that as these requirements increased, the motors had trouble enough without the added burden of trailers. So the fashion gradually changed, the trailers went into retirement and the long car was the mainstay of the equipment. That it did its work well nobody doubts, but as time has gone on and the light motors of ten years ago have been replaced by heavier ones, the use of trailers, particularly as an emergency measure, has sometimes seemed desirable.

In our study of this question, we must first accept the axiom that nothing should be done at rush-hour periods to decrease the running speed. Trail cars will prove only a detriment if the trains run so slowly that the aggregate seat-miles per hour during the rush-hour service is no greater, or only slightly larger, than if single motor cars are used. But with the increased power from four-motor equipments there seems to be no reason why a four-motor car should not haul a light trailer, on city streets with light grades, with no appreciable diminution of the schedule speed.

The question of increased capacity at rush hours is a very broad one, and there is more than one solution which does not involve a reduction in headway. Multiple-unit trains with either a master controller, or two cars with a two-car controller, or long cars for rush-hour service with short cars for intermediate service are at least theoretically possible, but the use of trailers possesses one or two conspicuous advantages for this service over any of those mentioned. They are lighter and less expensive to maintain than an extra motor car of the same capacity would be, and their first cost is considerably less. As regards their safety, when compared with individual motor cars, the testimony is contradictory. Trailers have been used extensively for electric service in only one city in this country, and the experience there as regards accidents has not been very favorable. On the other hand, the records of the German Street Railway Association show that in Germany, where trail cars are in very general use, the proportion of accidents attributable to them is very much smaller than with individual motor cars. There was a general feeling also, at the last meeting of the International Street Railway Verein in Vienna, that the municipal authorities were gradually giving up their antagonism to trail cars. In fact, the crux of the discussion related not so much to accidents but to the possible saving incident to their use. It is noteworthy also that trail cars are successfully used on the Continent even in the older cities, with their accompanying narrow and crooked streets.

If trailers are to be employed, it strikes us that there is no great difficulty in making them entirely safe if they are deliberately planned for use as such. Danger, if danger there be, comes from coupling cars together without provision for the safe entrance and exit of passengers. The point which should be looked out for carefully is the space between the pairs of cars, where there is risk of getting under the wheels of the second car, and the entrances and exits at this point should be carefully guarded. Now this trouble is largely constructional, and in our opinion could be remedied by proper design. A trailer ought to be so planned as to constitute an integral part of the train, and not a mere extra car towed in any way that comes handy. With a mechanical guard between the two cars, such as was formerly used on cable cars, and with Minneapolis gates for all platforms, or with possibly no forward entrance to the trailer, this danger ought to be reduced to a minimum. In other words, the desideratum is a highly specialized trailer designed for that purpose only, and therefore used under the most favorable conditions. Treated in this way, the trailer would greatly add to the capacity of a road whenever necessary and would effect a very considerable saving in the total cost of rolling stock and operating charges as well. It would give a reduction of the operating force during the rush-hour service by one-third or one-half, depending upon whether a conductor is used on the trail car, and a gain in headway owing to a doubling of the capacity of the moving unit without decreasing the clearance between the trains. Against the latter again there is the question of increased stops owing to the greater capacity of the train unit, although in amount this would depend on local conditions according to the number of stops necessarily made by a single motor car.

The advantage of using trail cars is not confined to city service, but applies equally, if not to a greater degree, to suburban systems. Although the time interval between cars is greater on suburban roads, many of these are single track and demand a considerable interval between trains, in order to minimize the meeting of trains, with the consequent delay incident thereto.

We hold no brief for the trail car and admit that the question is one which has not yet been satisfactorily solved. Nevertheless, at least two large cities are conducting experiments to determine the value of this system of operation for city traffic, and any light upon it would be welcome.

THE ELECTRIFICATION OF THE LONDON UNDERGROUND ELECTRIC RAILWAYS COMPANY'S SYSTEM

BY S. B. FORTENBAUGH,
Electrical Engineer, Underground Electric Railways Company, Ltd.

By way of introduction to this article, particularly for those not entirely familiar with the London traffic conditions, it seems advisable to present first a brief history and general description of the various independent railways included in this undertaking, and more particularly with reference to the Metropolitan District Railway. The Underground Electric Railways Company of London, Ltd., was incorporated April 9, 1902, for the purpose of supplying and distributing power to a number of electric railways in London, and is under the control and management of the well-known financier and operator, Charles T. Yerkes. All work in connection with the electrification of the Metropolitan District and other railways controlled by the Underground Electric Railways Company is being executed under the direction and personal supervision of James R. Chapman, general manager and chief engineer.

The accompanying map, Fig. 1, shows all the various roads, including such parts of the Metropolitan and other railways over which the Metropolitan District trains have running powers, as well as the relative location of the generating station and the twenty-four sub-stations included in the general scheme. The number of independent roads to be supplied with power by this company, mileage, etc., is given in the accompanying table.

The longest continuous run is from Barking to Uxbridge, the length of this run and the average distance between stations being 29.73 miles and 3650 ft., respectively,

The corresponding figures for the "Circle" portion are 13.07 miles and 2556 ft., respectively, over which route the schedule speed will be about 15.5 m.p.h.

All the necessary power for the above roads, exclusive of the Metropolitan portion of the "Circle" and the Harrow and Uxbridge extension, will be supplied from the Chelsea generating station. This station, together with the cable installation, sub-stations, track work, rolling stock, etc., required for the operation of the Metropolitan District Railway, will be completed and electric traction substituted for the present steam service early in 1905. The Baker Street & Waterloo "Tube" Railway will probably be opened for passenger traffic toward the close of 1905, the Great Northern, Piccadilly & Brompton about the middle of the year 1906, and the Charing Cross, Euston & Hampstead toward the latter part of the year 1906.

TABLE SHOWING RAILWAYS TO BE SUPPLIED WITH ELECTRIC POWER BY THE UNDERGROUND ELECTRIC RAILWAYS CO.

Railways.	Miles of double track.	No. of passenger stations.	Average Dist. bet. stations feet.	Average Schedul Speede M. P. H.
Metropolitan District Railway.	*56.07	77	3,125	17.0
Great Northern, Piccadilly & Brompton Railway	10.41	22	2,620	14.0
Charing Cross, Euston & Hampstead Railway	8.02	17	2,640	14.0
Baker Street & Waterloo Railway	4.45	11	2,350	14.0
Edgware & Hampstead Railway	**4.70			

* Includes District mileage and all other lines over which the District Railway has running powers i. e., the upper or Metropolitan portion of the "Circle" (8.35 miles), Metropolitan extension from South Harrow to Uxbridge (6.18 miles), lines jointly owned by the District Railway and all contingent lines now being electrified.

** Light railway and virtually an extension of the Charing Cross, Euston & Hempstead Tube Railway, beyond Golders Green.

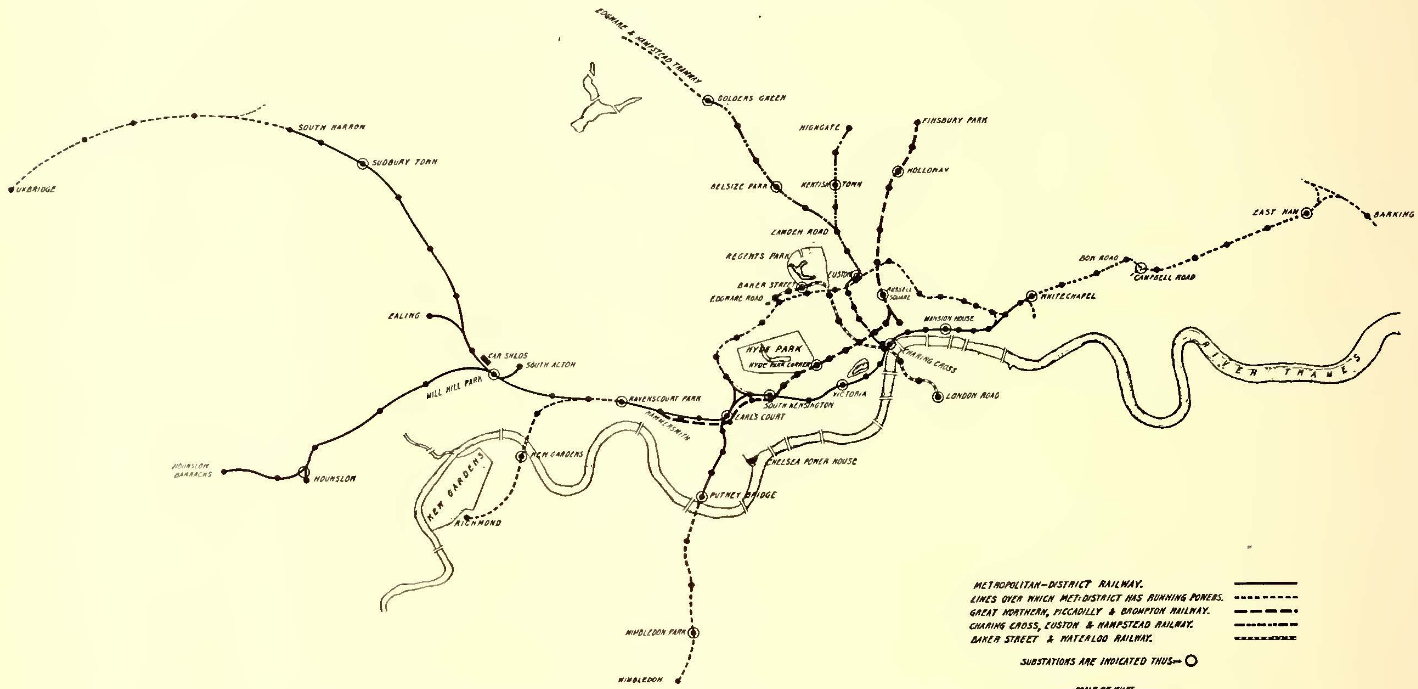


FIG. 1.—NETWORK OF THE UNDERGROUND ELECTRIC RAILWAYS COMPANY, LIMITED, OF LONDON

METROPOLITAN DISTRICT RAILWAY

About 1.2 miles of the Metropolitan District Railway was first opened for passenger traffic in October, 1868, and from that date until June, 1903, there have been, at irregular intervals, various additions and extensions of "running powers," the total length of double track over which these trains will operate when electrified being about 56 miles. Approximately one-fourth of the above mileage is of shallow tunnel construction, substantially as shown in Fig. 2, with inadequate ventilation, and consequently more or less discomfort to passengers. The electrification will free this line of smoke, sulphur and dirt, and at the same time increase the maximum possible number of trains per hour in each direction from eighteen to forty and the average schedule speed from approximately 12.3 m.p.h. to 17 m.p.h. It is expected that these changes will add greatly to the comfort and convenience of the public, more than double the present traffic and in a comparatively short time bring prosperity to a road, the present condition of which is anything but satisfactory. From 1878 to 1882 a dividend was paid on the ordinary stock at rates varying from ½ per cent to 1¼ per cent per annum, but since that time the ordinary shareholders have received no return.

In 1897 and again in 1900, the District Railway Company obtained parliamentary powers authorizing a change from steam to electric traction, and in 1898, jointly with the Metropolitan Railway, decided to electrically equip and operate experimentally .76 of a mile of double track between the Earls Court and High Street Kensington stations. The equipment and installation of the temporary power house, experimental train, track work, etc., necessitated an expenditure of about £22,000, a very costly experiment to demonstrate that electricity could be successfully introduced as the motive power in lieu of steam, particularly in view of the fact that direct-current installations had been in successful commercial operation for some years, both in Great Britain and in America.

The experimental train consisted of six cars—two end motor cars and four trailers—the weight of each motor car and the unloaded train being 54 tons and 180 English tons, respectively. In all the experiments which were made, the leading motor car only was used, the trailing motor car running idle.

Specifications covering the electrification of the "Inner Circle" (13.07 miles) were issued in August, 1900, by the electrical traction joint committee of the Metropolitan and Metropolitan District Railways, and in January, 1901, the committee recommended the acceptance of the three-phase system of electric traction as proposed by Ganz & Company, of Buda-Pest. The essential features of this proposition were the supply of three-phase, 12,000-volt, a. c. current to a number of sub-stations equipped with static transformers, the employment of three working conductors, two overhead, for distributing current to the trains at 3000 volts pressure, and two groups of three-phase motors per car, with water rheostatic control, these to be arranged for a combination of the "cascade" and parallel system of connections. Mr. Yerkes became interested in the District Railway just about the time of this report favoring the adoption of the Ganz system, and immediately decided to adhere to the almost universal direct-current practice rather than risk

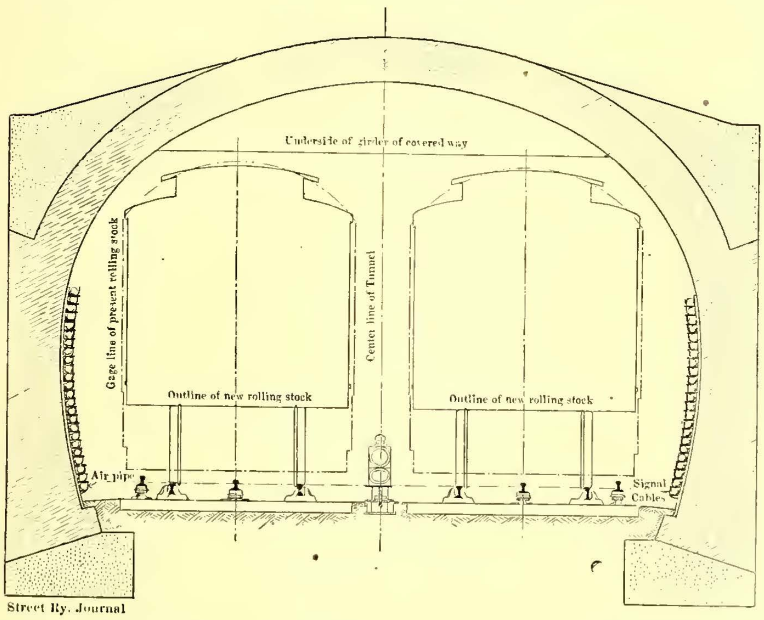


FIG. 2.—CROSS SECTION OF DISTRICT RAILWAY TUNNEL, SHOWING ARRANGEMENT OF CONDUCTOR RAILS AND HIGH-TENSION CABLES ON TUNNEL WALLS
Scale—⅛ in. = 1 ft.

the comparatively untried system for such an extensive and exacting service. It was essential that the Metropolitan and Metropolitan District Railways—two separate and distinct organizations operating over each other's tracks and physically united by the continuous track forming the "Inner Circle"—should use the same system of electric traction over at least a portion of the total mileage controlled by them. It was therefore necessary to appeal to arbitration, under the auspices of the Board of Trade, for the choice of system to be adopted, as each company was committed to its respective system and there

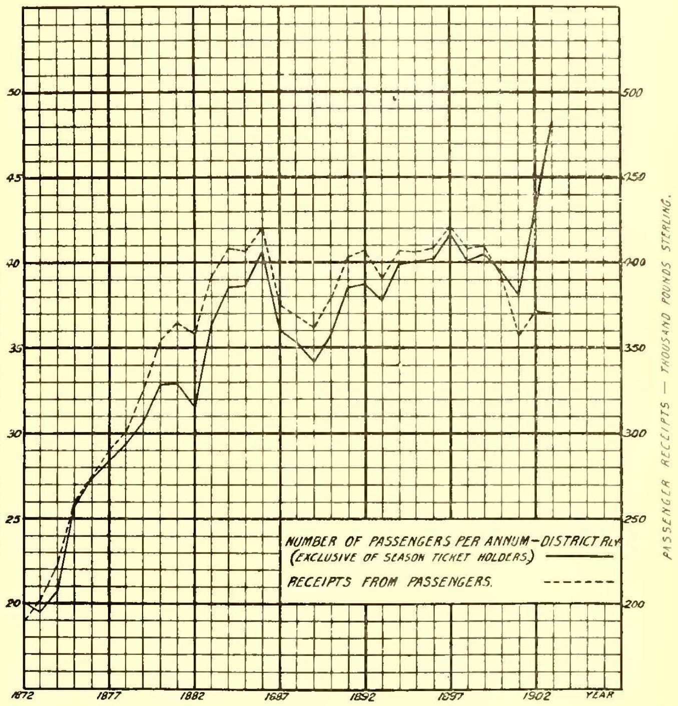


FIG. 3.—PASSENGERS AND RECEIPTS, DISTRICT RAILWAY

seemed no possibility of a compromise. The arbitration proceedings began Oct. 7, 1901, and toward the end of the following month a decision was finally given in favor of the direct-current system, as proposed by the District Railway, and which is now being installed in harmony by both companies.

Fig. 3 shows graphically the total number of passengers carried per annum, exclusive of season ticket holders, and the receipts therefrom. With the advent of the new management came timely and repeated reduction in fares, resulting in the rapid and unprecedented increase in the number of passengers carried during the last two years.

TUBE RAILWAYS

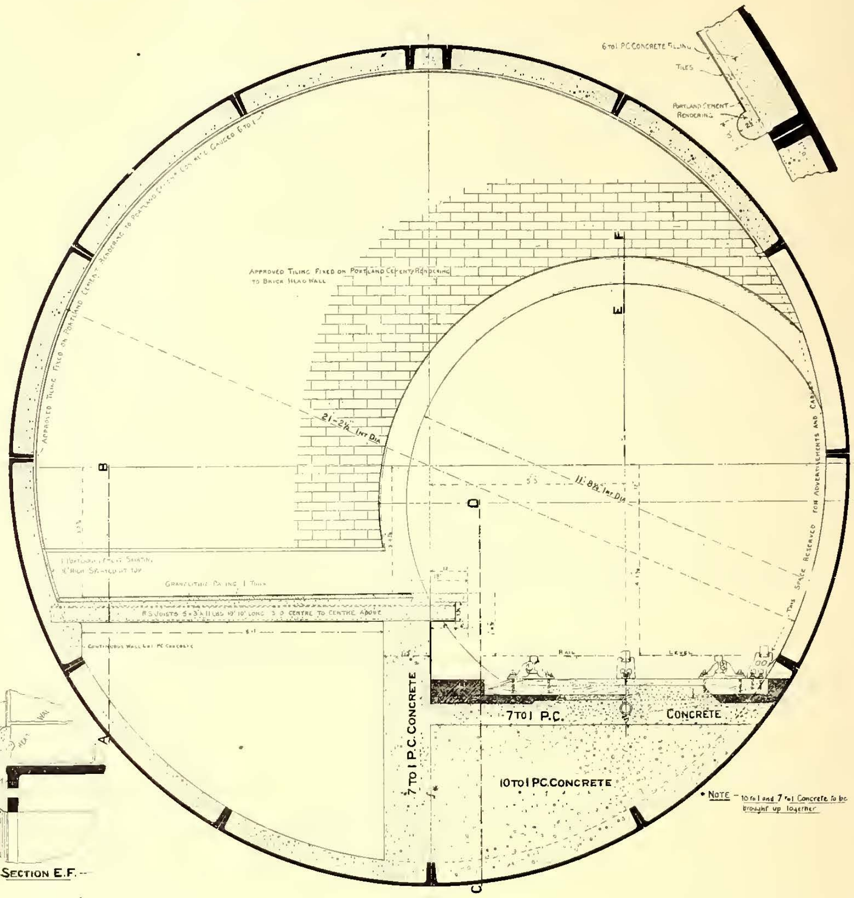
The accompanying map shows the relative direction and extent of the deep level "tube" roads now being constructed by this company underneath the streets of London, and Fig. 4 a type section. All these lines are being built with cast-iron linings at an average depth of about 70 ft. below the surface, the variation in depth depending upon local conditions and ranging from 30 ft. to 185 ft. A grand total of approximately 170 lifts will be required for these roads, these to be electrically operated by direct current at 550 volts to 600 volts pressure, and each capable of carrying a load of 10,000 lbs. continuously in either direction at a speed of 200 ft. per minute. Practically all the lift shafts will be 23 ft. in diameter, with two lifts per shaft, the openings to and from the lift cages being on opposite sides of the shafts so as to facilitate the rapid loading and unloading of passengers. Electrically-operated blower sets will be installed at practically every passenger station for ventilating purposes, each set being capable of removing 20,000 cu. ft. of air per minute. It is estimated that the number of passengers carried on these tube roads will reach 150,000,000 per annum.

CHELSEA GENERATING STATION

The site comprises 3.67 acres of land, with a frontage of 1100 ft. and 824 ft. on the Thames River and Lots Road sides, respectively, the outline of the property and general arrangement of buildings being shown in Fig. 5. The main building is entirely of fireproof construction, without ornamental features, and consists of a self-supporting steel frame, weighing about 6000 tons, enclosed with brick and terra-cotta. It is 453.5 ft. long, 175 ft. wide, 140 ft. in height from the ground floor to the peak of the boiler room roof, and is divided longitudinally by a brick wall. The inside dimensions of the engine and boiler room are 72.5 ft. and 96.5 ft., respectively. Figs. 6, 7, 8 and 9 show the general appearance of the building during the various stages of construction, and Figs. 10 and 11 the east and Thames River elevations, respectively.

There are four chimneys built of Custodis brick, each 19 ft. internal diameter and 275 ft. high. Concrete, expanded metal and asphalt are used in the construction of the roof and all floors, other than the engine room, which is floored with checkered steel plates. Figs. 12 and 13 show, respectively, a cross section and plan of the engine and boiler rooms, with the general arrangement of apparatus, steam and exhaust piping.

Great care was necessary in the construction of the concrete piers and foundations required for the support of the building, chimneys, dock walls and turbo-alternators. A grand total of approximately 220 piers were required, these being carried down to the London clay at an average depth of 30 ft. to 35 ft. below the ground floor level. An aggregate of about 40,000 cu. yds. of concrete was used in the construction of these foundations, necessitating over 100,000 cu. yds. of excavation. The building is arranged for ten 5500-kw turbo-alternators and one split unit of 2700 kw, a total normal full load capacity of 57,700 kw. On this basis the cubic feet per kilowatt (including office building) is 139, and the square feet per kilowatt is 1.36.



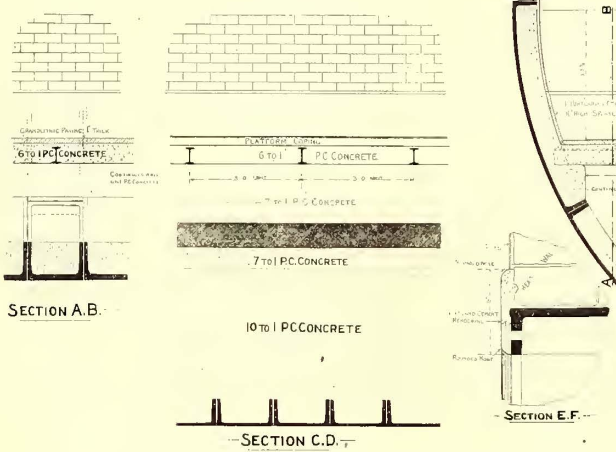


FIG. 4.—TYPICAL CROSS SECTION OF TUNNEL, SHOWING PLATFORM, TILING, CONCRETING, ETC.

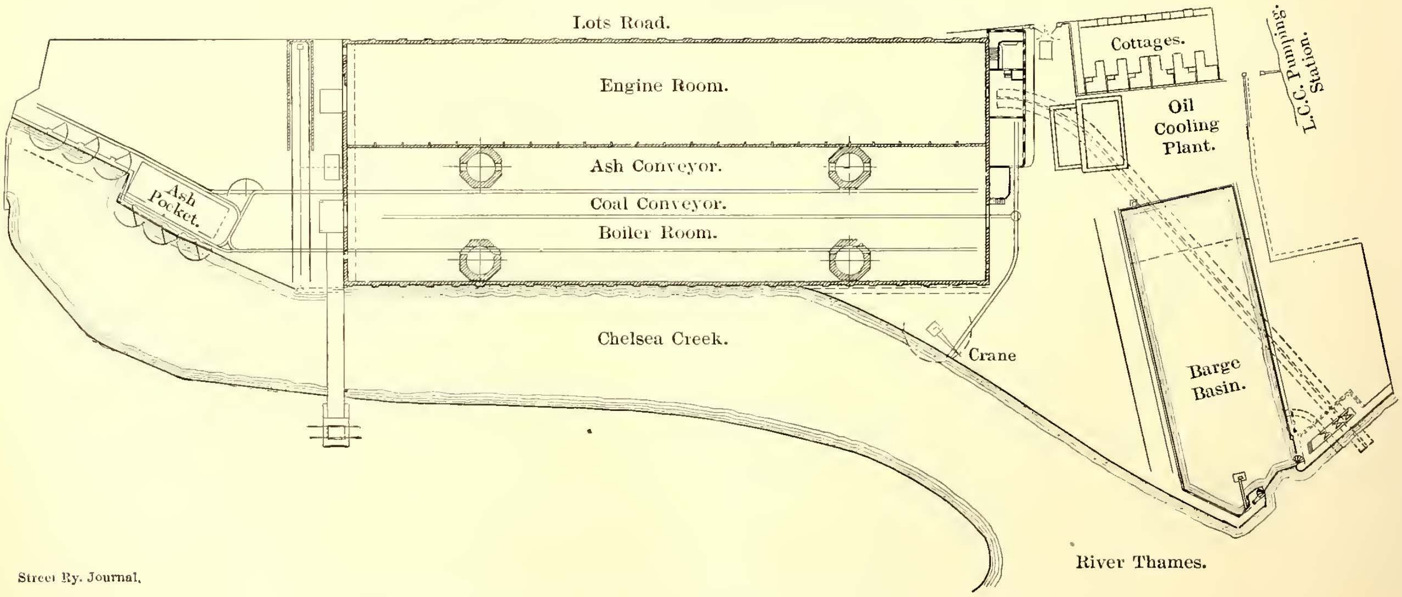


FIG. 5.—OUTLINE OF PROPERTY, CHELSEA GENERATING STATION

STEAM PLANT

The boiler room is designed for an ultimate equipment of eighty Babcock & Wilcox horizontal water-tube boilers, each boiler having 5212 sq. ft. of heating surface and 672 sq. ft. of superheating surface.

They are carried directly on the steel frame of the building, entirely independent of the brick work, arranged two stories high, and are piped in groups of eight, with no steam connections between the several groups, except one supplemental header between two groups for supplying steam to the exciter engines, air compressor and house pump. With this exception, the main generators are arranged on the "unit" system, each unit consisting of one turbo-alternator and condenser, eight boilers and one boiler feed-pump.

The working pressure is 175 lbs. with 150 degs. of superheat, the steam from each group being collected in one header and led direct to its turbine.

Each boiler is fitted with two electrically-operated Babcock & Wilcox chain-grate stokers, the two grates having 85 sq. ft. of surface. A general view of the boiler room and apparatus is shown in Figs. 14 and 15.

A large tank in the oil-cooling house is used for the storage of feed-water, this tank being supplied either from an artesian well on the premises or from the city mains. River water can be turned into a secondary suction pipe connected to each pump in the event of failure from both the above sources of supply.

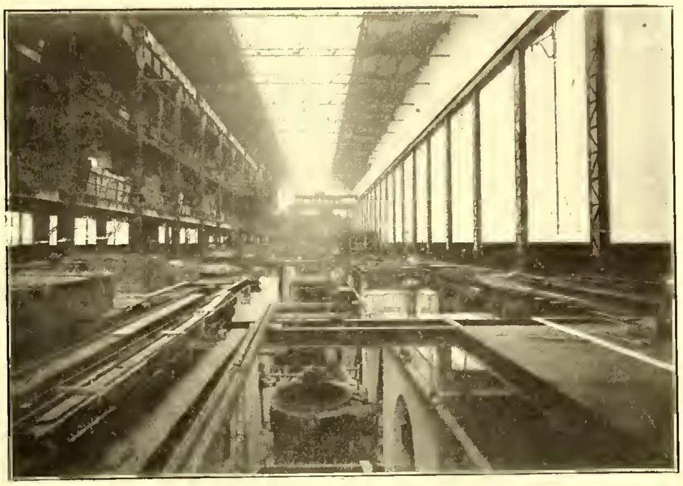


FIG. 8.—CONDENSER PITS AND APPARATUS

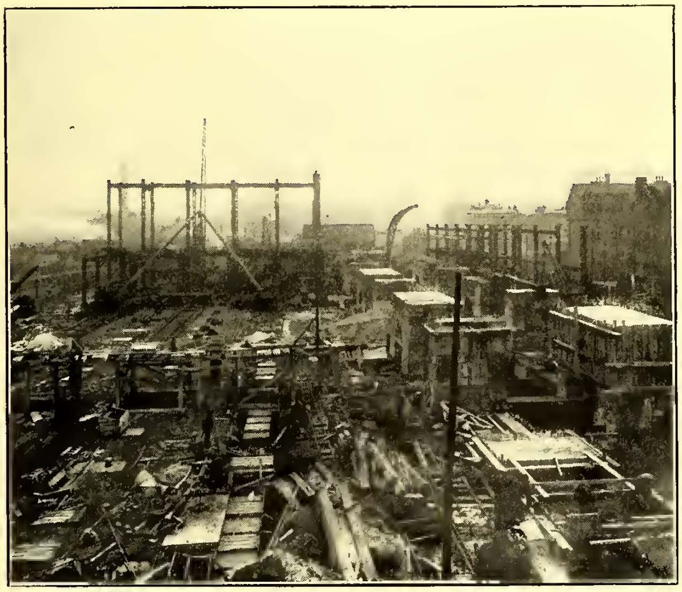


FIG. 6.—ENGINE AND BUILDING FOUNDATIONS, CHELSEA GENERATING STATION, LOOKING WEST

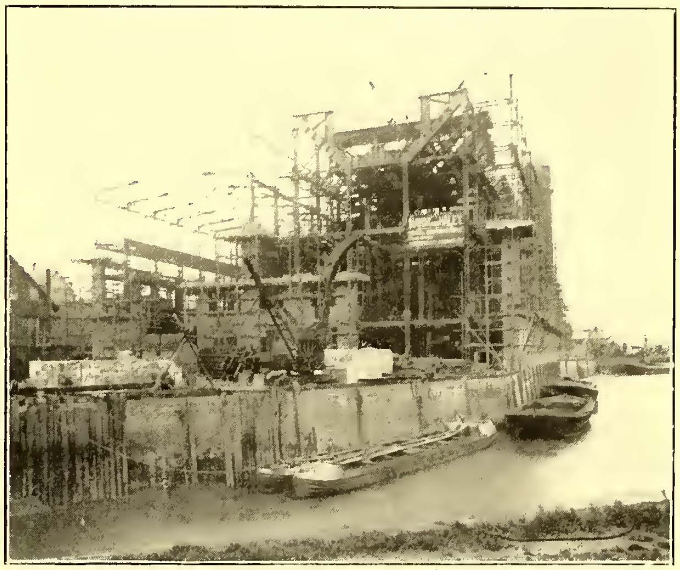


FIG. 7.—THAMES RIVER ELEVATION, WEST END

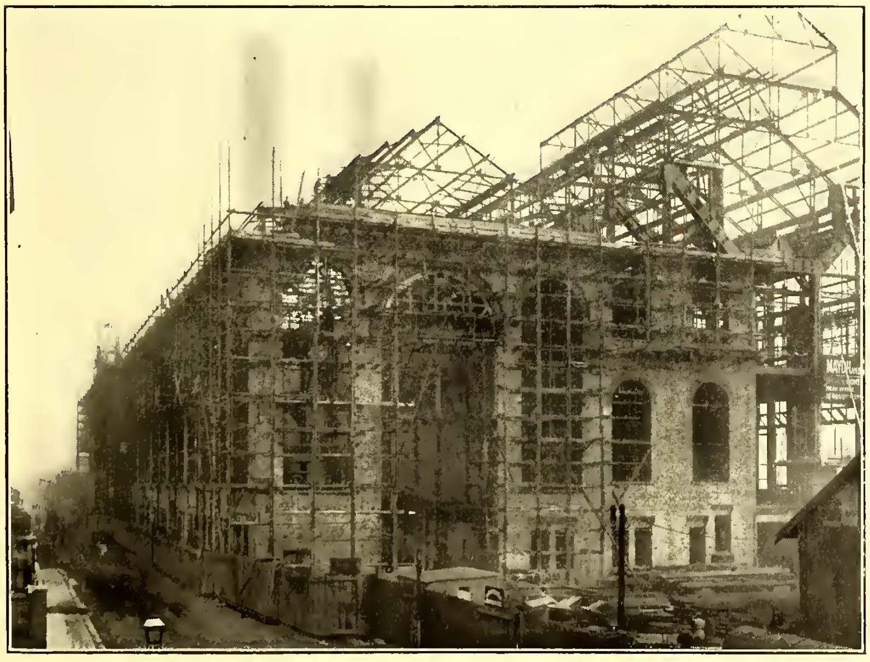


FIG. 9.—WEST ELEVATION OF CHELSEA GENERATING STATION

The boiler feed-pumps are located on the basement floor and supply ring mains on both boiler room floors. While each pump has sufficient capacity for two groups of boilers, the arrangement is such that for test purposes one pump will supply the group from which its steam is obtained. Under normal conditions only alternate pumps will be in service. Each ring main header is supplied by two pumps and so arranged that either pump may supply either of two groups or both when the turbines are running on light load.

Green economizers are installed, these being constructed with tubes further apart than the usual practice, and arranged in nests behind each group of boilers with the usual by-pass flues, 1540 sq. ft. of heating surface being provided for each boiler.

All the brick work for the boilers, economizers and flues is carried on the steel frame.

Vertical condensers, each with 15,000 sq. ft. of cooling surface, are located in pits between the engine foundations, and are designed to work on the dry vacuum principle, the air and condensed water pumps being separate.

The circulating water is supplied by two 66-in. pipes, which extend to the edge of the Thames channel, and are arranged on the syphonic principle. The intake and discharge mains are

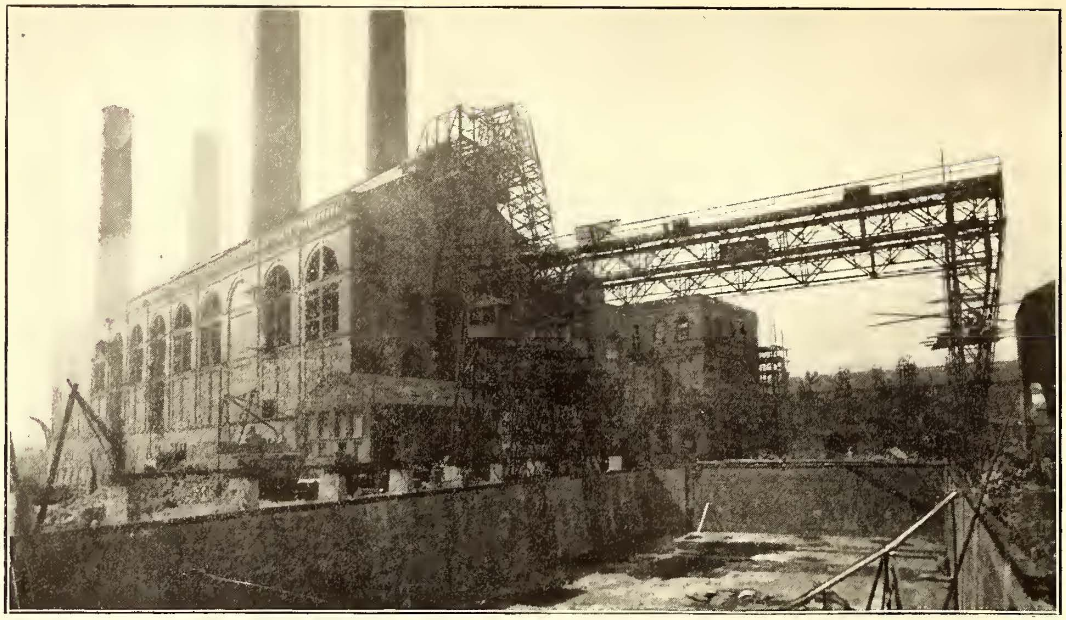


FIG. 10.—EAST ELEVATION OF CHELSEA GENERATING STATION

further arranged for reversible flow, so as to dispose of any sediment which may collect, there being no screens at the mouth of the pipes to stop floating material.

Provision has been made for the delivery of coal either by barge or rail and at opposite ends of the building. Barge coal will be received at the east end of the building, unloaded by two traveling cranes spanning the barge basin and weighed in the tower constructed on each of these cranes. From the weighing machines it falls on to the belt conveyor, passes through the coal crushers and is thence raised 140 ft. by duplicate inclined elevators to the coal conveyors in the top of the building. Rail coal will be taken from a hopper under the coal cars by an inclined elevator at the west end of the building, and in either case the distribution over the coal bunkers is made by duplicate belt conveyors so arranged that the direction of travel of either belt can be reversed as required. The storage capacity of the bunkers is 15,000 tons and the average daily consumption will be about 800 tons.

The ashes will drop into self-dumping skips and be removed by a storage-battery locomotive to the dock wall at the west end

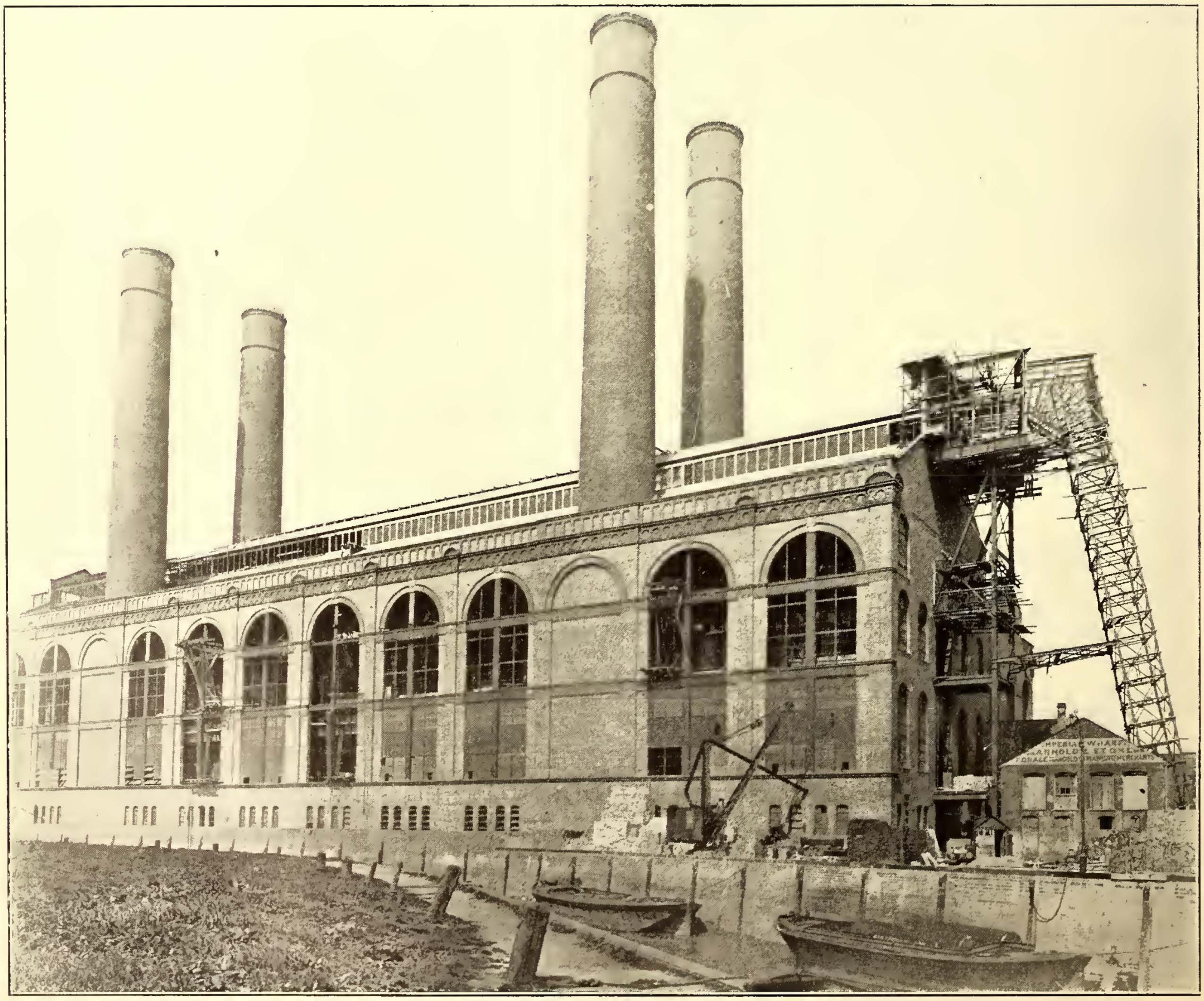


FIG. 11.—RIVER ELEVATION OF CHELSEA GENERATING STATION

of the premises, thence loaded into barges by pneumatic hoists or stored in the ash pocket if no barge is available. The coal handling apparatus at the east end of the building is illustrated in Figs. 16, 17, 18 and 19, and the construction of the coal bunkers in Fig. 20.

An oil-cooling plant, with a total capacity of about 20,000 gals., has been erected adjacent to the main building, and contains three coolers, each of which has approximately 686 sq. ft. of cooling surface. The oil flows by gravity from the storage tanks in the top of the oil house through the engine bearings back to a second set of tanks in the basement, and from which it is forced by centrifugal pumps, through the coolers, to the tanks located in the top of the building.

The working capacity of this plant is 350 gals. of oil per minute, about 5 per cent of which is by-passed through filters.

TURBO-ALTERNATOR SETS

The turbo-alternators are of Westinghouse manufacture and consist of a single-cylinder, double-flow, steam turbine direct connected to a rotating field, turbo-generator. The present installation will consist of eight units, the normal full load of each machine being 5500 kw, with a guaranteed overload capacity of 50 per cent for two hours. The coupling connecting the turbine and generator is of the flexible claw type of forged steel and runs in oil. This coupling, although transmitting the full power of the shaft, has sufficient latitude to allow the generator and turbine shafts to revolve about independent centers without the one affecting the other. Fig. 21 shows the general arrangement of the turbo-alternator complete, mounted upon its own cast-iron bed-plate.

TURBINES

These machines are designed to operate at a speed of 1000 r. p. m. with a steam pressure at the throttle of 165 lbs. per square inch and 100 degs. F. of superheat. When operating under these conditions and exhausting into a vacuum of 26 ins. and 27 ins. of mercury, the approximate steam consumption per electrical horse-power per hour is as follows:

Output		Pounds of Steam per E. H. P. per hour	
		26" Vacuum	27" Vacuum
One and one-quarter load..	6,875 kw.	16	13.6
Full load	5,500 kw.	15.6	13.2
Three-quarter load	4,125 kw.	17.2	15.0
One-half load	2,750 kw.	18.4	16.0

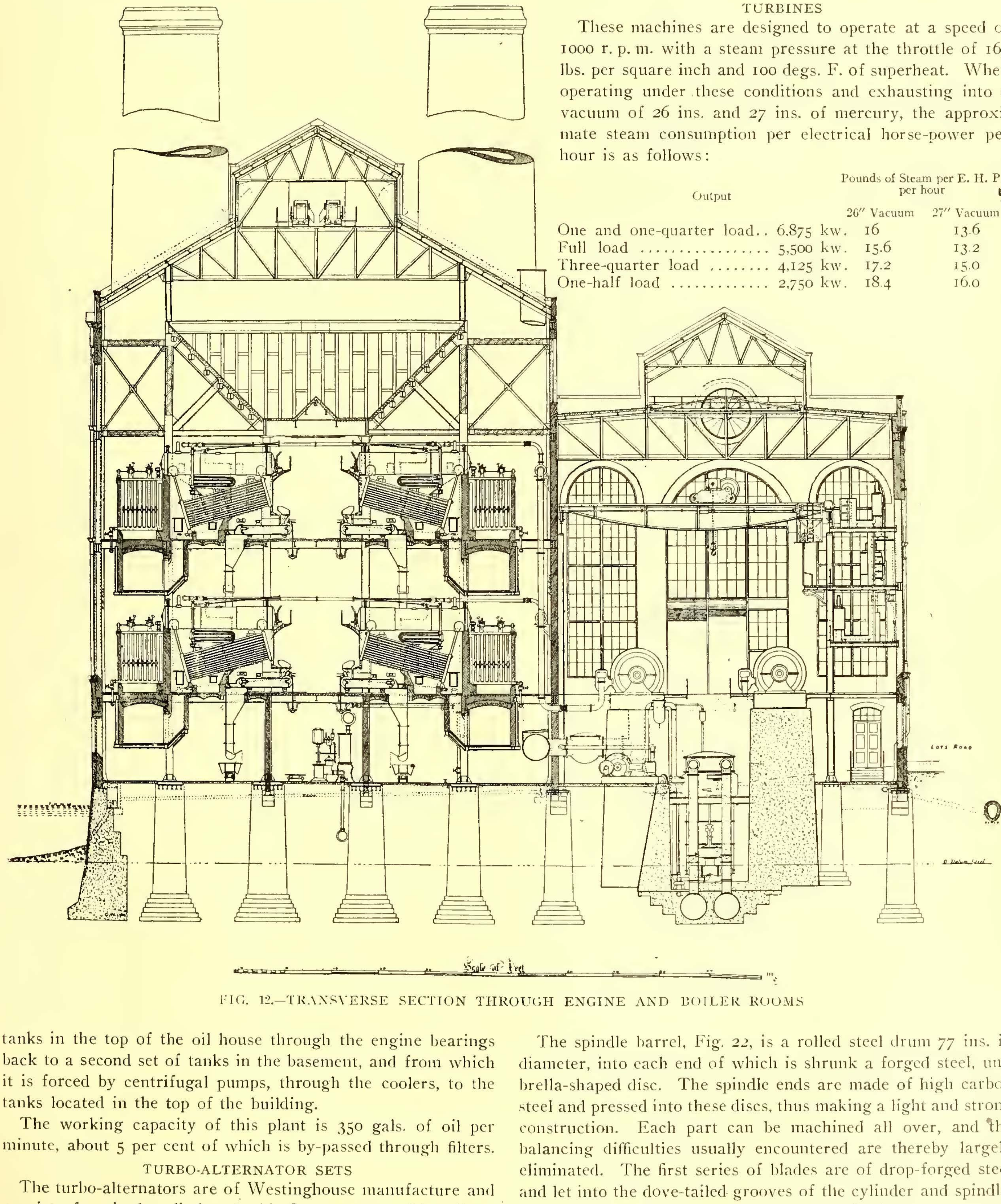


FIG. 12.—TRANSVERSE SECTION THROUGH ENGINE AND BOILER ROOMS

The spindle barrel, Fig. 22, is a rolled steel drum 77 ins. in diameter, into each end of which is shrunk a forged steel, umbrella-shaped disc. The spindle ends are made of high carbon steel and pressed into these discs, thus making a light and strong construction. Each part can be machined all over, and the balancing difficulties usually encountered are thereby largely eliminated. The first series of blades are of drop-forged steel and let into the dove-tailed grooves of the cylinder and spindle. The low-pressure blades are constructed of delta metal so as to prevent any corrosion due to wet steam at the point. The cylinder is of ordinary close-grained cast iron. Steam enters

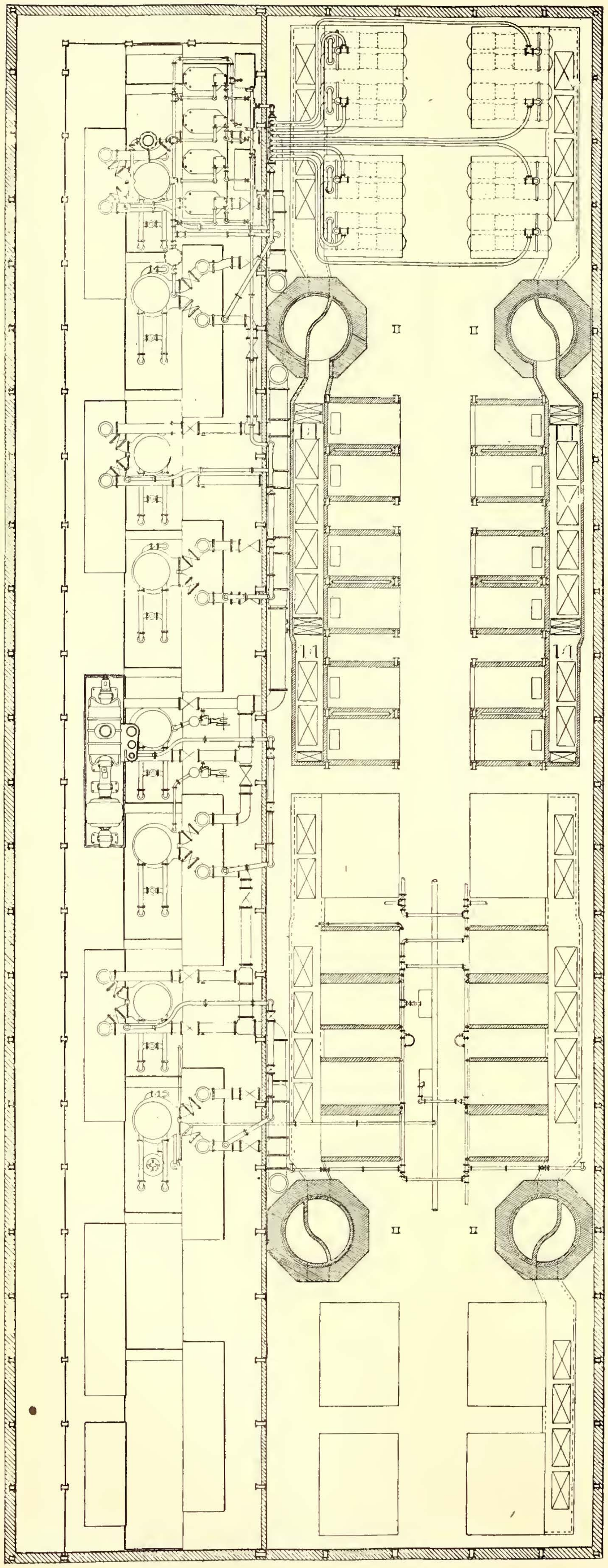


FIG. 13.—DIAGRAM SHOWING ARRANGEMENT OF STEAM AND EXHAUST PIPING, CHELSEA GENERATING STATION

through a main stop valve of the disc type, which is operated by gear wheels connected to handles on the platform, then passes through an emergency shut-down valve, steam strainer and governor valve of the double-seat poppet type into the center of the cylinder. A centrifugal governor directly driven through gearing from the turbine shaft operates this poppet valve through a small steam relay, and the admission valve is therefore under the direct control of the speed of the turbine. An emergency governor is fitted at the opposite end of the spindle to which the centrifugal governor is attached, and is set so that, should anything happen to the governor and the speed of the turbine reach a predetermined maximum, this governor comes into operation and opens a small valve, which closes the emergency throttle valve before referred to. From the center of the cylinder the steam issues through a series of nozzles and impulse blades (until it has been expanded to about atmospheric pressure), and thence through a series of blades, on the Parsons principle, to the exhaust at either end. Each turbine, in addition to the condenser connections, will have an atmospheric exhaust connection to one of the four 60-in. free exhaust pipes rising from the basement up through the roof. The steam entering at the center and flowing both ways will eliminate end thrusts and keep the shaft in equilibrium, but a thrust block is provided at the extreme end of the cylinder for the adjustment of the spindle relative to the cylinder. About 30 gals. of oil per minute will be supplied from the central gravity oiling system to the bearings of each machine, the bearings being provided with an emergency water-jacket requiring approximately 40 gals. of cooling water at 65 degs. F. per minute. The speed may be varied 10 per cent above or below the normal without otherwise disturbing the operation of the turbine, this adjustment being made electrically from the generator control board. The maximum variation in speed will not exceed 5 per cent when the full load is instantly thrown off the machine, and when operating under normal conditions the variation will not be greater than two and one-half natural degrees in one revolution.

GENERATORS

The normal output of the alternators is 5500 kw—i. e., 289 amps. per phase at 11,000 volts on non-inductive load. These are four-pole machines, with the armature stationary and exterior to the field, and are wound for three-phase current, the frequency being 33⅓ cycles per second. The revolving field, Fig. 23, is made from a solid forging of Whitworth fluid pressed steel, having high magnetic properties combined with strength. This steel is manufactured from the best brands of Swedish iron, melted in a Siemens-Martin furnace, then run into an extra strong and specially prepared steel mold and subjected, while still in a fluid state, to hydraulic pressure so as to obtain a better casting than is possible when done in the ordinary way. These castings are then reheated and forged by a powerful hydraulic press so as to insure the metal being thoroughly and uniformly worked, rough machined and carefully annealed before the finishing machine work is done. The normal excitation current is about 180 amps. when the armature is delivering its full current of 289 amps. per phase at 11,000 volts pressure and unity power factor. The armature winding consists of copper bars in partially closed slots, and is of the "built-up" type, with nine slots per phase per pole. After completion, the insulation of the armature winding from the main frame is subjected to a puncture test of 30,000 volts for one minute. Figs. 24 and 25 illustrate, respectively, the armature construction of the turbo-alternator and a general view of the alternators in the engine room. The guaranteed electrical efficiencies of these machines on non-inductive load is as follows:

Full load	97.25 per cent
Three-quarter load	96.50 "
One-half load	95.00 "
One-quarter load ..	90.00 "

When full load is thrown off the machine, the rise in electromotive force is approximately 6 per cent at unity power factor with constant speed and excitation. The temperature rise in any part of the machine will not exceed 35 degs. C. when operating under the above conditions.

EXCITER SETS

The exciter engines are of the compound, two-crank, double-acting, vertical-enclosed, high-speed type with forced lubrication, and were supplied by W. H. Allen, Son & Company. These engines are capable of indicating 200 hp with a steam pressure of 165 lbs. and 100 degs. superheat when exhausting into a condenser with a vacuum 4 ins. less than the barometric pressure. They operate at a speed of 375 r. p. m. and are direct connected to British Thomson-Houston 125-kw, 125-volt, compound-wound generators. Four of the above sets comprise the exciter system, these machines to be used for excitation only under normal conditions.

AUXILIARIES

The auxiliary electrical installation includes one 125-kw synchronous motor-generator set, nine single-phase 11,000-220-volt transformers, aggregating 1500 kw, and two small 125-volt storage batteries. The motor-generator set consists of a 125-kw, 125-volt, compound-wound, d. c. generator direct connected to a 220-volt, three-phase synchronous motor, and will be used primarily for charging the storage batteries and the supply of direct current for miscellaneous purposes. The transformers supply power to motor-generator set and the 220-volt, three-phase induction motors operating the various pumps, coal-handling machinery, stoker mechanism, etc., the storage batteries supplying current for operating the oil-switch motors.

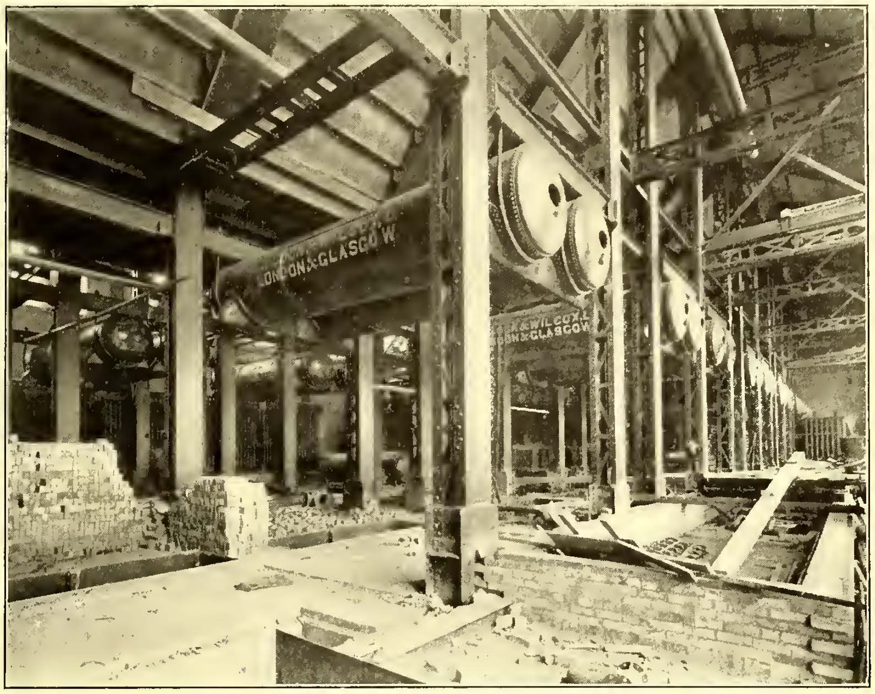


FIG. 14.—BOILERS AND ECONOMIZERS IN PROCESS OF ERECTION

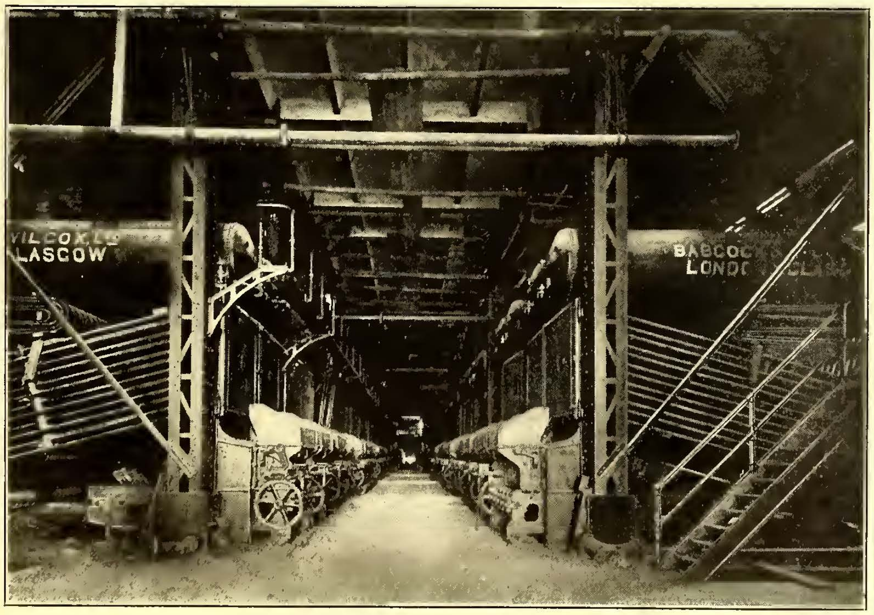


FIG. 15.—BOILERS AND CHAIN GRATE STOKERS IN PROCESS OF ERECTION

HIGH-TENSION SWITCHBOARD

All the equipment for both the main and auxiliary switchboards has been supplied by the British Thomson-Houston Company, this apparatus being essentially of standard Schenectady design and construction. Fig. 30 shows a general diagram of the main 11,000-volt circuits, and Fig. 31 is a similar diagram, showing the arrangement adopted by the Rapid Transit Subway Construction Company, of New York. This latter is reproduced from the STREET RAILWAY JOURNAL of Oct. 8, 1904, for easy comparison with the scheme adopted by this company, as the two stations probably represent the latest practice in Great Britain and America. Constructed for the same purpose, equipped with similar switching apparatus, and essentially of the same magnitude, this comparison should be an interesting one, particularly in view of the recent discussion by the American Institute of Electrical Engineers on "The Use of Group Switches in Large Power Plants." Only one set of main bus-bars is installed, and therefore the two generator selector switches and one group switch are not required. Bus junction switches are used, however, so that it is possible for the main bus-bars to be divided into five sections and the generators operated in groups of two or all in parallel if desired. The feeder cables are in duplicate, and so arranged that no two cables to the same sub-station are connected to the same set of feeder bus-bars, or—with two exceptions—to the same section of the main bus-bars. In no case are the cables to adjacent sub-stations on the same group switch, and all duplicate feeder cables are, furthermore, symmetrically arranged on opposite sides of the center point of the main bus-bars. For example, this latter feature is clearly illustrated in the general diagram of connections by the position of the feeder cables to the Earls Court and Holloway sub-stations. The general arrangement of the high-tension switching apparatus therefore provides that any of the generators, group switches or individual sections of the main bus-bars may be shut down without seriously interfering with the operation of the system. Motor-operated, type-H oil switches are used for the control of all 11,000-volt alternating-current circuits, the normal capacities being 1200 amps., 500 amps. and 300 amps. for the group and bus junction, generator and feeder switches, respectively. The generator, bus junction and group switches are non-automatic and entirely under the control of the operator. The generator switches are equipped with one reverse-current relay designed to light an alarm lamp should any generator fail, but not to operate the switch automatically. The automatic reverse-current feature can, however, be made operative at any time should it seem desirable.

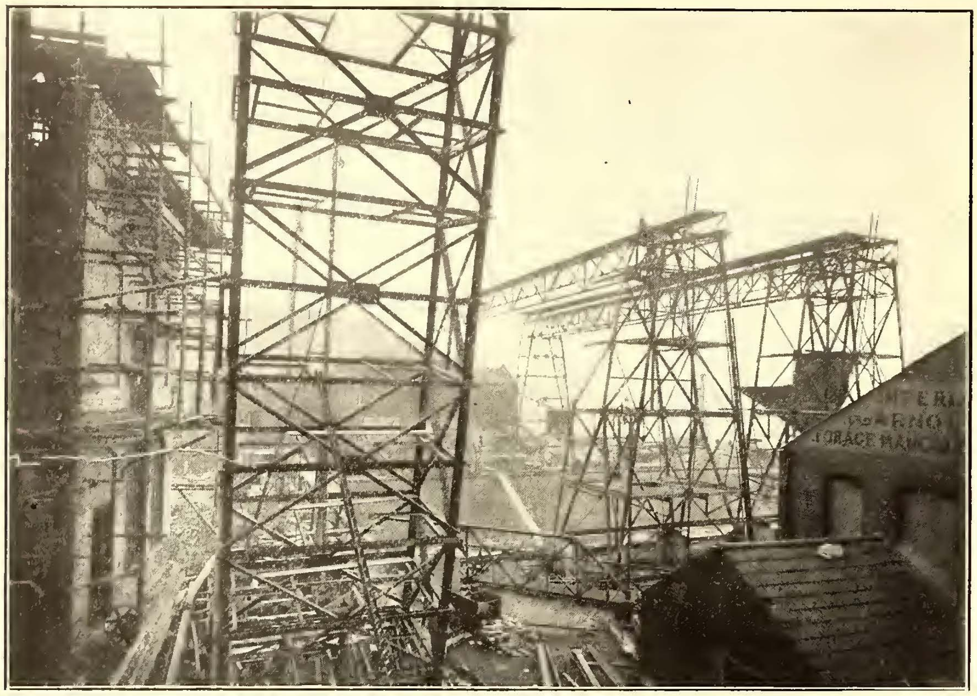


FIG. 16.—BARGE UNLOADERS AND COAL CONVEYORS

The individual feeder switches are the only automatic high-tension oil switches, these being equipped with overload time-limit relays. The time feature is obtained by an air dash so designed as to allow the relay contacts to close instantly in case of a short-circuit, while a moderate overload will only close the contacts after an adjustable time limit of several seconds. A relay is connected in each of the three phases of each high-tension feeder, so as to provide for operation with the neutral point earthed, and to take care of any possible break-down between conductors and the lead sheath. The three relay contacts are connected in parallel to supply the motor of the corresponding oil switch, and therefore a break-down to earth on any one of the three phases will completely disconnect the feeder at the generating station end. The relay contacts for all feeders are supplied through an alarm relay, which in turn rings a gong in case any high-tension switch opens automatically, this alarm relay being inactive when the switches are opened by hand control. One of the ten alarm lamps is simultaneously illuminated by this alarm relay, thus

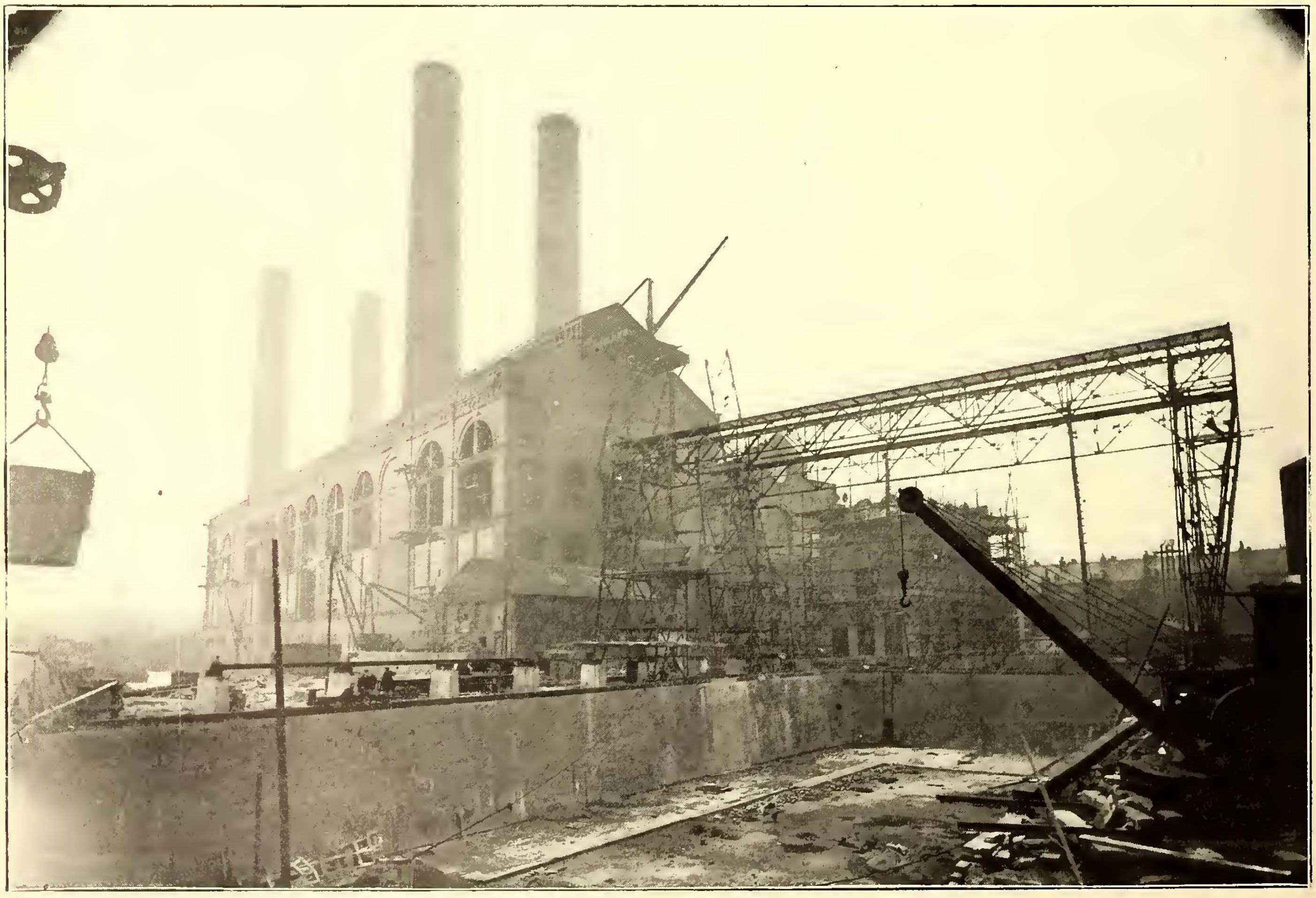


FIG. 17.—BARGE UNLOADERS AND COAL CONVEYORS AT CHELSEA GENERATING STATION

enabling the operator to readily see to which of the ten groups the faulty feeder belongs. A cast-iron grid resistance of about 6.5 ohms is inserted between the neutral high-tension bus-bar; i. e., the center point of the turbo-alternators and earth. The duty of automatically breaking any excessive current will fall entirely on the feeder switches, and the object of this protective resistance is, therefore, to limit the rush of current in the event of a dead short-circuit to earth, and so tend to preserve the continuity of supply from the main generators. The pressure between the neutral high-tension bus-bar and earth is approximately 6350 volts, and the maximum current to flow in the event of a ground will therefore be about 1000 amps. This earthing resistance is capable of carrying 75 amps. continuously, or 1000 amps. for ten seconds, without dangerous overheating. This resistance is, of course, not necessarily operative should the trouble by some remote chance occur entirely between phases. Isolating knife switches of the hook type are installed in connection with all high-tension type-H oil switches, instrument transformers, etc., so as to permit of all high-tension apparatus being completely disconnected for inspection and repairs at any and all times. Each phase of every high-tension circuit, whether in the oil switches or bus-bars, interconnections, etc., i. e., from the alternator terminals to the end bells of the individual feeders, is completely separated from the others by either brick or stone barriers. Soap-stone slabs are used for the oil-switch settings, molded stone and brick being used entirely in the construction of the switch and bus-bar compartments and for all high-tension barriers.

Small iron doors for inspection and maintenance are provided in the construction of all bus-bar chambers opposite the bus-bar isolating switches and supports and for all potential transformer compartments and oil switches. Protection doors are also provided for the static dischargers and all exposed interconnecting cables and terminals between the feeder bus-bars and oil switches, these doors being constructed of molded fire-resisting material.

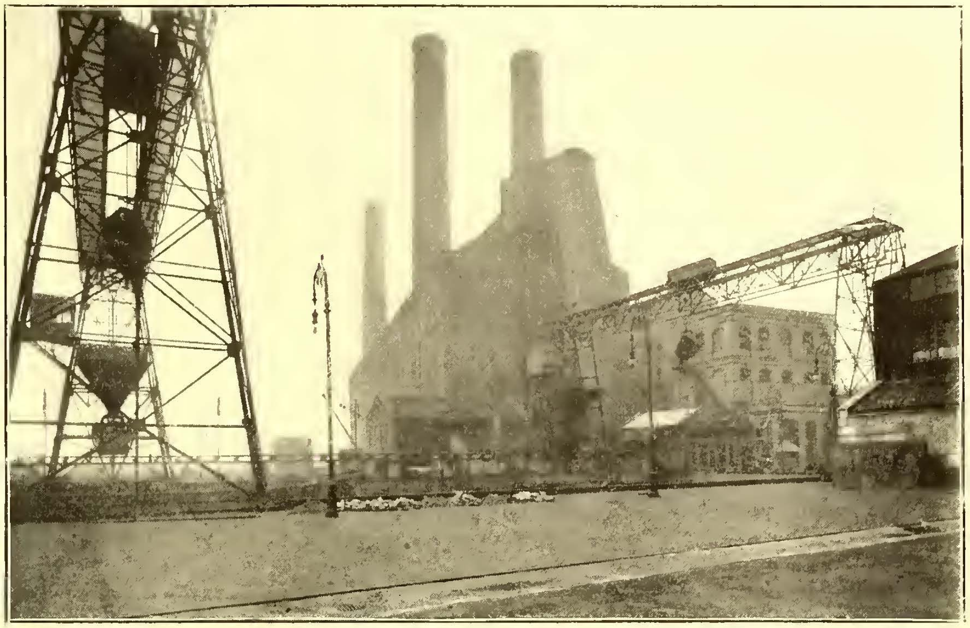


FIG. 18.—BARGE UNLOADERS AND COAL CONVEYORS

The three main high-tension switchboard galleries run the entire length of the building, and are extended across the office end of the building for the auxiliary station transformers, motor-operated generator rheostats (Fig. 37) and auxiliary switchboard (Fig. 36).

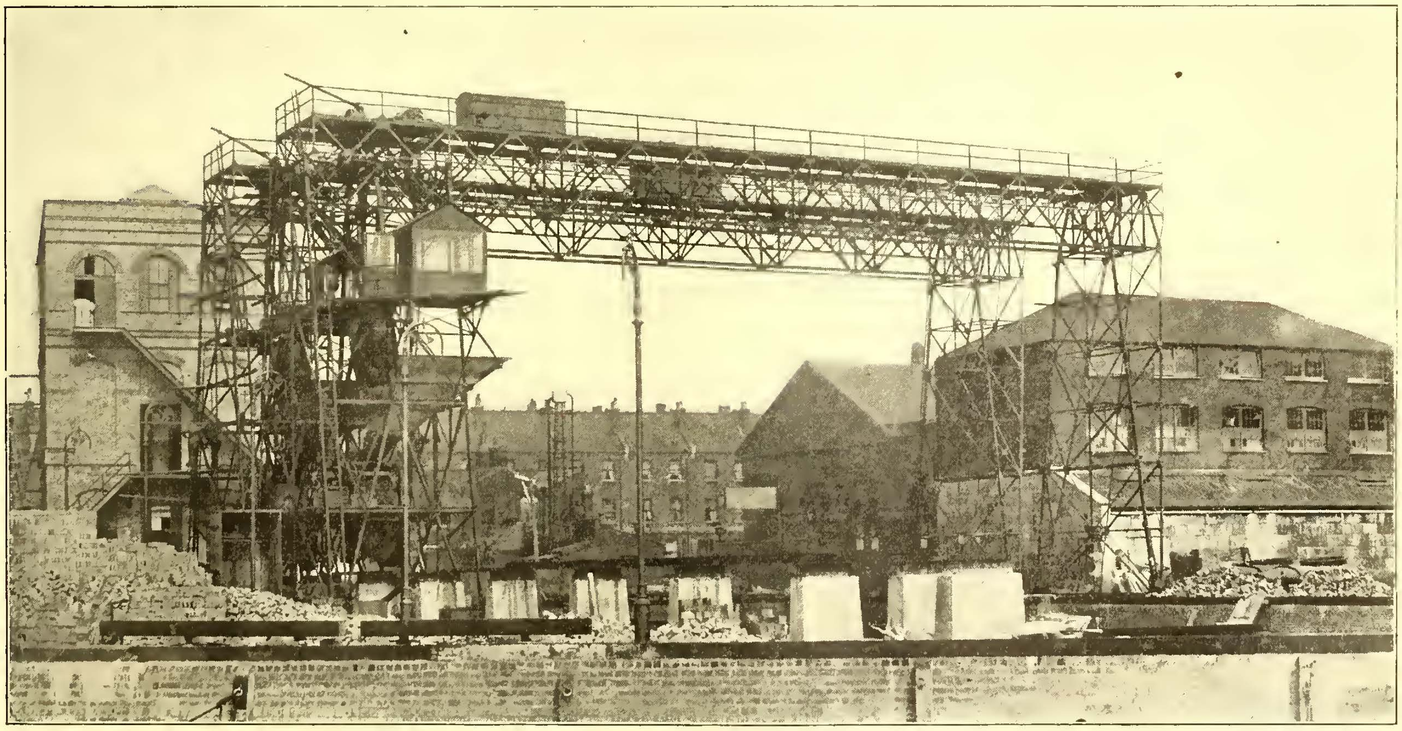
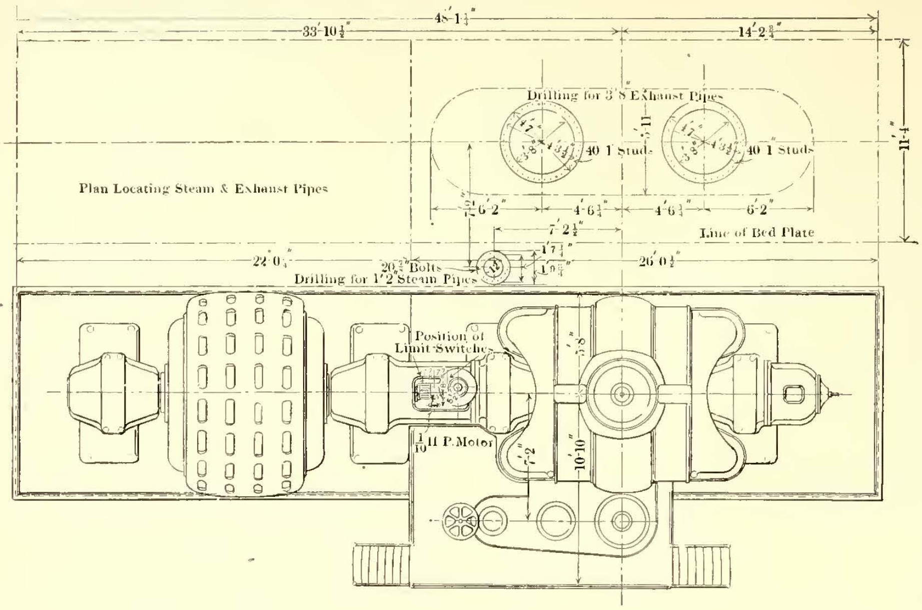


FIG. 19.—OIL COOLING HOUSE, BARGE UNLOADERS AND CHELSEA CREEK RETAINING WALL AT CHELSEA CREEK GENERATING STATION, EAST END

INSTRUMENT AND CONTROL BOARDS

The generator and feeder instrument and control panels (Fig. 34) are located in the center of the house on the middle switchboard gallery, all high-tension switching and apparatus being controlled from this point. All the instrument and control leads from the three galleries to these central controlling



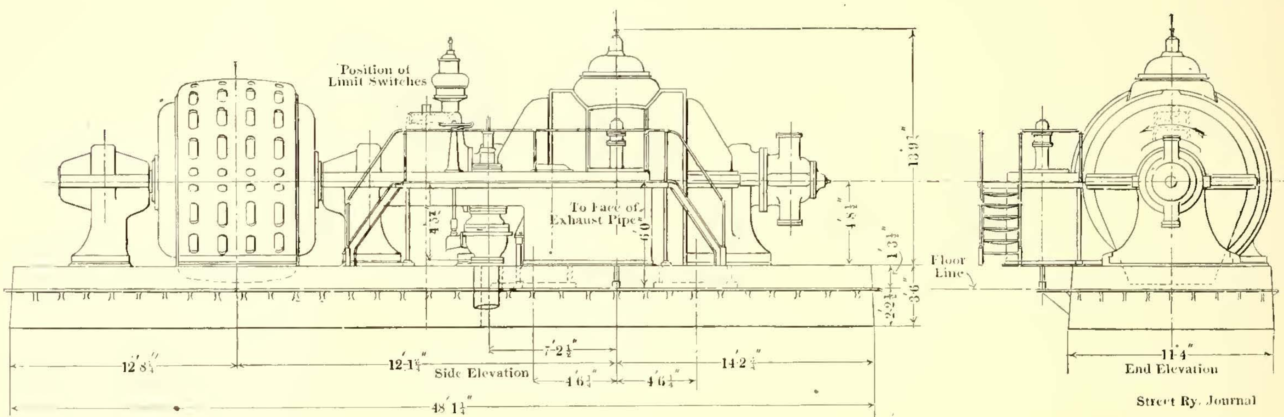


FIG. 21.—PLAN, LONGITUDINAL AND END ELEVATION OF 5500-KW TURBO-GENERATOR

boards are run in extra heavy screwed piping laid on top of the gallery floor joists and embedded in the concrete floors. This piping is laid without junction boxes of any kind from beginning to end, all necessary crossing of leads being effected by crossing the individual pipes themselves in the concrete

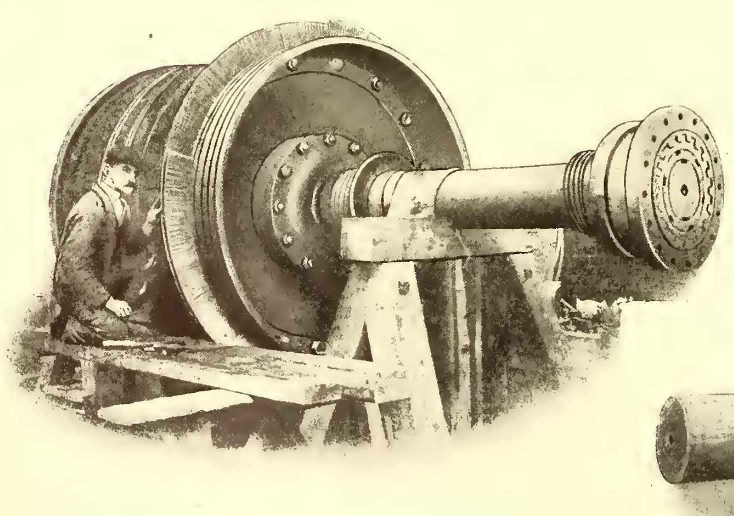


FIG. 22.—SPINDLE OF 5500-KW TURBINE

flooring. The generator instrument board is of the "fresh-air" type, with the standard pattern of bench-board for the control of the generators immediately in front, this combined board being mounted on a projecting bay of the gallery, from which the operator has a full and uninterrupted view of the engine-room floor. On each of the eleven generator-instrument panels are mounted three a. c. ammeters, voltmeter, indicating wattmeter, integrating wattmeter, power-factor meter and field ammeter. The generator-controlling panels contain the necessary controlling switches for the generator, bus-junction and group oil switches, indicating lamps, field rheostat controller, field-discharge switch, engine governor-control switch, engine signal, synchronizing plugs and receptacles. The combined instrument and control board for the sixty-eight feeders is located immediately behind the generator board—the two boards facing each other—four feeders being controlled from each of the seventeen panels comprising this board. These panels are equipped with one ammeter and integrating wattmeter per feeder, in addition to the necessary controlling switches, indicating lamps and overload time-limit relays. An additional panel is installed at the extreme left end of this board, on which is mounted the necessary instruments, switches, etc., for the distribution and control of the direct current required for the operation of all the type-H oil-switch motors. The usual red and green indicating lamps are provided on both the generator and feeder control boards, to indicate that the corresponding switch is closed or open. A large electric gong is mounted on the controlling circuit panel, in connection with each feeder-switch control circuit, so as to provide an audible

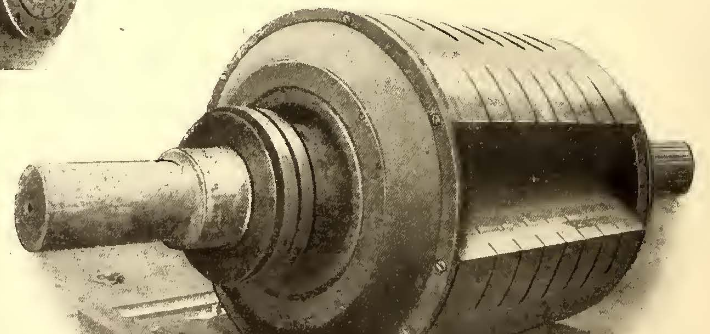


FIG. 23.—REVOLVING FIELD OF 5500-KW TURBO-ALTERNATOR

signal for the operator—in addition to the indicating lamps—when the feeder switches open.

AUXILIARY SWITCHBOARD

The auxiliary switchboard collectively (Fig. 36) consists of two batteries, two d. c. feeders, two motor generators, one load, four exciters and thirteen a. c. panels, a total of twenty-four panels. It is installed on the lower-end gallery and arranged for the control and distribution of the current from four 125-kw exciter sets, nine single-phase, 11,000-220-volt transformers arranged in sets of three, one 125-kw synchronous motor-generator set and two small storage batteries. This board is arranged for distributing power to eighty-nine three-phase, 220-volt and twelve d. c., 125-volt motors, aggregating about 1900 hp, to the 93 type-H oil-switch motors, and for station lighting and miscellaneous purposes. The exciter panels are single pole, the positive bus only being mounted on these panels. The negative bus runs direct from the exciters to the generator fields, and this polarity, together with the equalizer, is controlled by switches mounted on pedestals adjacent to the machines. The exciter bus is sectionalized into two parts, so that continuous service can be given by the plant while alterations or repairs are being made on either part of the bus at times of light load. Three high-tension feeder cables are used for supplying power to the three banks of transformers—one for each bank—and three transformer panels for controlling the supply of low-tension current to the a. c. bus-bars. The controlling switches for the three individual oil switches supplying power to these transformers are mounted on these panels. The 220-volt a. c. bus-bars are located under the gallery floor, immediately below the panels, and are likewise sectionalized into two parts. The low-tension connections are so arranged that one bank of transformers normally feeds each half of this bus, while the third bank can be connected to either or both sections as desired. The a. c. feeder panels are equipped with hand-operated oil switches fitted with straight overload release, the individual motor switches and starters being mounted on or adjacent to the distributing panels and near the machines. The battery panels are provided with suitable end-cell switches for charging and regulating purposes, the connections being such that either the motor-generator or one of the exciters may be used for charging. Emergency switches are provided, so that current for operating the oil-switch motors may be obtained either from the motor-generator or one of the exciters, in the event of accident to either or both batteries.

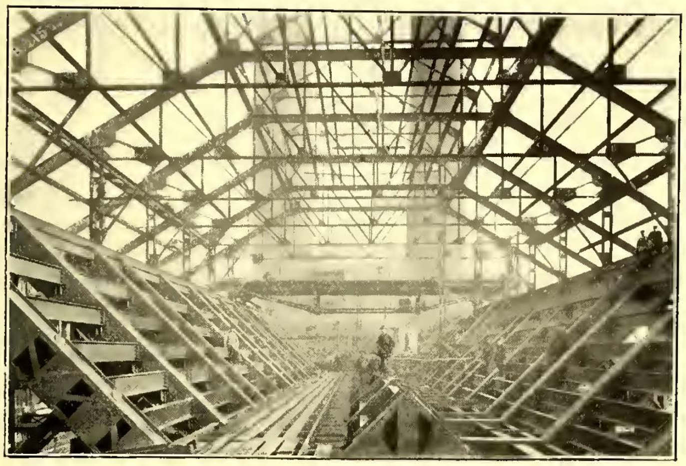


FIG. 20.—COAL BUNKERS IN PROCESS OF ERECTION

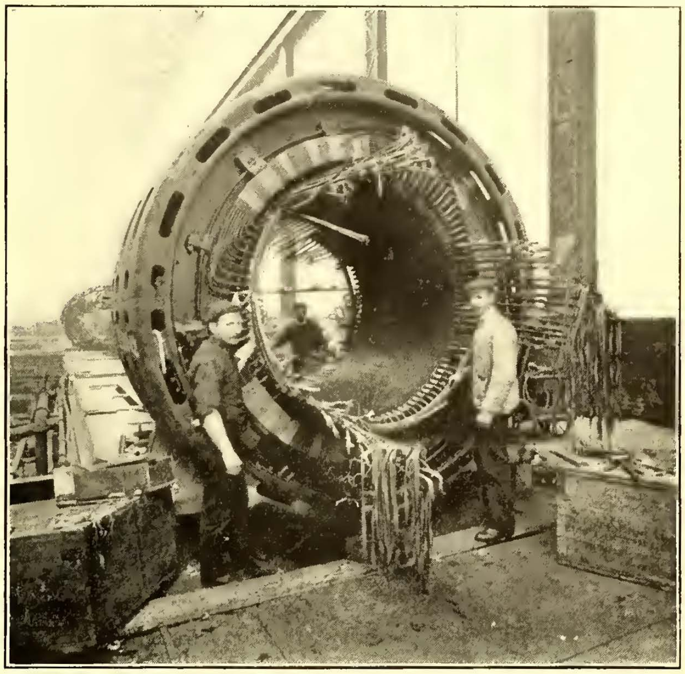


FIG. 24.—ARMATURE OF 5500-KW TURBO-ALTERNATOR

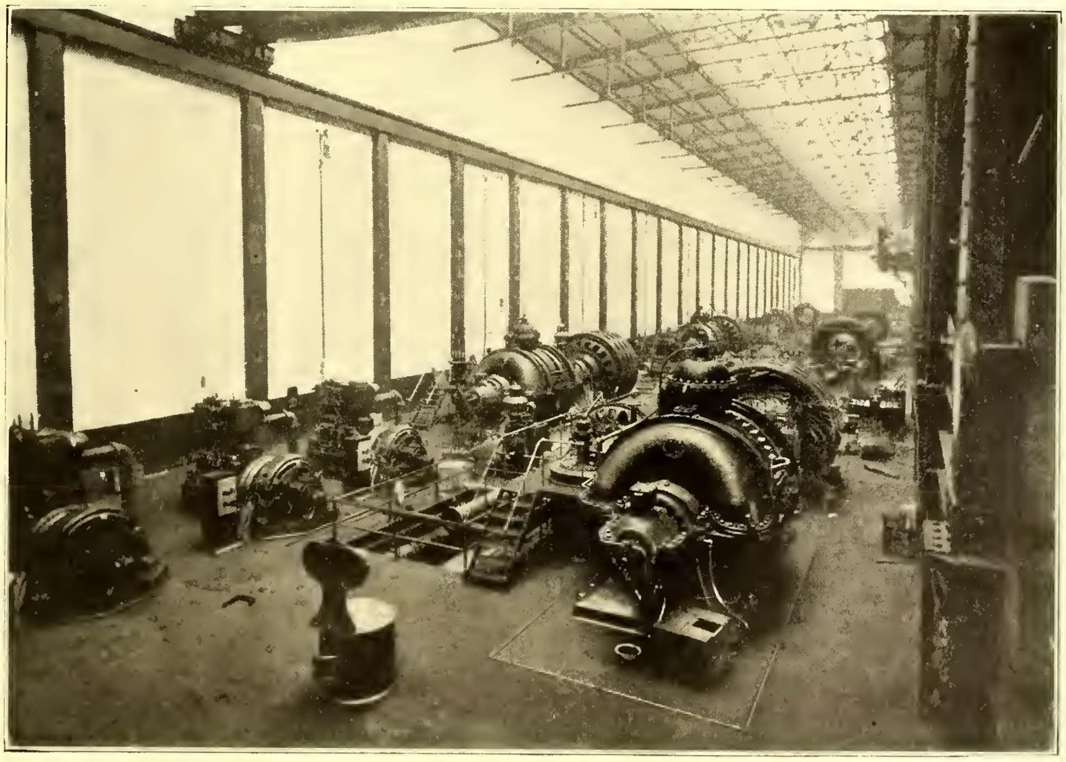


FIG. 25.—GENERAL VIEW OF 5500-KW TURBO-ALTERNATORS AND ENGINE ROOM OF THE CHELSEA GENERATING STATION

HIGH-TENSION CABLES

The high-tension three-phase cables are installed in duplicate, with one exception, between the generating station and each sub-station, the total final installation aggregating about 365 miles. There are four cables to the Whitechapel, Charing Cross, Earls Court, Mill Hill Park and Golders Green sub-stations, and two cables each to all others, East Ham excepted. East Ham and Campbell Road sub-stations jointly have but two cables, but in all other cases one-half the total number of cables to any sub-station can safely carry the normal full-load current for the total ultimate equipment. They are carried from the generating station to the District Railway at Earls Court in a cableway consisting of sixty-four earthenware ducts laid in concrete, the section of this pipe line and type of manhole being shown in Fig. 38. The duplicate cables are carried on opposite sides of the 9-in. longitudinal wall forming the double manholes, and from Earls Court on opposite sides of the railway, either in conduits or on the tunnel walls, so that the cables to any sub-station are practically run by two independent routes. Provision has been made for a maximum of eighteen high-tension cables on either side of the tunnel walls eastward from Earls Court, the details of the troughing, supports and general arrangement of the cables in the troughing being shown in Figs. 39 to 45, inclusive. The cables are protected from one another in the manholes and at the joints on the tunnel walls by asbestos tape about ⅛ in. thick, with the

FIG. 28.—ALTERNATOR FIELD DURING ERECTION

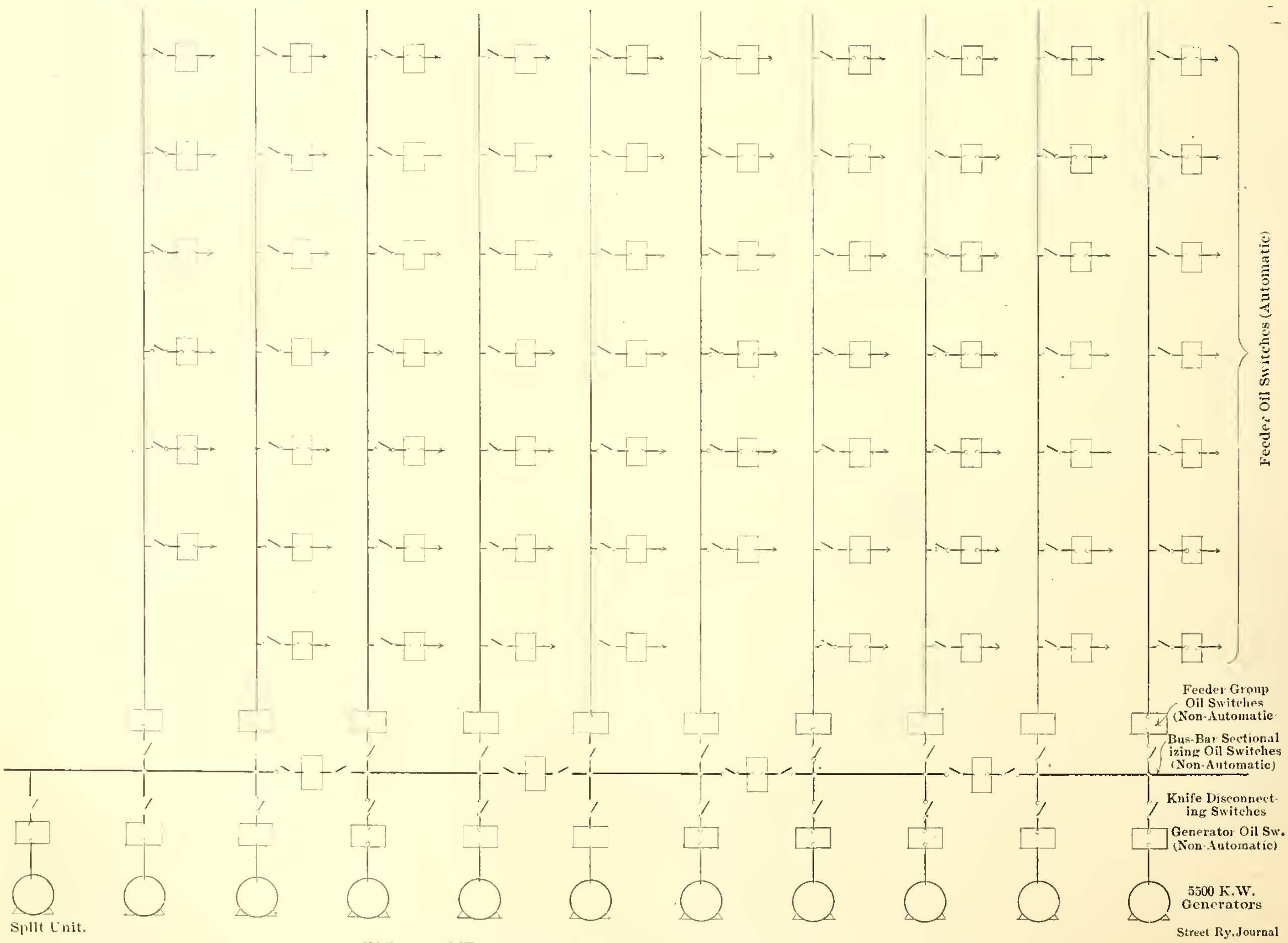


FIG. 29.—KEY DIAGRAM OF SWITCHBOARD CONNECTIONS

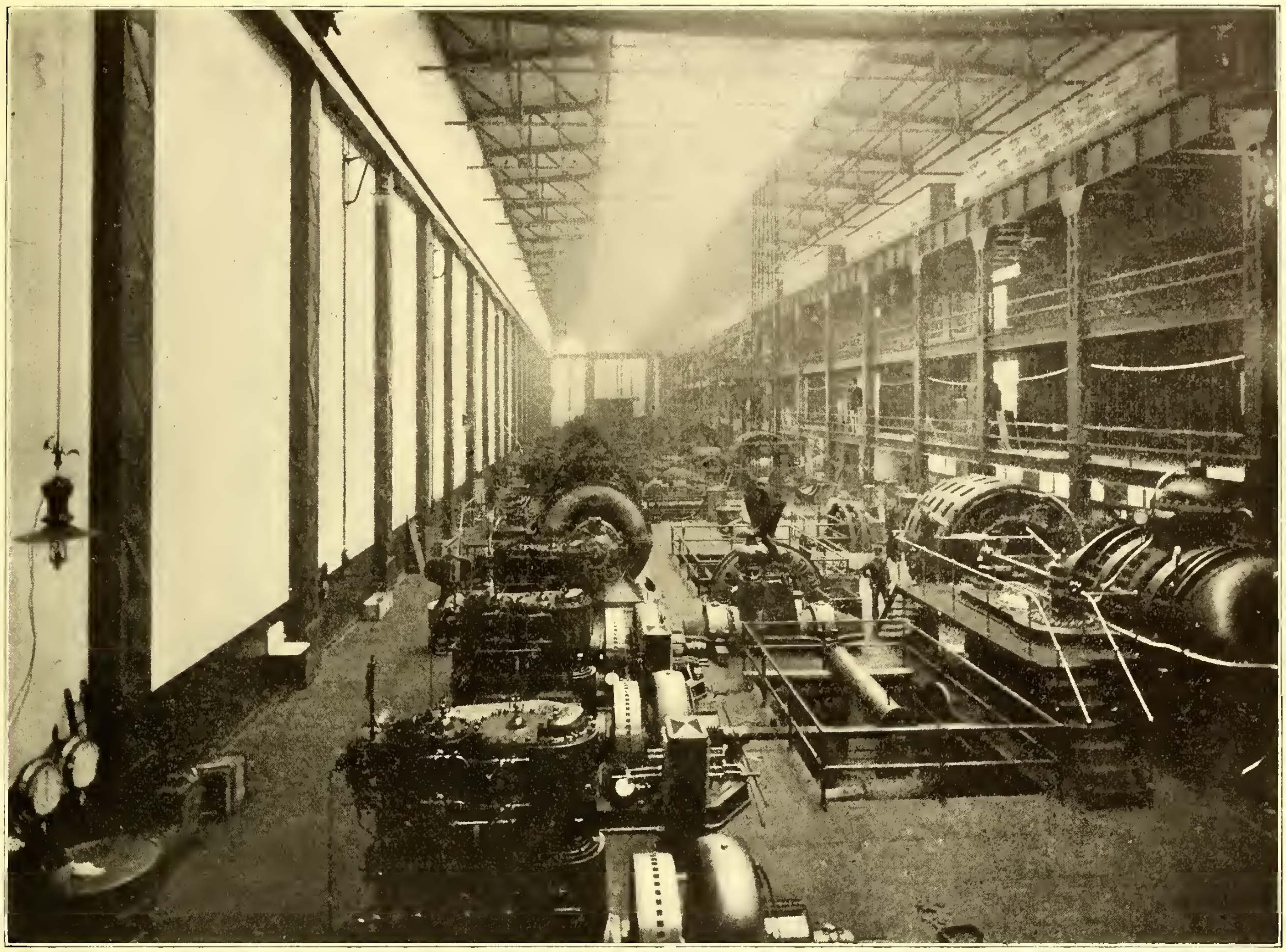


FIG. 26.—ENGINE ROOM AND SWITCHBOARD GALLERIES OF THE CHELSEA GENERATING STATION

FIG. 27.—TURBO-ALTERNATORS BEING ASSEMBLED

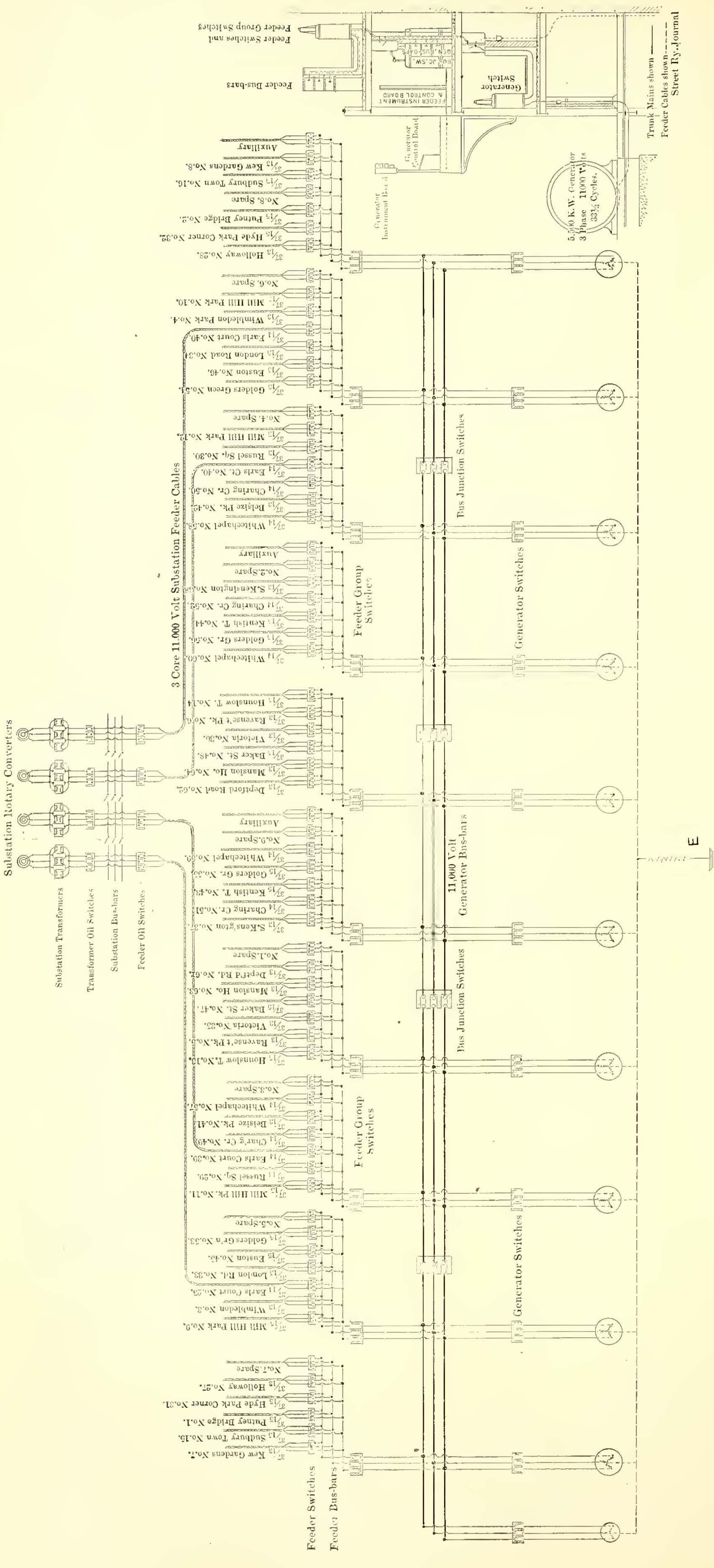


FIG. 30.—GENERAL DIAGRAM OF 11,000-VOLT CIRCUITS, CHELSEA GENERATING STATION

edges overlapping, and then served with an asbestos paint to make the covering waterproof. Three-core, paper-insulated, lead-covered cables are installed, the conductors being of the standard English or "clover leaf" pattern, substantially as shown in Fig. 46. They are subjected to a factory pressure test of 33,000 volts, and again tested at 22,000 volts after being laid and jointed. The particulars of the three sizes used will be found in the table on page 406.

The insulation resistance of these cables will probably average 300 megohms per mile at a temperature of 60 degs. F., a value much less than the usual English and Continental practice. The contracts for this work include the laying, jointing and testing, with the usual one-year maintenance guarantee, have been placed with the British Insulated & Helsby Cables, Callenders Cable & Construction Company, W. T. Henley's Telegraph Works Company, Western Electric Company and The Electrical Company. Considerable difficulty was experienced in the installation of the cable on the tunnel walls, so as not to interfere with the regular traffic in any way, and because of the limited storage room and facilities for loading drums. The time allowed for the actual installation of cable in the tunnel was limited to two and one-half hours for six nights of the week and about four and one-half hours on Saturday nights. Care was necessary in loading the cables intended for the tunnel walls so as to have the drums in proper sequence, due consideration being also given to the direction of the moving train and the particular side of the tunnel for which the cable was intended. On arriving at the site, the lower trough was turned down, drum jacked up and the cable end brought over and placed in position in the trough. The engine moved slowly forward, unreeling the cable, with the men following and pushing the cable into position. Two men closed the trough and prepared the one above for the next cable. In this way three to five drums were installed per hour, depending upon the nature of the track, and the maximum number of drums disposed of in one night of four and one-half hours was fifteen, containing 8000 ft. The conditions under which the jointing was done were exceptionally trying, owing to the limited time and the necessity of protecting the unfinished joint from damp during the hours of traffic. Each man made two joints in three nights, an average of six hours per joint. The major portion of the work for which

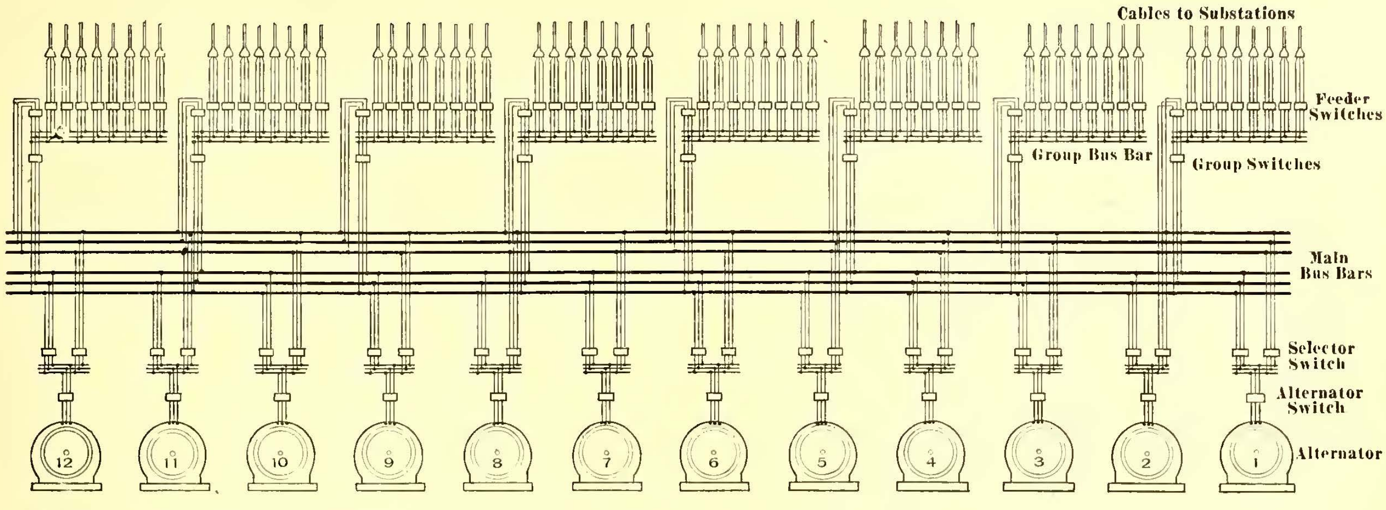


FIG. 31.—GENERAL DIAGRAM OF 11,000-VOLT CIRCUITS IN MAIN RAPID TRANSIT GENERATING STATION, NEW YORK

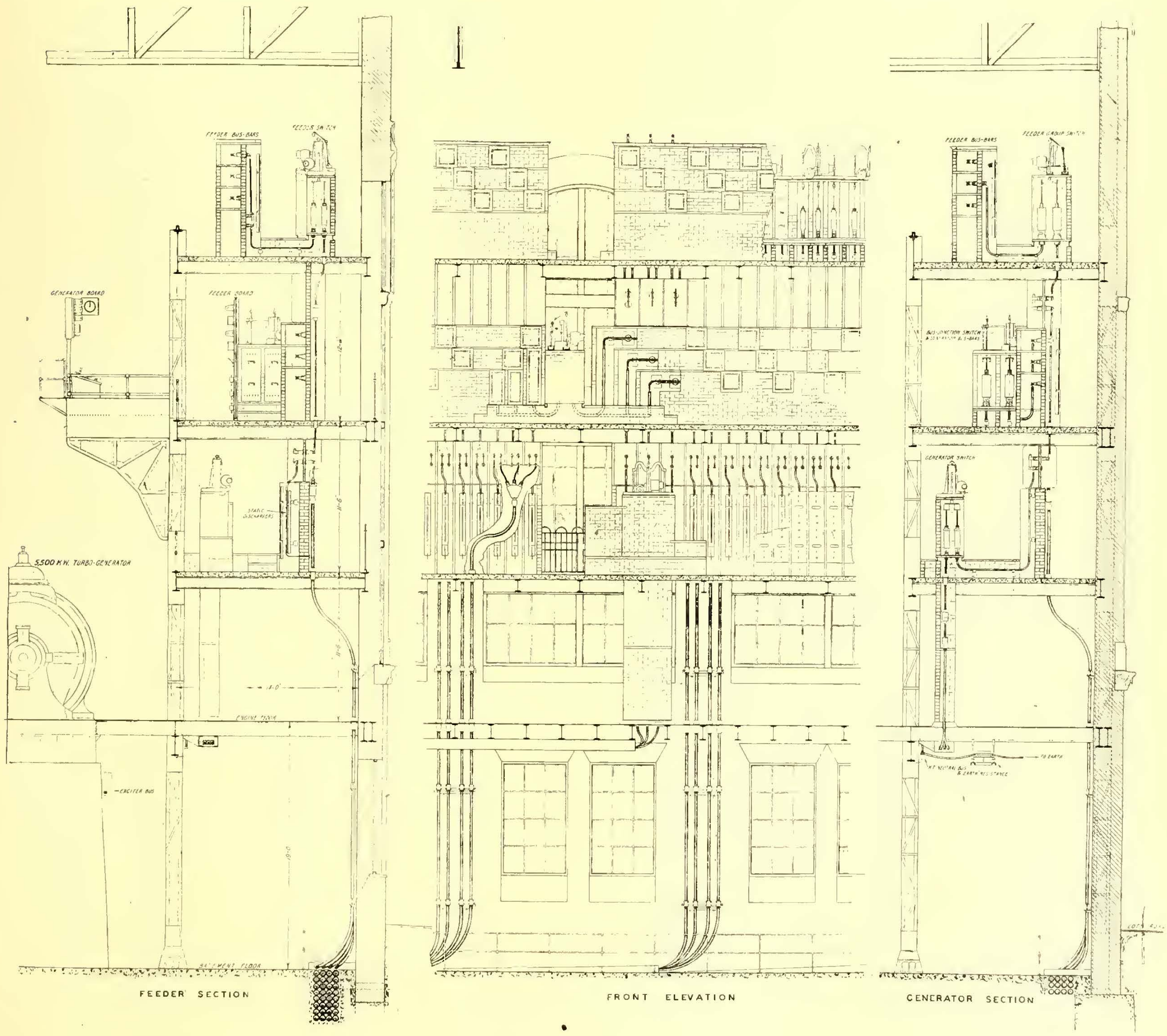


FIG. 32.—CONNECTIONS OF HIGH-TENSION SWITCHBOARD OF CHELSEA GENERATING STATION OF THE LONDON UNDERGROUND ELECTRIC RAILWAYS SYSTEM

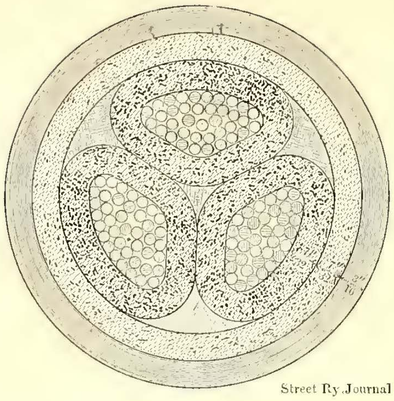


FIG. 46.—TYPICAL SECTION OF 11,000-VOLT THREE-CORE CABLE

contracts have now been let—from the Chelsea Generating Station to Charing Cross, and from Whitechapel to East Ham, an aggregate of about 190 miles—has been installed by the British

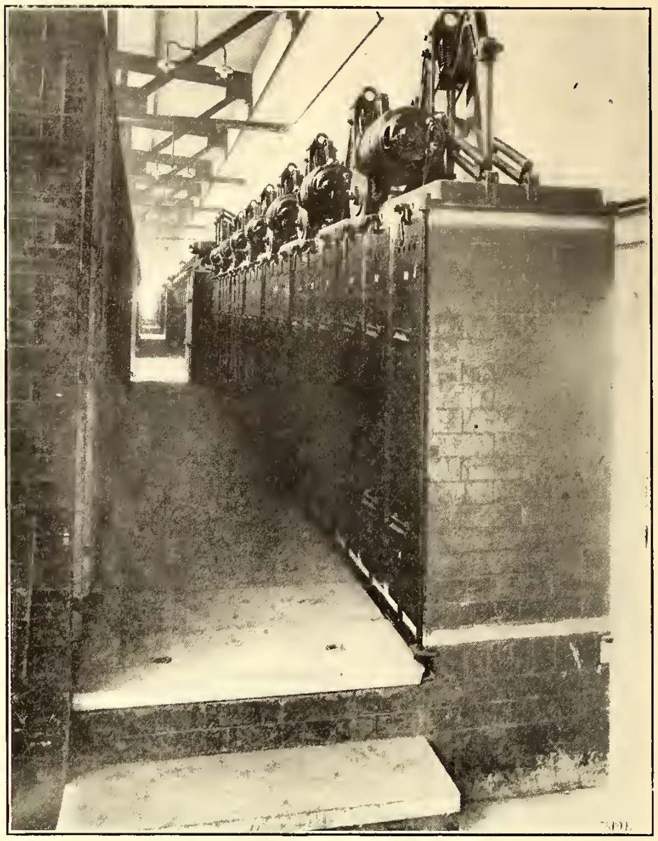


FIG. 33.—LINE OF OIL SWITCHES IN CHELSEA POWER STATION

Insulated and Helsby Cables, of Prescot. This company has thus far completed and tested over 100 miles of cable, including

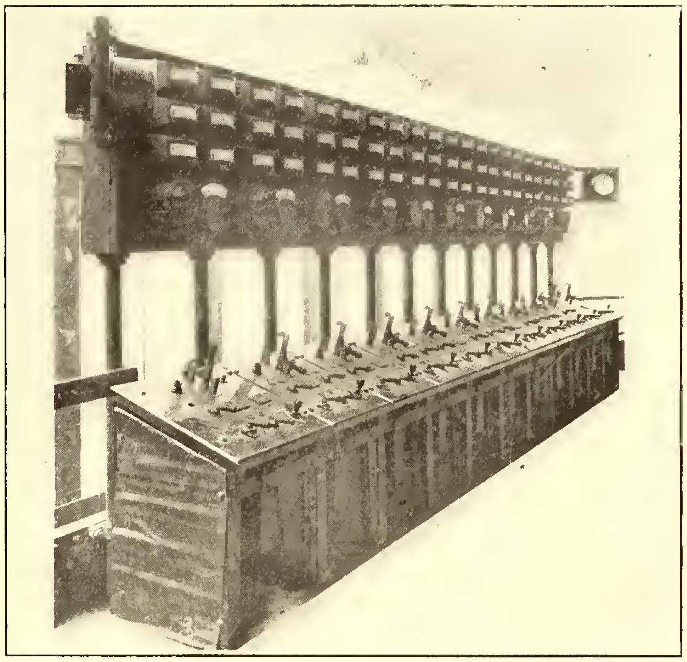


FIG. 34.—GENERATOR INSTRUMENT AND CONTROL PANELS

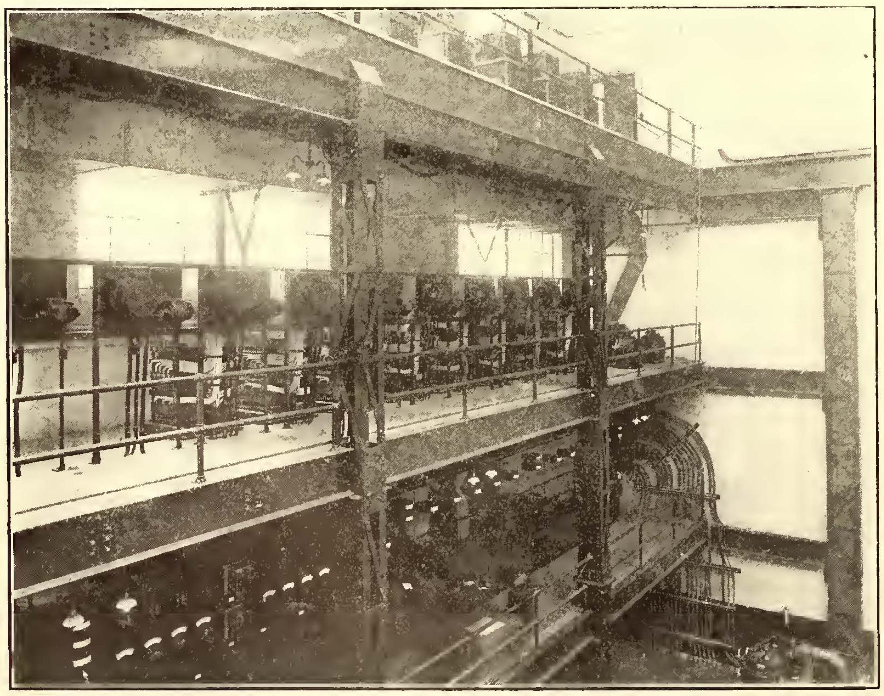


FIG. 37.—MOTOR OPERATED MAIN RHEOSTATS IN GALLERY

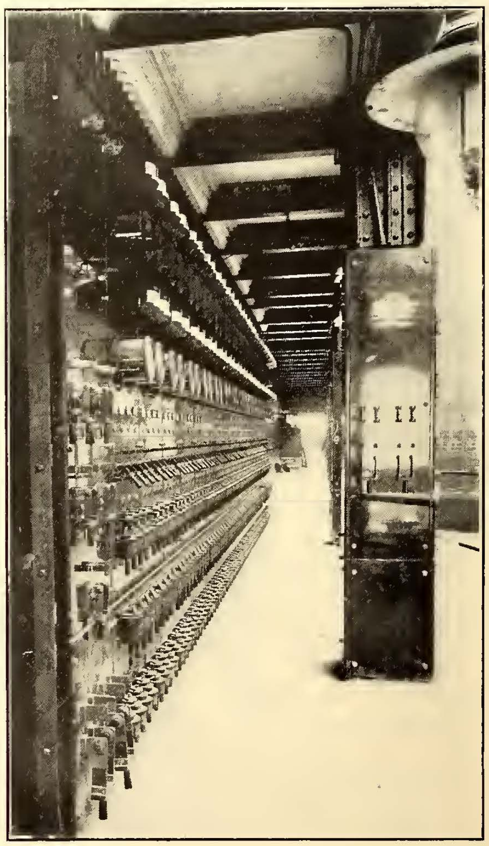


FIG. 35.—SWITCHBOARD FOR HIGH-TENSION FEEDERS, CHELSEA POWER STATION

1800 joints and 56 terminal connections, with the loss of but one joint and five cable lengths. The methods and apparatus employed by the several companies in making the final acceptance tests were radically different in several essential details. Contrary to the usual English and Continental practice, no charging devices of any kind have been installed at the generating station for gradually applying pressure to the three-core feeder cables.

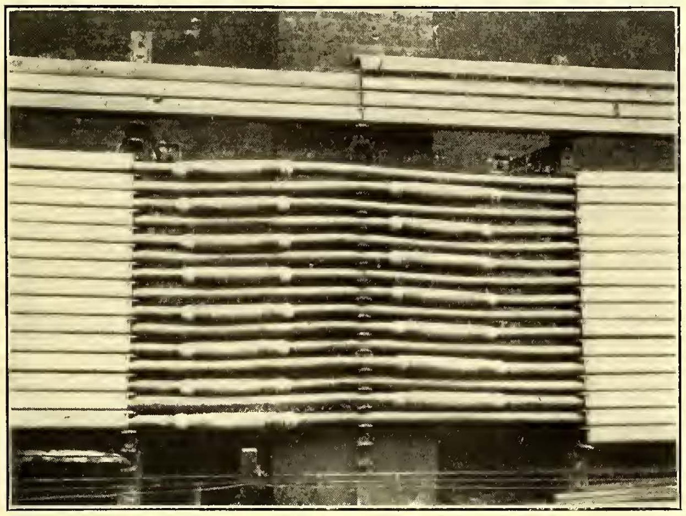


FIG. 40.—HIGH-TENSION CABLE JOINTS AND TROUGHING, EAST END OF EARL'S COURT STATION

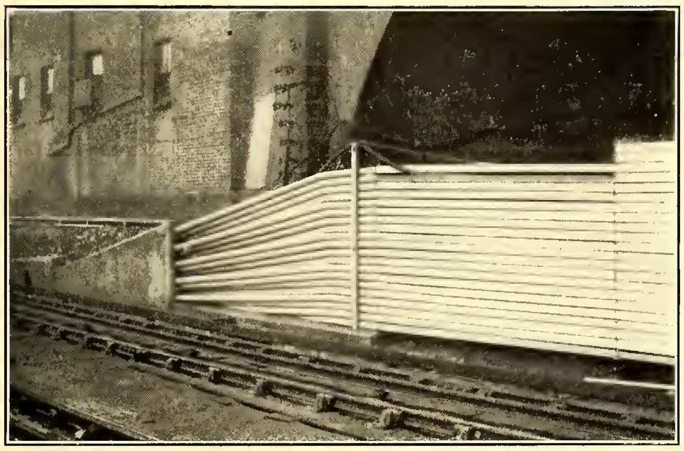


FIG. 42.—CABLE TROUGHING CONSTRUCTION UNDER HIGH STREET BRIDGE, EAST END

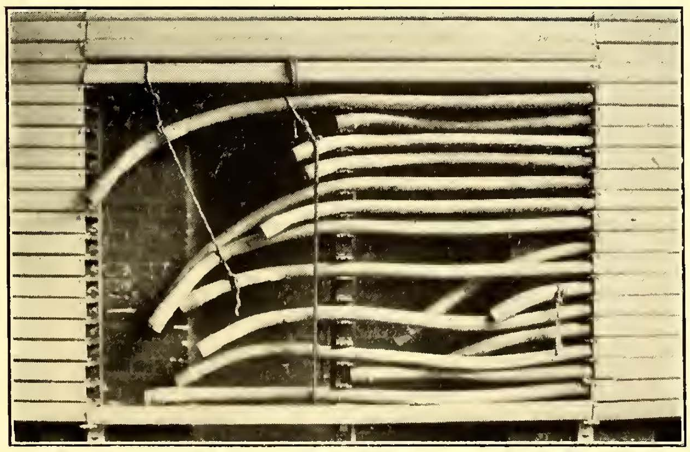


FIG. 44.—HIGH-TENSION CABLES IN TROUGHING BEFORE JOINTING, HIGH STREET TUNNEL

A cast-iron end bell or three-way dividing box (Fig. 47) is used for the feeder end connections at the Chelsea generating station and at all sub-stations. A wiped joint is made between the cable sheath and brass gland, the three individual conductors of the three-core cable passing through the box without joints to the terminals above. The stranded conductors are carefully filled with solder well below the level of the insulating compound so as to prevent the entrance of moisture along the

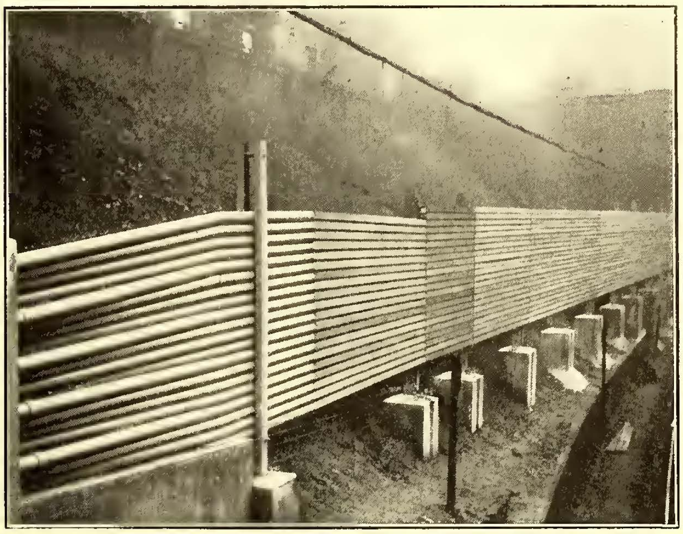


FIG. 41.—CABLE TROUGHING CONSTRUCTION, HIGH STREET TUNNEL, LOOKING WEST

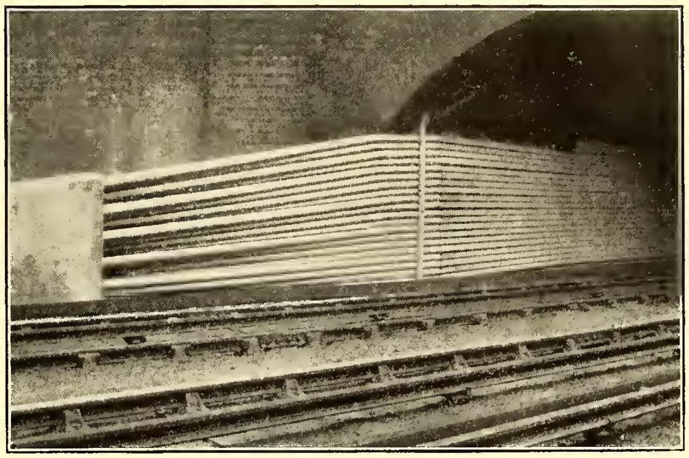


FIG. 43.—CABLE TROUGHING CONSTRUCTION UNDER HIGH STREET BRIDGE, WEST END

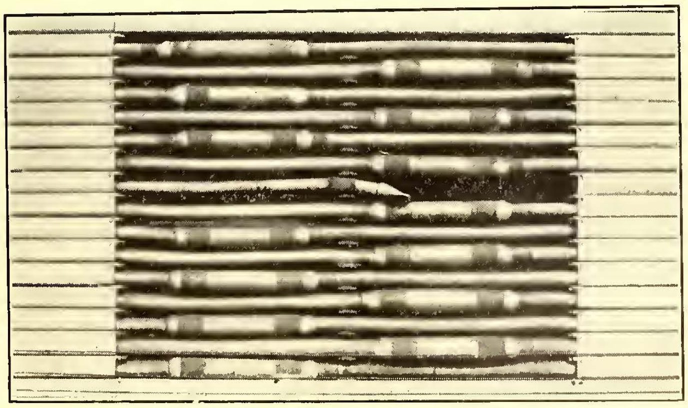


FIG. 45.—CABLE JOINTS, EARL'S COURT STATION

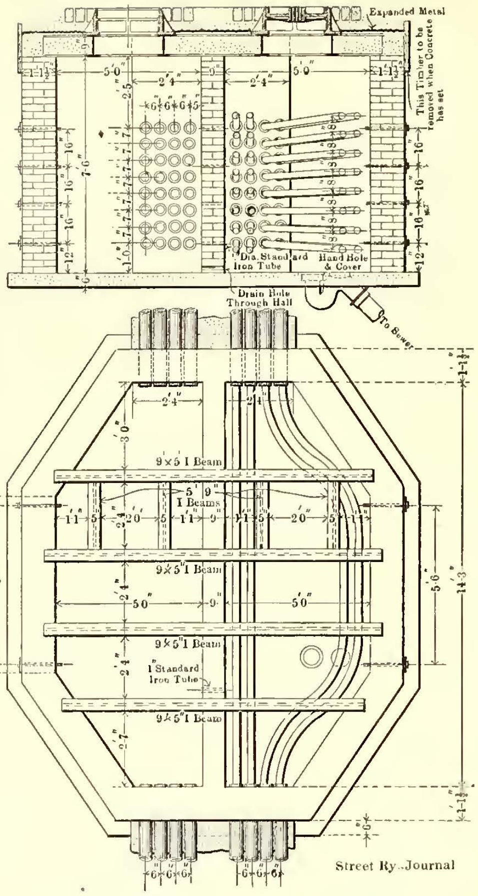


FIG. 38.—DESIGN FOR MANHOLE

GENERAL DETAILS OF THREE-CORE, PAPER-INSULATED LEAD-COVERED CABLES

General exhibit	No. 37/15	No. 37/14	No. 37/13
Sectional area of each conductor, square inch	.15	.19	.25
Insulation between conductors and between conductors and earth	7/16"	7/16"	7/16"
Thickness lead sheathing	3/16"	3/16"	3/16"
Approximate diameter of cable	2.7"	2.8"	3.0"
Approximate diameter of joints	4.0"	4.25"	4.5"

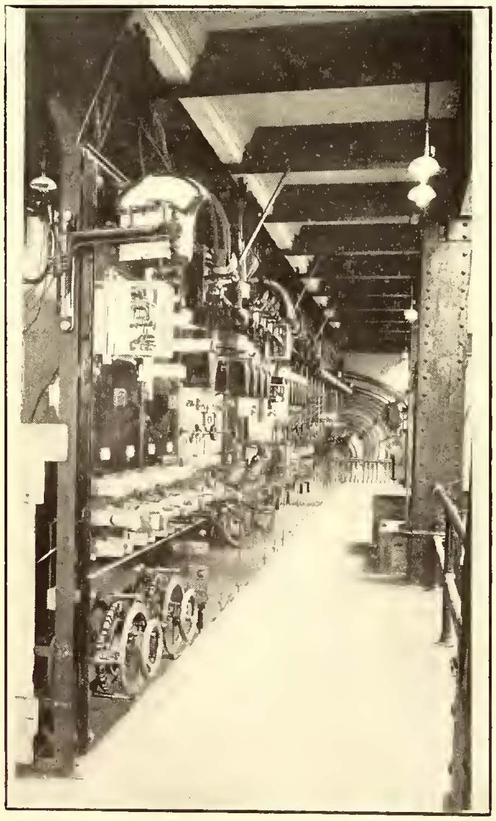


FIG. 36.—AUXILIARY SWITCHBOARD

individual strands, and then reinsulated above the box as a protection against accidental contact. Fig. 48 shows the general distribution of the high-tension feeder cables.

SUB-STATIONS

The Chelsea generating station will supply power to a total of twenty-four sub-stations. The location of these sub-stations,

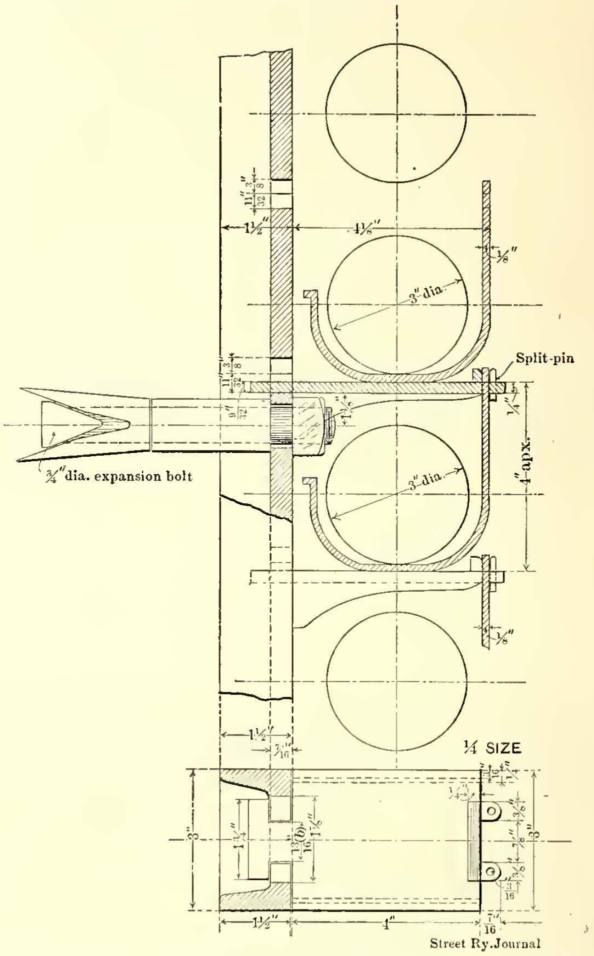


FIG. 39.—SHOWING METHOD OF SUPPORTING CABLES IN TUNNEL WALLS

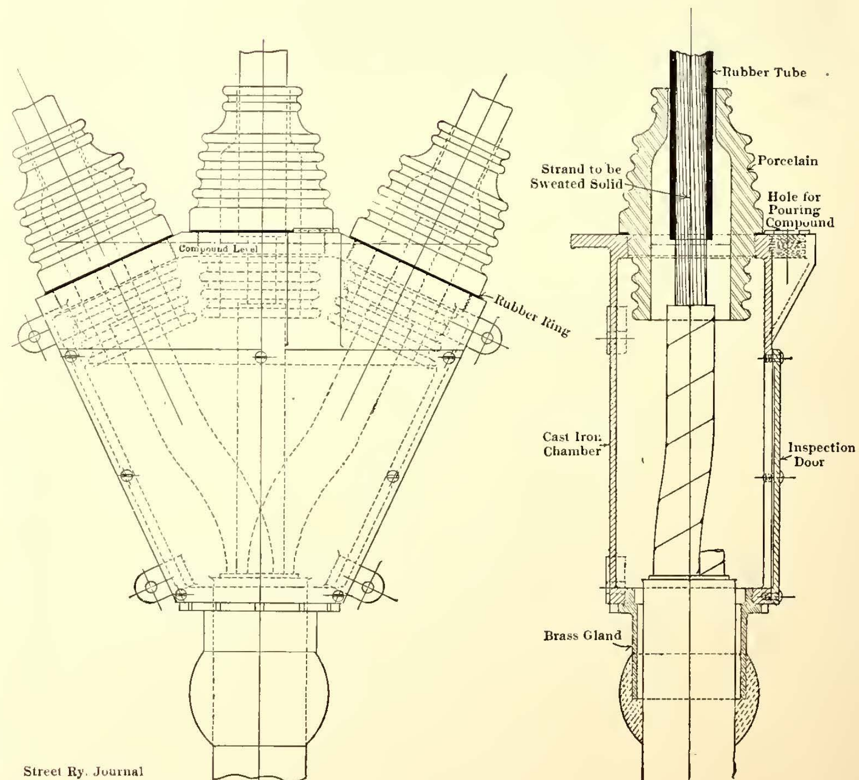


FIG. 47.—END CONNECTION FOR THREE-CORE CABLE. ONE-SIXTH ACTUAL SIZE

together with the ultimate proposed equipment and approximate distance from the generating station, is as follows:

Location of Sub-stations	Distance from Generating Station, Miles	Rotary Converters Number	Rotary Converters Total KW Capacity
East Ham*	13.34	3	3,600
Campbell Road Junction*	10.35	3	3,600
Whitechapel	8.15	4	6,000
Mansion House	6.37	3	4,500
Charing Cross	5.07	4	6,000
Victoria	3.72	3	3,600
South Kensington	2.31	3	4,500
Earls Court	1.30	4	6,000
Putney Bridge	3.29	3	2,400
Wimbledon Park**	5.83	3	3,600
Ravenscourt Park	3.27	3	4,500
Kew Gardens**	6.10	3	3,600
Mill Hill Park	5.45	4	4,800
Hounslow Town	9.90	3	2,400
Sudbury Town	9.59	3	2,400
Euston Station	6.62	3	2,400
Kentish Town	8.30	3	2,400
Belsize Park	9.15	3	3,600
Golders Green	11.36	4	3,200
Hyde Park Corner	3.34	3	2,400
Russell Square	5.62	3	3,600
Holloway	7.83	3	3,600
Baker Street	7.37	3	2,400
London Road	6.42	3	2,400
Totals	160.05	77	87,500
Averages	6.67	—	3,646

*London, Tilbury & Southend Railway. **London & South Western Railway.

The arrangement of apparatus will be practically the same in all cases, the sub-stations differing only in size and number of units, except where local conditions necessitate changes in the general design. Two of the fifteen sub-stations—Mansion House and Victoria—to supply current for the District Railway trains are built on heavy steel girders spanning the tracks. The Charing Cross sub-station is entirely below ground, the rotary floor of this station being 20.5 ft. and 33 ft. below the District rail level and mean high tide, respectively. This location—previous to the construction of the Victoria Embankment—was originally part of the Thames River bed, and considerable difficulty has therefore been experienced in the construction of the retaining walls and basement floor in order to prevent the entrance of moisture. There are no surface openings to this sub-station, the entrance being from the District Railway platform. The other nine sub-stations will supply current only for the "tube" railways now under construction, and of these only the Hyde Park Corner sub-station will be entirely below the surface. The London Road sub-station will be built on heavy girders spanning the yard tracks, this construction being essentially the same as that used for the Mansion House and Victoria sub-stations. All the buildings are of brick and steel construction, fireproof and without ornamental features, the general arrangement being clearly shown in Figs. 49 to 51, inclusive. The rotary converters, low-tension switchboard, high-tension oil switches, signal apparatus and blower sets are all on the first floor. A shallow basement is used for the cable installation between the rotaries and switchboard and the switchboard and tracks. A gallery about 23 ft. in width extends along one side of the building and on which is located the high-tension bus-bars and lowering transformers. The transformer air duct is constructed of galvanized iron and suspended from the under side of the gallery immediately below the transformer openings. Hand-operated traveling cranes are erected in each sub-station for the installation and any subsequent handling of the rotaries and transformers.

All sub-station machinery and apparatus—exclusive of the cranes and main cable installation—is being supplied and erected by the British Westinghouse Electric & Manufacturing Company, Limited.

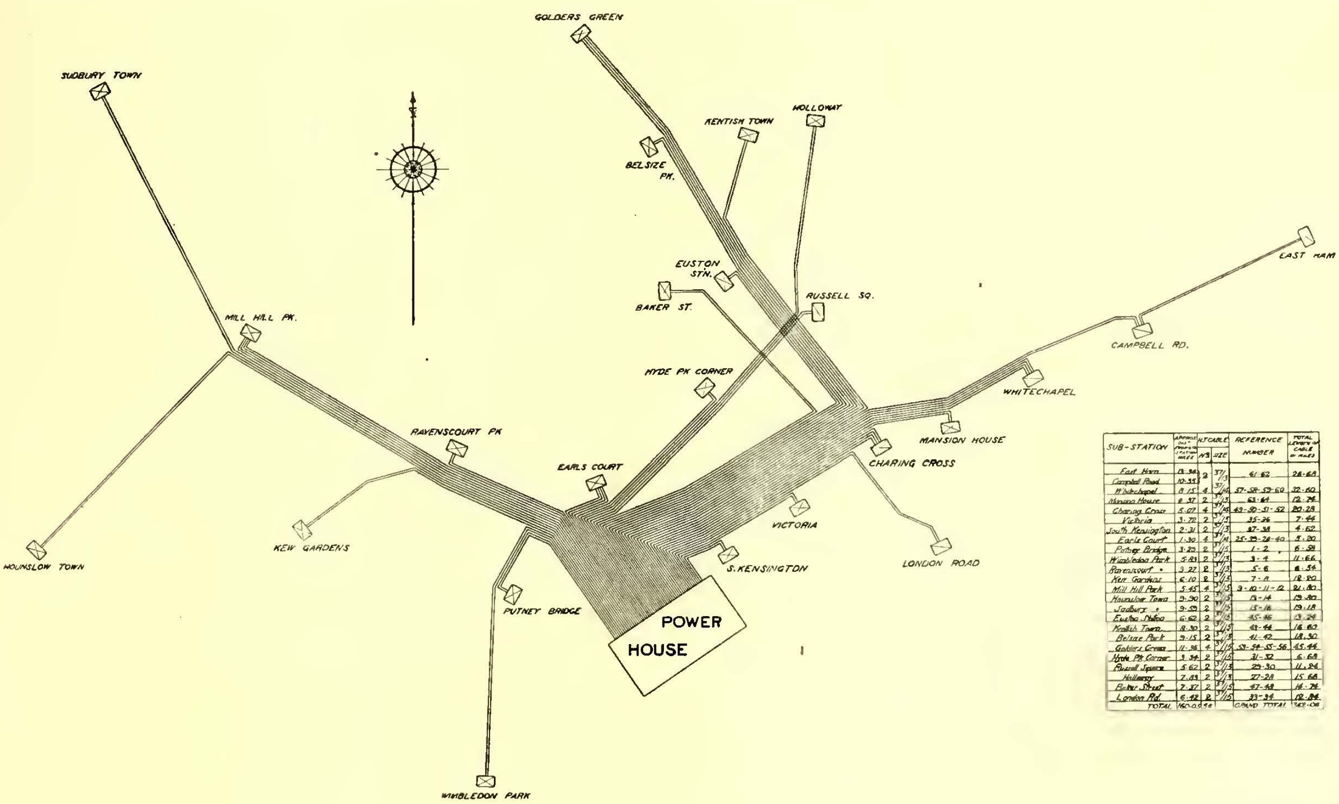


FIG. 48.—DISTRIBUTION OF HIGH-TENSION FEEDER CABLES

ROTARY CONVERTERS

Each of the rotary converters with its starting motor is a self-contained unit (Fig. 52), the two bearings and the lower half of the field frame being mounted on a common bed-plate. They are started by induction motors, the revolving part of the motor being mounted directly upon an extension of the armature shaft. The fields are compound wound, the series and shunt coils being separated by air spaces and the pole pieces beveled at the edges in order to support massive copper shields. These shields consist of heavy copper rings around the pole tips, with lips extending from both edges of the pole toward the center, the arrangement being such as not to interfere with the ventilation. The fly-wheel capacity of these machines is relatively small, and they are guaranteed to stand an overload of not less

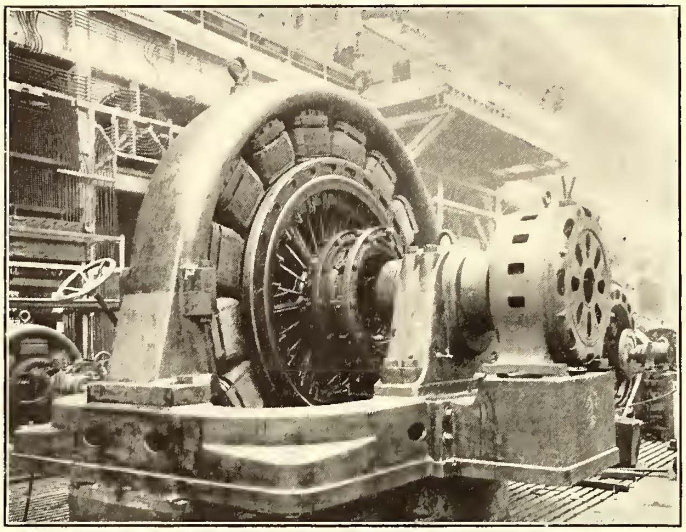


FIG. 52.—ALTERNATING-CURRENT END OF 1500-KW ROTARY CONVERTER

than three times the normal full load without falling out of step. No adjustment of the brushes is necessary between the limits of no load and 50 per cent overload, and no injurious sparking or permanent injury will result from occasional momentary fluctuations reaching two and one-half times the normal full load. All windings are subjected to a puncture test of 3500 volts alternating for one minute. The particulars of the rotary converters are as follows:

ROTARY CONVERTERS

	Kilowatt Capacity		
General Exhibit	800	1,200	1,500
Number of poles................	10	12	16
Speed—r. p. m..................	400	333	250
Alternations per minute.........	4,000	4,000	4,000
Efficiency, one and a quarter load	95.3	96.2	96.25
Efficiency, full load	95.0	95.7	96.00
Efficiency, three-quarter load.....	94.3	95.0	95.25
Efficiency, one-half load	92.3	93.5	94.00

POWER TRANSFORMERS

The transformers are of the vertical, air-blast type, with the primary and secondary coils wound in sections, each section being encased in a slot of insulating material. They are assembled by alternating the primary and secondary sections, suitable ventilating spaces being provided between coils so as to distribute a flow of air along all parts of the coils. Each transformer is assembled on an iron base containing dampers for regulating the supply of air, and is also provided with a ventilating damper or shutter on the top. A number of taps have been provided on the primary winding for adjusting the ratio of transformation, so that the potential of the current delivered to the rotaries shall be essentially the same in all sub-stations. These transformers are delta connected on both the high and low-tension sides, the three transformers with their rotary being connected and operated on the "unit" system.

LIGHTING TRANSFORMERS

Two 11,000-220-volt, single-phase, 150-kw transformers of the same general design and construction as the main power transformers are installed in the majority of the sub-stations

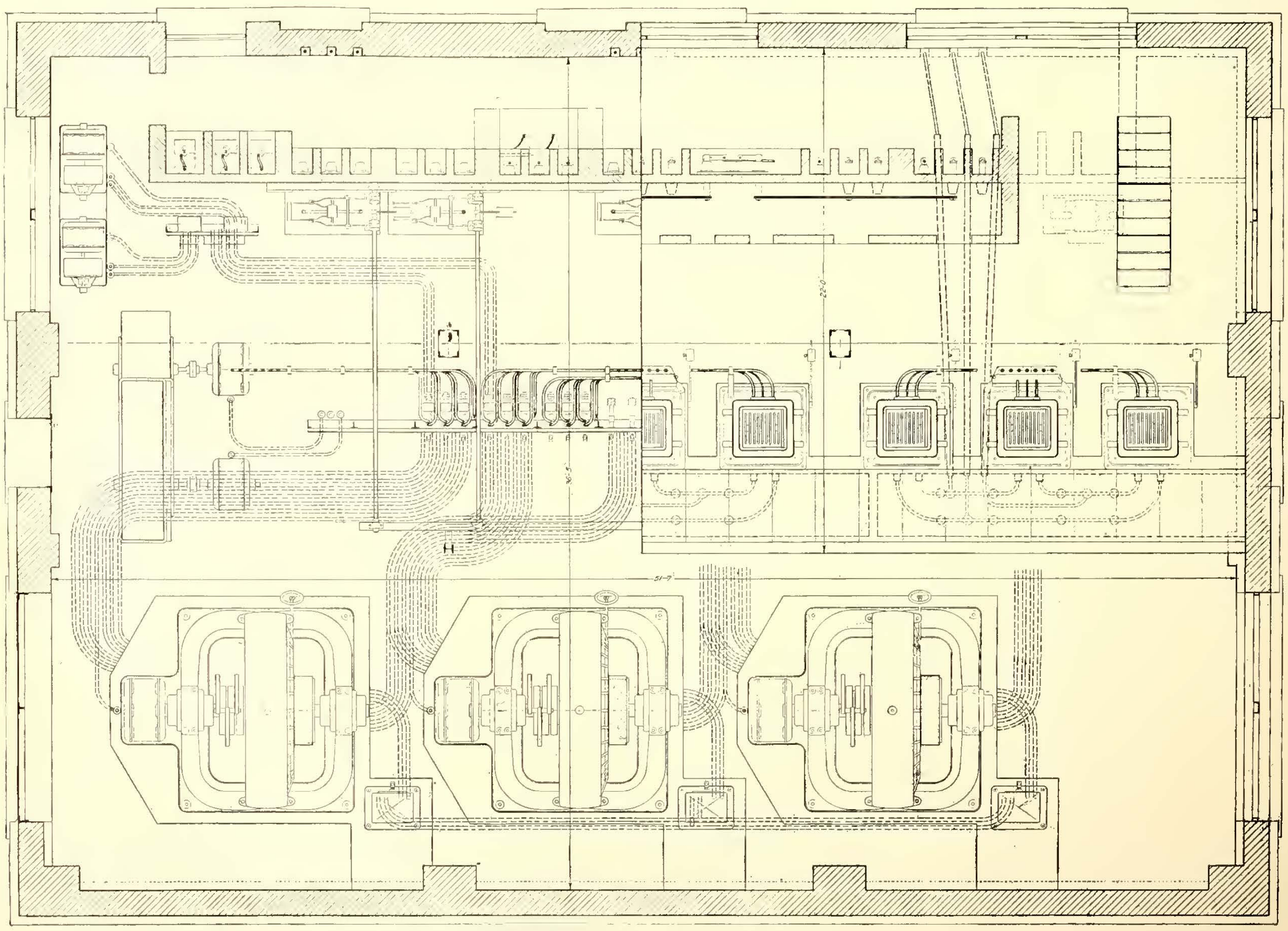


FIG. 49.—SECTIONAL PLAN, PUTNEY SUB-STATION

so that the station and tunnel lighting will be practically independent of the sub-station power circuits. These transformers are "V" connected so as to balance the load on the high-tension side, power being supplied direct from the center point of one of the high-tension bus junction switches. The temperature rise is guaranteed not to exceed 35 degs. C. for continuous lower portion of the fan. Each fan is driven by a direct-connected, constant-speed induction motor operated and controlled from the sub-station switchboard. These motors are supplied with power from the low-tension side of the main power transformers, the two motors being connected to different sets so that one blower unit is available when one rotary unit is shut down.

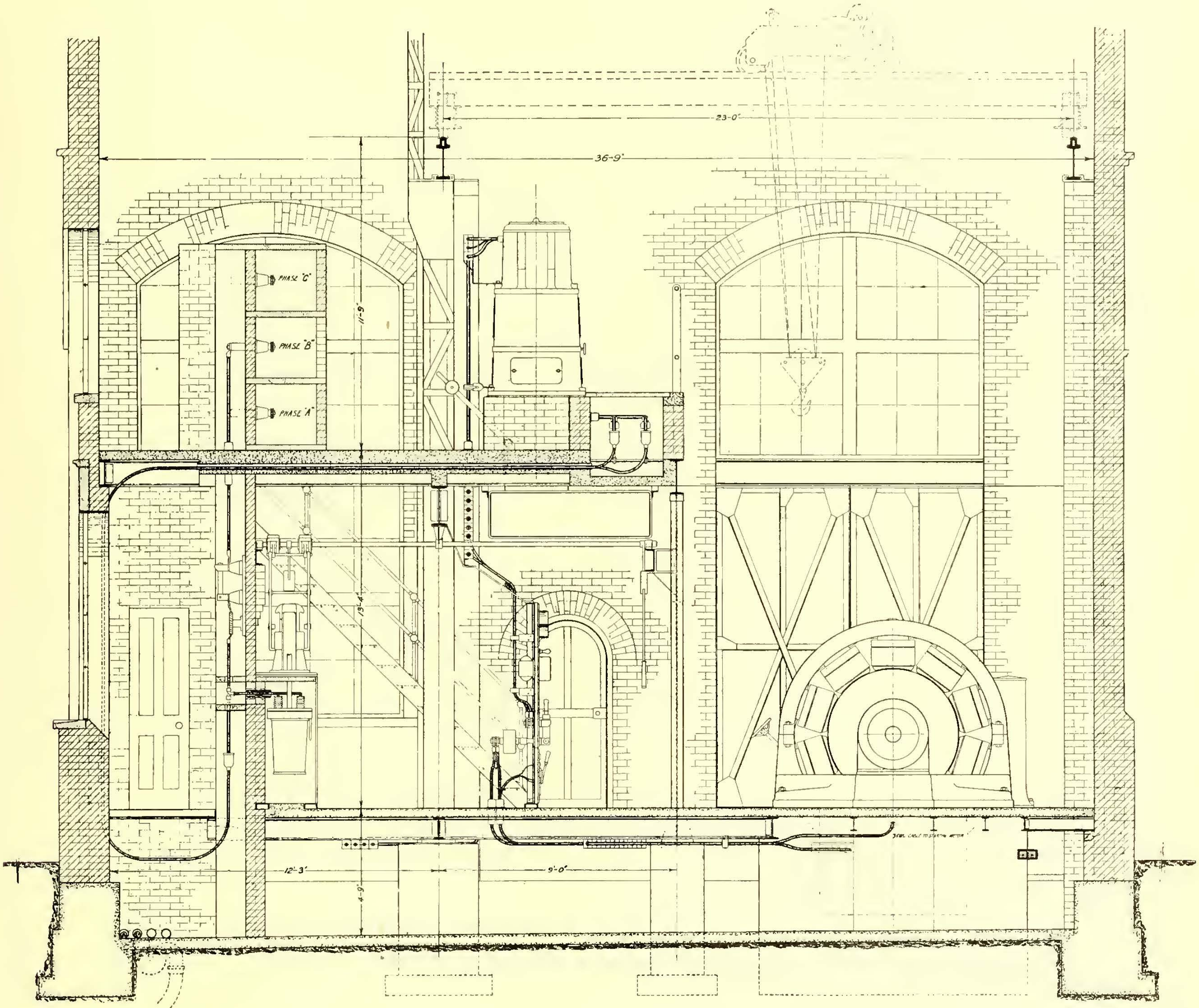


FIG. 50.—CROSS-SECTION OF PUTNEY SUB-STATION

operation at normal full load output, the guaranteed efficiencies of these transformers being as follows:

TRANSFORMERS

	Kilowatt Capacity		
Efficiencies	300	435	550
One and one-half load...........	97.6	97.85	98.0
One and one-quarter load........	97.7	97.9	98.0
Full load	97.7	97.9	98.0
Three-quarter load...............	97.5	97.7	97.85
One-half load....................	96.9	97.1	96.9
One-quarter load	94.5	95.0	95.2

BLOWER SETS

Blower sets have been provided in duplicate in each sub-station for the ventilation of the air-blast transformers, each set being capable of ventilating all the transformers under normal working conditions. The fans are of the three-quarter housing type—that is, the sheet steel housing stops at the floor line and the masonry foundation forms the housing for the

SWITCHING APPARATUS

The switching apparatus is designed for the control of the incoming 11,000-volt feeders, single-phase lowering transformers, three-phase rotary converters, direct-current traction and lift feeders and a. c. station and tunnel lighting. Figs. 53 and 54 shows a rear elevation of the high-tension switchboard and an outline diagram of connections for a two and four-feeder station, respectively. The 11,000-volt, three-conductor cables from the power house enter the sub-stations approximately on the basement floor level, and as such terminate underneath the rotary floor in a cast-iron end bell or dividing box similar to those used in the power house. The three separate conductors pass through these boxes without joints to the feeder isolating switches, thence through the feeder oil switches to the high-tension bus-bars on the gallery. Bus junction switches are installed so that the high-tension bus-bars may be divided into sections—one section for each rotary unit—either for inspection or repairs, or so that the feeder cables may be operated

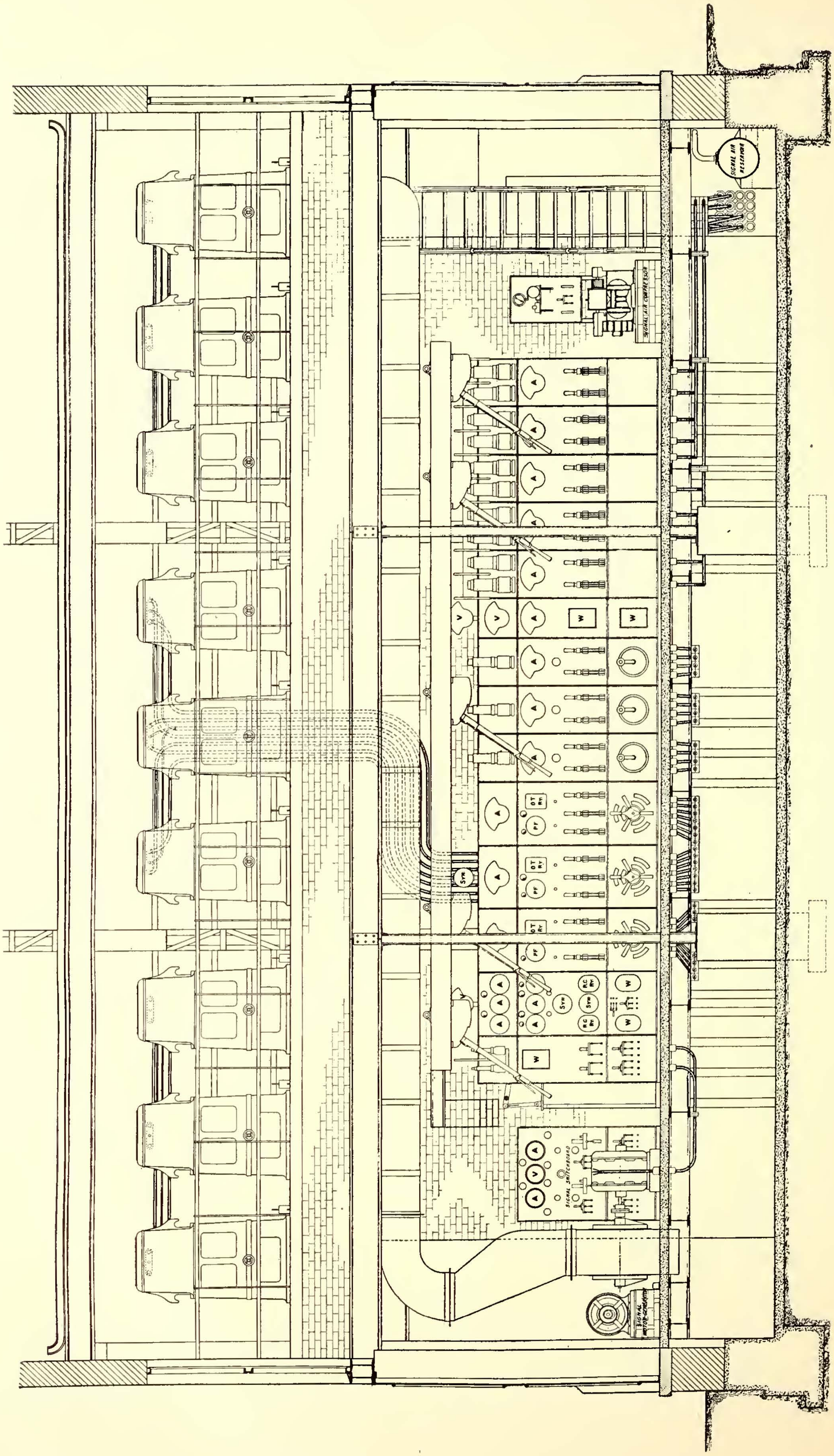


FIG. 51.—LONGITUDINAL SECTION OF PUTNEY BRIDGE SUB-STATION

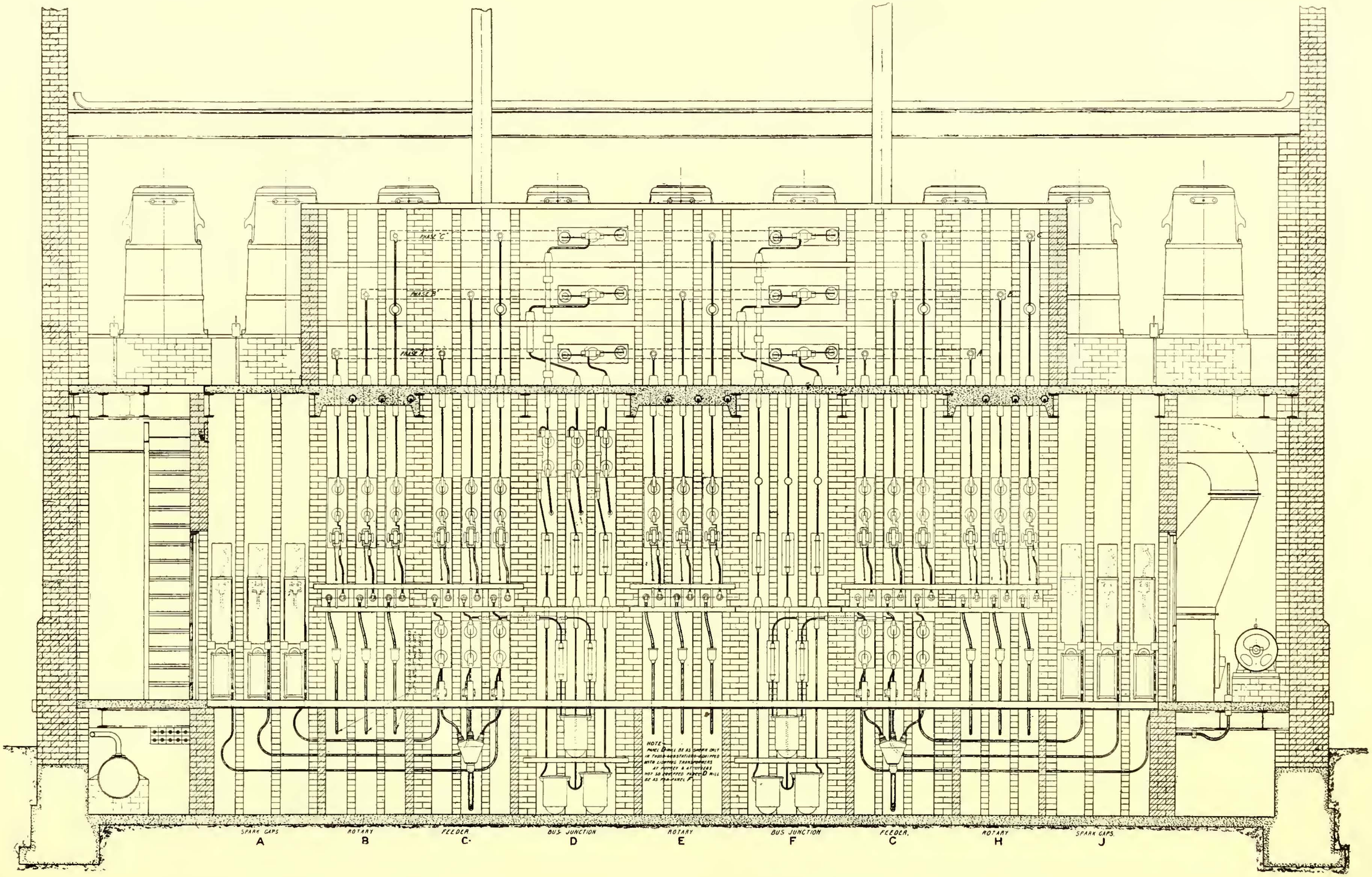
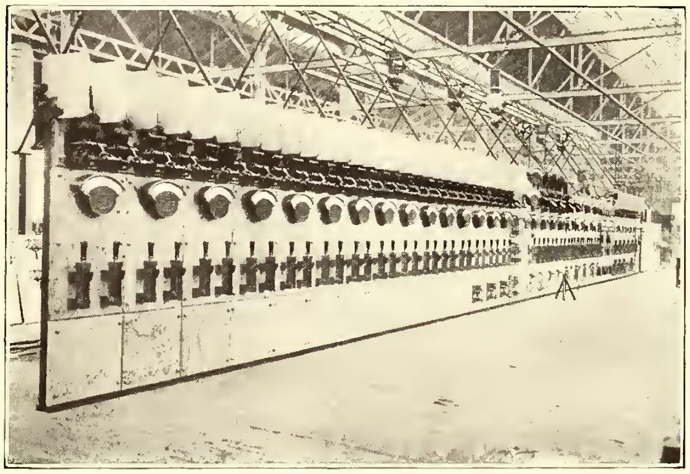
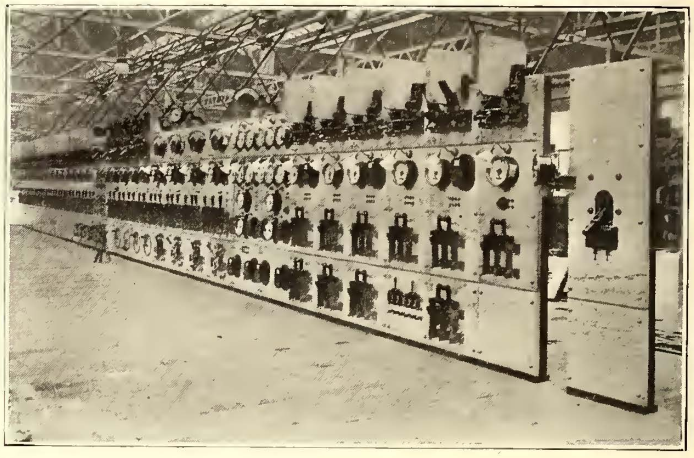
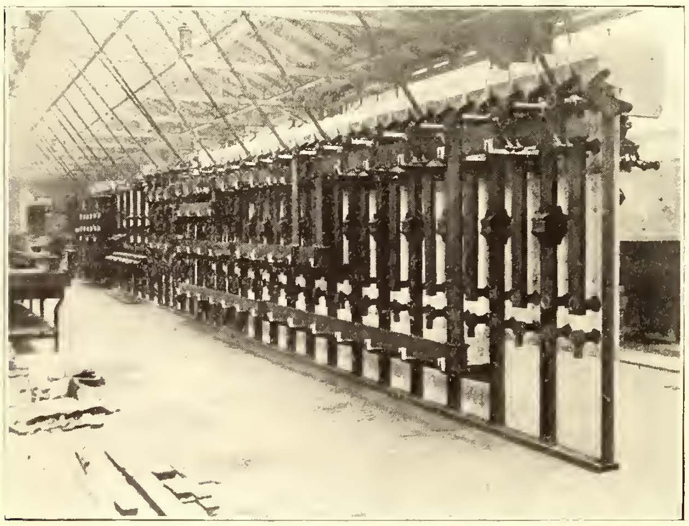
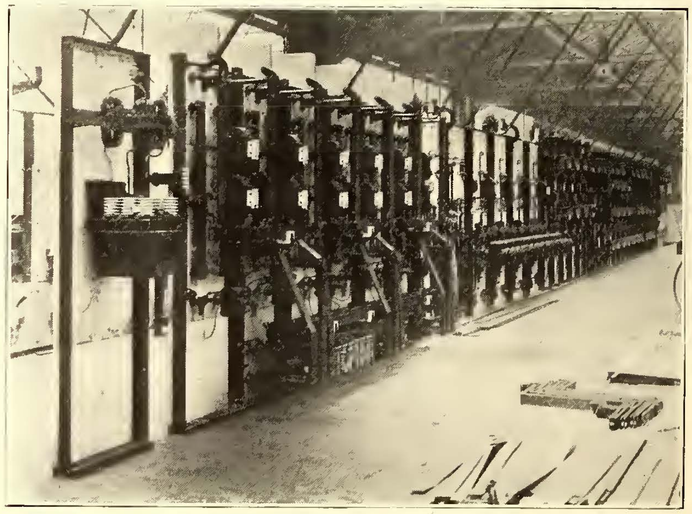


FIG. 53.—REAR ELEVATION, HIGH-TENSION SWITCHBOARD OF PUTNEY BRIDGE SUB-STATION

separately or in multiple. Isolating switches are installed in connection with all high-tension feeder and rotary oil break switches, transformers, static dischargers, etc., so that it is possible at any time to inspect or repair any piece of high-tension apparatus with safety and without interfering with the general operation of the sub-station. The high-tension oil break feeder and rotary switches are hand-operated through the medium of levers suitably connected to the switch proper by a link mechanism, the construction and arrangement of the levers being similar to those used in railway signal work. These switches are erected in a masonry structure, with each pole and the oil tank, in which it is immersed, in a separate fireproof compartment. There are two stationary contacts per pole, one connected to the incoming lead and the other to the outgoing lead of the same phase, while the movable contact for each pole consists of a U-shaped copper piece fastened to the end of a stout wooden rod. The wooden rods are fastened at their upper ends to a common cross bar, which, through a system of levers giving a straight line of motion, is raised by means of the levers assisted at the beginning of its motion by a pair of balancing springs. A toggle joint automatically locks this system of levers when the switch is in a closed position. The toggle is released by a blow from the tripping magnet, which, by gravity and the assistance of a powerful spring, causes the cross bar with the movable rods and contacts to drop to the open position. The oil tanks are constructed of heavy sheet metal, the interior being lined with insulating cement, and each is provided with a small sight gage to show the oil level. The feeder and rotary switches, respectively, are automatically tripped by reverse current and overload time limit relays connected to the series transformers in the main circuits. The rotary switches can also be electrically tripped by a push-button on the rotary panels. All high-tension cables, series and potential transformers, static dischargers, etc., are mounted on the rear of the high-tension brick wall, each in its own brick cubicle and quite isolated from adjacent apparatus. In the four feeder stations the static dischargers are installed in front of the high-tension wall in fireproof chambers fitted with inspection doors, these being adjacent to the main oil switches and similar in appearance.

FIGS. 55 AND 56.—TWO VIEWS OF CHARING CROSS SWITCHBOARD

FIGS. 57 AND 58.—TWO REAR VIEWS OF THE CHARING CROSS SWITCHBOARD

SWITCHBOARD PANELS

One-third of the total number of sub-stations supply current to two or more contingent or independent railways, making it necessary to meter separately the power supplied to each road, whether for traction, tunnel and station lighting or elevators. The use of an insulated return, in addition to these metering requirements, makes the construction and operation of the low-tension switchboard much more extensive and complicated than is usually the case for this class of work. All panels are of blue Vermont marble and somewhat wider than the usual standard practice, owing to the double-pole construction. The general arrangement of the panels and apparatus is clearly shown by Figs. 55 to 60, inclusive, the number varying from fourteen to thirty-three, and depending upon local conditions and the number of independent roads to be supplied from any individual sub-station. All high-tension feeder panels are arranged for the control of two feeders, these being equipped with three ammeters, one integrating wattmeter, one synchroscope, indicating

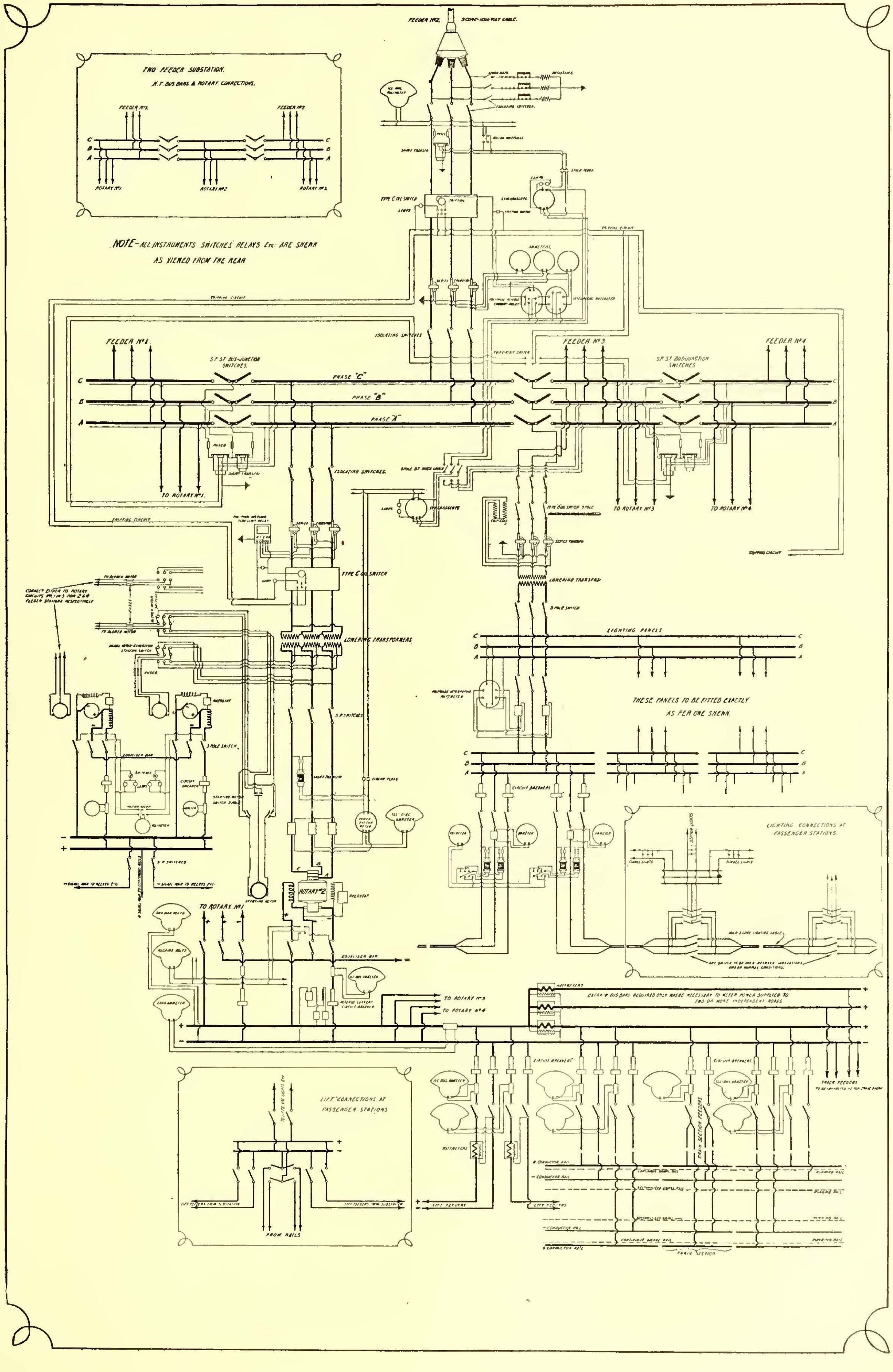
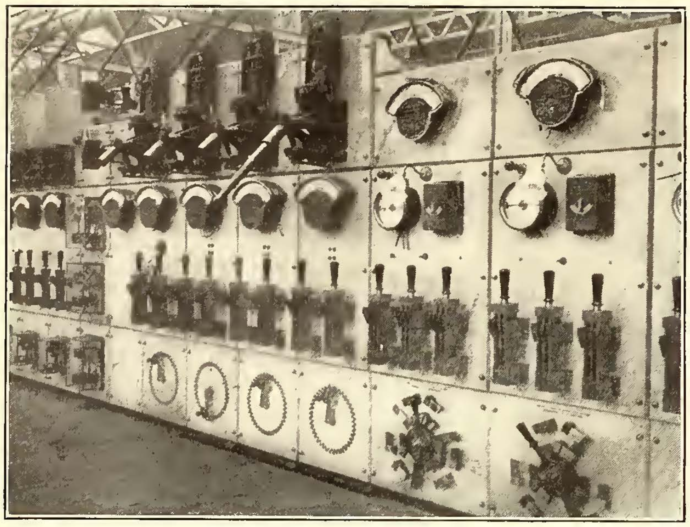
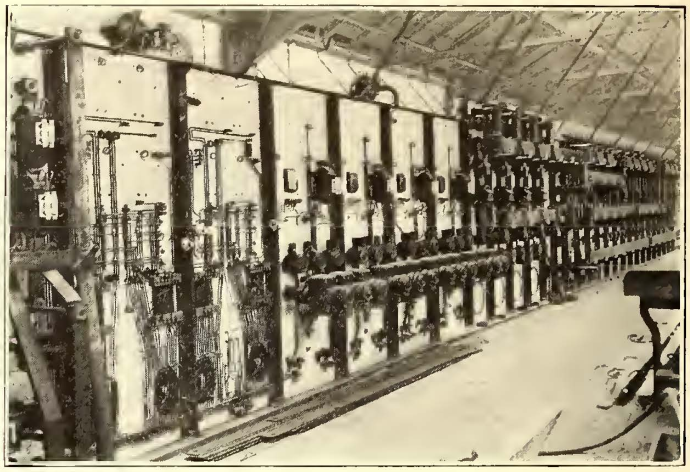


FIG. 54.—TYPICAL OUTLINE DIAGRAM OF SUB-STATION CONNECTIONS

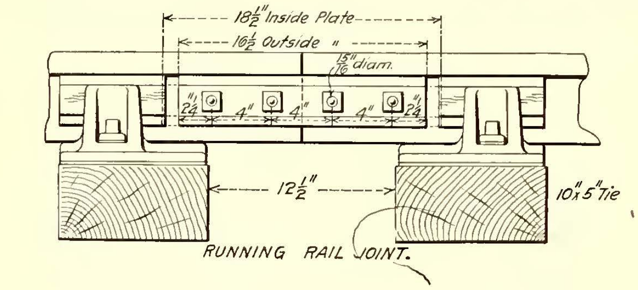
lamp and reverse current relay for each feeder. Two push-buttons for electrically tripping the feeder switches and a common voltmeter are also mounted on these panels. The low-





FIGS. 59 AND 60.—FRONT AND REAR ELEVATIONS OF SWITCHBOARD AT CHARING CROSS

of bus-bars is used, in order that any individual feeder or set of feeders may be disconnected from the main supply without in any way affecting the other circuits. On the base of these panels is mounted the switch connecting the transformers to the main bus-bars as well as the group switches between the main and auxiliary bus-bars provided for each road. The switches controlling the individual circuits are connected to these auxiliary bus-bars, each circuit on the individual panels being equipped with its own ammeter and a double-pole circuit breaker. The transformers in the Charing Cross sub-station supply power to three independent roads, and, in the event of these transformers being out of service, it is possible for the adjacent sub-stations on any or all of these roads to independently or collectively feed through this station. A voltmeter common to all circuits, together with two three-pole,



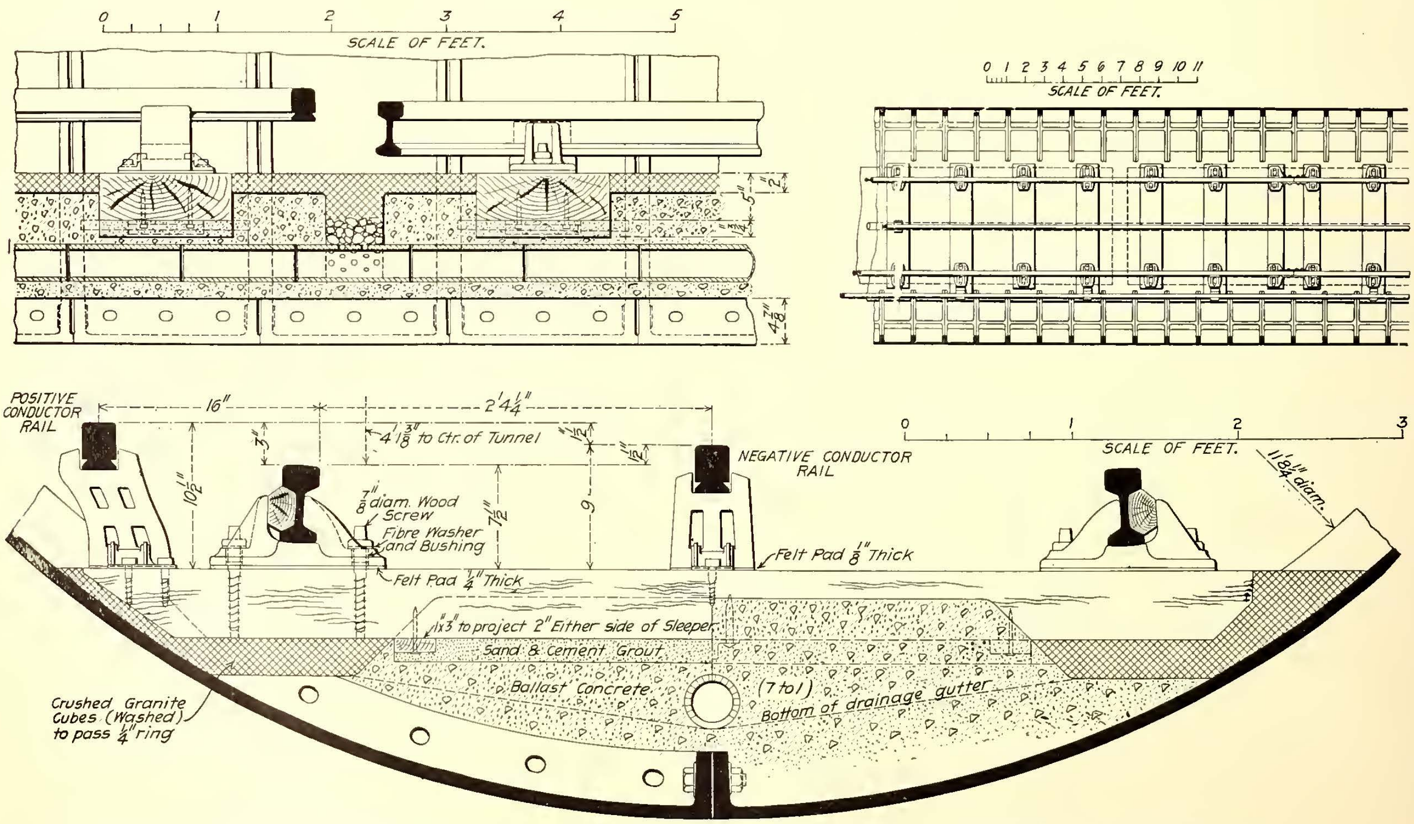


FIG. 61.—PLANS, SECTIONS AND SIDE ELEVATIONS, ILLUSTRATING TYPE OF CONSTRUCTION OF PERMANENT WAY

tension a. c. lighting panels are arranged in pairs for the control of two circuits to each railway, each pair of panels being supplied with current from a common bus and equipped with an integrating wattmeter. Where current is supplied to two or more independent roads from any one sub-station, a second set

double-throw switches for the control of the blower motors, complete the equipment of these panels. The a. c. rotary panels are each equipped with the usual ammeter, power-factor meter, overload time-limit relay and three single-pole switches. On the load panel is mounted the d. c. bus-bar and machine voltmeters, main ammeter for the total d. c. output and the traction wattmeters. The d. c. rotary panels are each equipped with one single-pole circuit breaker with reverse current attachment, but all other d. c. panels have a circuit breaker in both the positive and negative side of the circuit. Each lift panel is equipped with an integrating wattmeter connected so that the power supplied to the lifts will be metered independently of the traction circuits. Illuminated dial instruments are used on all rotary and d. c. feeder panels. A triple-pole automatic oil switch is used to protect the lighting transformers, this switch being mounted on a standard switchboard panel and installed between the rotary and feeder oil switches.

SIGNAL APPARATUS

Duplicate motor-generator sets and an air-compressor equipment are installed in each sub-station for the operation of the signal system. Each motor-generator set consists of a 7.5-kw, 70-volt, compound-wound, d. c. generator, direct connected to a three-phase, 365-volt induction motor. The armatures of the two machines are mounted on a common shaft and the frames on a common bed-plate. The main rotary transformers supply power for the operation of these sets, connection being made to two independent transformer sets through the rotary starting motor switches on the base of the a. c. rotary panels. An independent two-panel switchboard is installed for the control of the current to and from this apparatus. A 550-volt, d. c. motor direct connected to a Christensen air compressor, together with the necessary controlling panel, air reservoir, etc., completes the signal equipment installed in the sub-stations.

TUNNEL AND STATION LIGHTING

The incandescent lighting for the passenger stations and tunnels is arranged so as to be practically independent of the sub-station traction circuits. Independent lighting transformers are installed in the various sub-stations, the high-tension current supplying these transformers being taken directly from the sub-station bus-bars. The distribution system is arranged for emergency interconnection between sub-stations. All "tube" passenger stations will, in addition, be provided by an independent lighting system from some outside and entirely independent source, these emergency lights to be in continuous service.

The tunnels and stations generally will be lighted by incandescent lamps supplied from the three-phase, 220-volt mains. Arc lamps will be used for the general illumination of the station platforms, booking halls or ticket offices, etc., these to be operated in series and supplied from the elevator and traction, 550-volt, d. c. circuits.

PERMANENT WAY

The permanent way of the District and "Tube" Railways is of standard English construction, with the bull-head type of running rails. Figs. 61 and 62 illustrate this type of construction in addition to the arrangement and location of the two conductor rails.

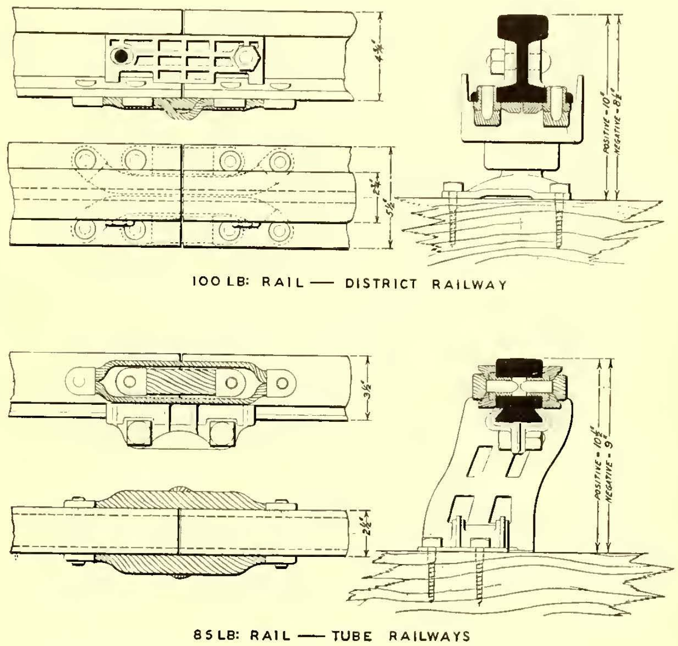


FIG. 62.—BONDING AND SUPPORTS FOR CONDUCTOR RAILS

CONDUCTOR RAILS

The position and protection of the "third" rail (see STREET RAILWAY JOURNAL, July 4, 1903; also June 25, 1904), as adopted by the Mersey, Lancashire & Yorkshire, North Eastern Metropolitan and Metropolitan District Railways, leaves much to be desired in the way of "standard" construction. The question of uniformity in the location of the conductor rail is apparently a matter largely determined by local or existing conditions, and unfortunately is no nearer solution in Great Britain than in the United States or on the Continent. Two insulated conductor rails, positive and negative, are used per track,

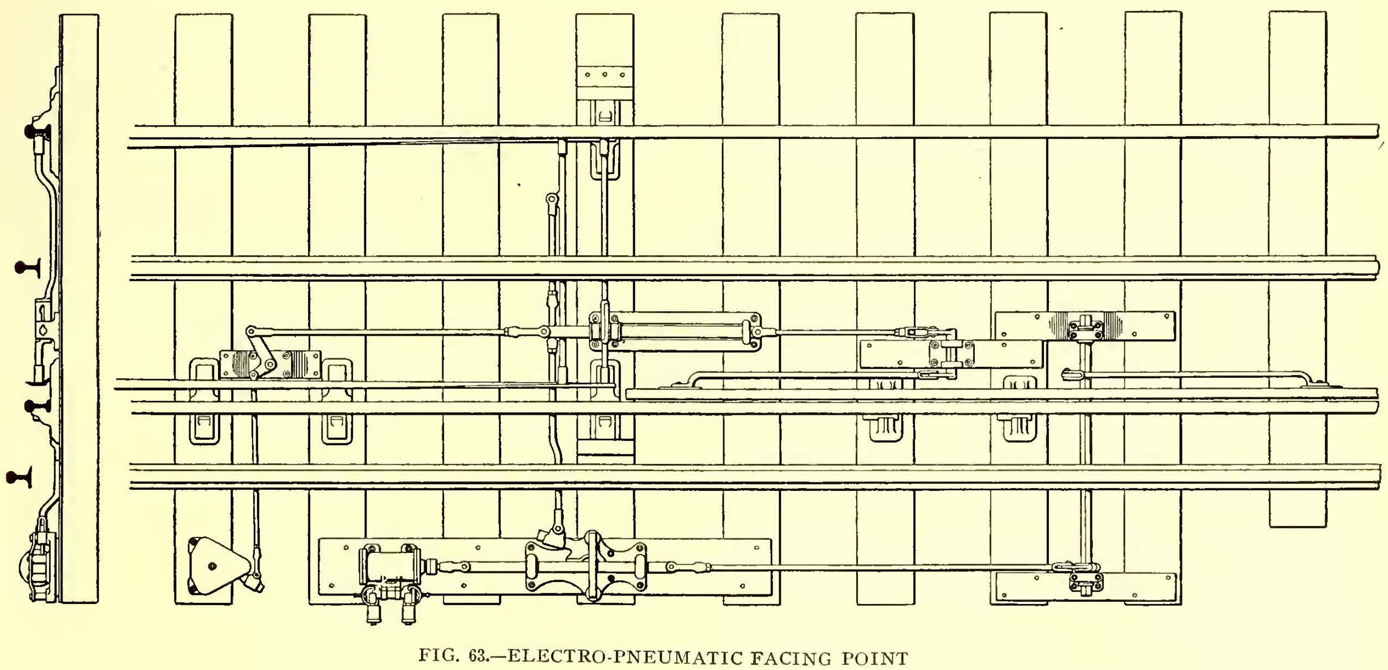


FIG. 63.—ELECTRO-PNEUMATIC FACING POINT

the former being placed 16 ins. outside the running rail and the negative centrally between the track rails. They are 3 ins. and 1½ ins., respectively, above the running rails.

A 100-lb. T-section, with an extra broad and thick base, is used for the conductor rails on the District Railway, while a section similar to that designed by W. B. Potter, of the General Electric Company, is used for the "Tube" Railways. The latter is of rectangular section, with dove-tails at the bottom, and weighs 85 lbs. per yard. The dove-tail or V-groove construction provides an easy and satisfactory method of securing the rails by a special design of fish-plates.

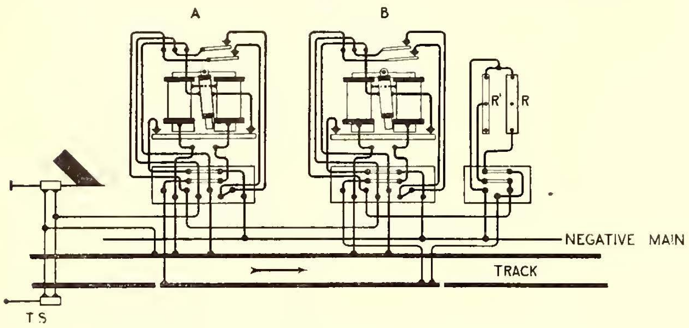


FIG. 65.—TWO RELAY CIRCUITS OF ELECTRO-PNEUMATIC SIGNALING

The resistance is guaranteed to be not more than 6.4 times the equivalent section of copper; the chemical constitution necessary to obtain the above figure is about as follows:

Carbon	.05
Manganese	.19
Sulphur	.05
Phosphorous	.05
Silicon	.03

Individual analyses and tests of these rails show essentially the results as above given, and that they are easily the best electrical conductors of some forty-five samples tested in the laboratory of the General Electric Company, the results of these tests having been given in a paper presented to the New York meeting of the American Institute of Mining Engineers by J. A. Capp, Oct. 15, 1903 (see STREET RAILWAY JOURNAL, Oct. 24, 1903). From actual tests it was found that the relative resistance of this conductor rail, six months after being bonded and ready for service, including bonds, bond contacts, etc., was 7.76 to 1, compared with Matthieson's standard of conductivity.

The bonds are of the "Crown" type, as manufactured by the American Steel & Wire Company, the diameter of the heads being 1 in., and the total effective sectional area of the four bonds 2,000,000 circ. mils and 1,700,000 circ. mils for the 100-lb. and 85-lb. rails, respectively. The total contact area is 9.4 sq. ins. and 10.5 sq. ins., and the ratio of contact to rail area, based on the guaranteed conductivity, is 6.1 to 1 and 7.9 to 1 for the T and rectangular sections, respectively.

The main line conductor rails are separated by an isolated "train section" opposite all sub-stations and at all main line junctions. The connections to this section are substantially as shown on the typical diagram of sub-station connections, all special work incidental to cross-overs, etc., being included in this section.

TELEPHONE SYSTEM

A complete and independent telephone system is being installed, each of the several railways and the generating station to have its own exchange. These will be interconnected by trunk lines, the exchange at the generating station to have through communication with each of the twenty-four sub-stations independently of and in addition to the connection through its local exchange. The general scheme provides for telephone instruments at every passenger station, signal cabin, sub-station, offices, etc., on the system, the main exchange being located on the ground floor of the signal cabin, which is situated at the west end of Earls Court station.

A 300-line board and distributing frame, the latter being fitted with fuses, test jacks and facilities for cross connecting, is installed in this exchange, to which will be connected all the District Railway instruments, together with the trunk lines from the other exchanges. Each tunnel of the several "Tube" roads will be equipped with an emergency telephone system, in addition to the general scheme briefly outlined. The essential features of this emergency system are: A central telephone set placed at any desired location, two bare copper wires supported from the tunnel shields opposite the motorman's window, and a portable set without batteries in the motorman's cab on each train. The portable set is provided with a flexible connection terminating in two specially constructed contact clips, by means of which the instrument can easily and quickly be connected to the lines when occasion arises. When connected, the motorman can either send or receive a call from the central instrument, and therefore establish communication with the general system.

TIME SYSTEM

A time system is being installed along lines similar to those employed for the telephone system, all clocks to be regulated by one master clock at the Chelsea generating station. Both single and double-dial clocks will be used, each one of which will have its own independent movement and be electrically wound. They will be arranged to operate on a metallic circuit in groups of about twenty, this circuit to be supplied with current from the signal motor-generators in the sub-stations at approximately 70 volts pressure. Any number of circuits can be synchronized from the master clock by the insertion of a relay or relays in series with the synchronizing line at the end of any circuit and making a new tap to the 70-volt mains at this point.

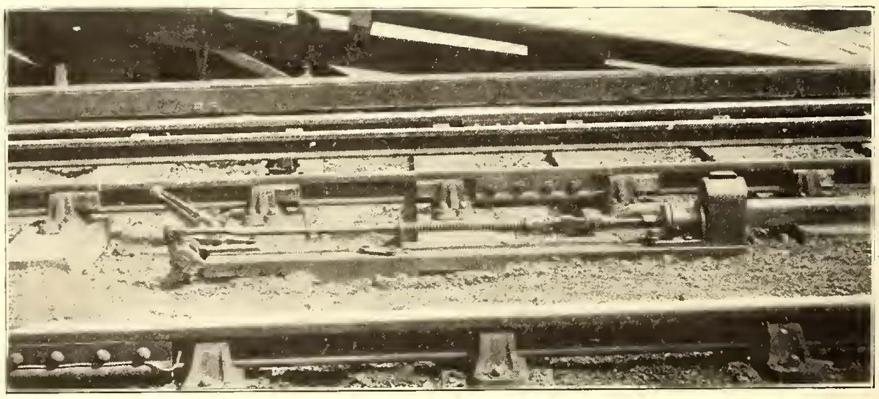


FIG. 64.—AUTOMATIC TRAIN STOP

AUTOMATIC SIGNALING

The Westinghouse electro-pneumatic systems of automatic signaling and power interlocking have been adopted. The power interlocking is similar to that installed in the United States, one of the more important differences being in the switch layouts. In Fig. 63 it will be seen that the detector bar, bolt lock and indication box are in series; also that the plunger passes through two blades, one blade being fixed to each switch point. This insures the proper position of both switch points before the plunger passes through the lock blades and prevents a return indication being received if any part of this series is defective.

The block system is on the normally clear principle, compressed air holding the signal clear as long as its valve magnet is energized. A train entering a track section de-energizes the track instruments, thereby opening the circuit, including the valve magnet. The valve magnet being de-energized, closes the port admitting air to the signal motor, at the same time opening the motor cylinder to the atmosphere and causing the signal to go to danger by gravity.

Each signal is provided with an automatic train stop, Fig. 64. When the signal goes to danger, the stop arm is raised to a vertical position near the right-hand running rail. Should a train attempt to pass a signal at danger, this arm would engage with and open a cock on the train, causing an emergency application of its brakes. When the signal goes clear, the train stop arm is lowered, allowing the train to pass without interference. An overlap averaging 400 ft. has been allowed so that a signal cannot go to safety until the tail end of the train is the length of the overlap beyond the next signal. A train stopping anywhere therefore has the signal at danger behind it, never nearer than the length of the overlap, a distance greater than is required to stop the train with an emergency application of the brakes when at maximum speed.

The connections of the track circuits controlling the automatic signals are shown in Fig. 65. The track circuit as ordinarily applied to steam roads would be unsafe on a road using electricity for motive power. The presence in the track rails, forming part of the track circuit, of current extraneous to the signal system would cause false indications of safety.

The track rails do not normally carry any of the traction current, a second and negative conductor rail being used; but defective insulation of train apparatus, cables or conductor rails, although possibly infrequent, would create extraneous current conditions prohibiting the use of any system not beyond their influence.

The track-circuit system adopted was invented by H. G. Brown, one of the Westinghouse Company's engineers, this system being selective between the normal signal and extraneous currents. One of the running rails is electrically continuous throughout the entire length of the road, and constitutes the positive conductor from the signal generator to the individual track sections. The other rail is divided into block sections by insulated joints, all other uninsulated rail-joints being bonded to insure good electrical continuity. Power is supplied from the signal motor-generator sets installed in each sub-station at 70 volts pressure, the negative terminal of these machines being connected to an insulated conductor running the entire length of the system. This main is connected to each section of the sectionized track rail at a point near the latter end of the block—that is, the end at which the train leaves the section. Resistances are interposed in the connections between the negative main and the sectionalized rail, which reduce the potential difference between the rails to 3 volts to 6 volts, according to the length of block and local conditions. These resistances prevent the short-circuiting of the generators when a block is occupied, and are sufficient to prevent the generators being overloaded when all the blocks are occupied by trains.

There is considerable variation in the resistance of the roadbed, according to weather conditions, but the operation of the signals has in no wise been interrupted by repeated and extensive flooding of the tracks. The relay track coils are permanently connected across the rails, and are therefore energized and close the local signal circuit when a difference of potential exists in the normal direction between the rails—that is, when no train is on the block. The polarized relays are energized in the normal direction by the signal current when the section is clear, and when so energized close the local signal circuit, as shown in Fig. 65. When a train enters a section, the relays are short-circuited, thereby opening the local signal circuit, causing the signal to go to danger.

Fig. 66 shows the mounting of the relays, these being in multiple in relation to the signal current.

When a train is in the section they are in series in relation to extraneous currents flowing in the continuous rail, and therefore one of them is reversed when illegitimately energized and the signal circuit thereby opened at that point. With a grounded train in a section, the current flowing from the sectionized rail to the continuous one would reverse both relays. The local signal circuit is always open when the section is occupied, as one relay is always shunted from or reversed by an extraneous current, and in the majority of cases both are either shunted or reversed.

Small air compressors are located in the sub-stations, which deliver air at 80 lbs. pressure to the automatic signals and

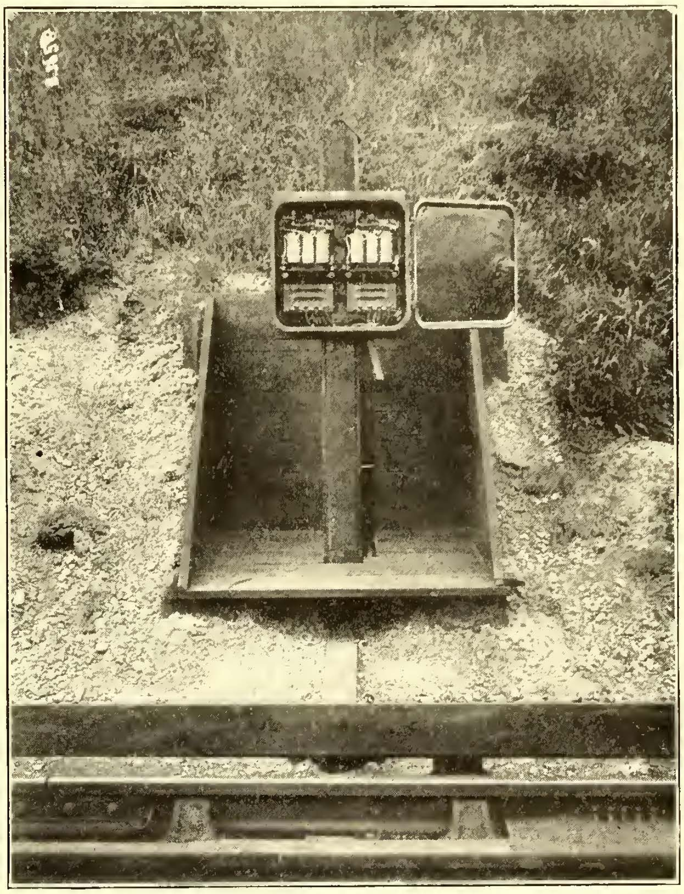


FIG. 66.—MOUNTING OF SIGNAL RELAYS

power interlockings by means of a pipe extending the entire length of the system.

TRAIN DESCRIBER

A magazine train describer is being installed in connection with the signal system, the line between the sending and receiving stations having a capacity varying from five to twenty trains. Illuminated signs will be erected on the station platforms, these to indicate the three next trains in the order of their arrival. The departing train cancels its own description, the remaining two descriptions moving up simultaneously with a new announcement. For illustration we will assume that cabin A is sending descriptions of passing trains to cabin F, and that B, C, D and E are intermediate stations. Cabin A may send ten descriptions to F, providing the line has sufficient capacity, before the first train reaches F, these descriptions being automatically stored in their proper sequence in the receivers at B, C, D, E and F. The cancellation of the passing trains by cabin F causes the next description stored within the instrument to be displayed, this operation at the intermediate stations being done automatically, as previously described. It is expected that this method of announcing arriving trains will greatly facilitate the loading, and thereby shorten the station stops.

TRAINS

Seven-car trains, consisting of three motor cars and four trailers, will be used on the District Railway; six-car trains, with two end motor cars and four trailers, on the Great Northern Piccadilly & Brompton and the Baker Street & Waterloo Railways, and five-car trains, with two end motor cars and three trailers, on the Charing Cross, Euston & Hampstead Railway. The seating capacity of these trains is 364, 304 and 250, and the estimated train weights, without passenger load, are 137.5 tons, 135.7 tons and 116.9 tons (2244 lbs. per ton), respectively. The Board of Trade regulations in regard to "tube" railways do not permit the use of a motor car in the center of the train, and all tube trains therefore have but two motor cars, one at either end of the train.

The District cars are constructed mainly of Oregon pine and white ash, with mahogany trimmings, all woodwork being thoroughly treated and thereby rendered absolutely non-inflammable. The automatic couplers are of the vertical plane type, with manganese steel jaws. The buffers are of cast steel, with horizontal corrugations, the object of this construction being to effectively lock the couplings and so prevent any individual car from rising in case of accident. Both ends of the cars are protected by a ¼-in. steel plate, extending from the end sills to the roof carlines, with an arched center opening and no door.

Luggage accommodation is required by statute on a portion of the District trains, a compartment for this purpose being provided in the driving end of the end motor cars only. The motorman's cab is located in one corner of this compartment, the design being such that the cab in the trailing motor car may be easily and quickly folded back when not in use. The platforms of these cars are entirely enclosed and constructed with side and end sliding doors instead of the customary gates. Double sliding doors are provided in the middle of the cars for the exit of passengers at the same time that they are being loaded from the end doors. All side doors are opened and closed by compressed air controlled by a lever on the end of the car, this operation being performed by the train guards. The cars for the "tube" railways will be of steel construction throughout, without luggage compartments, and with the usual platform gates. Figs. 67 to 71 show the general construction and arrangement of the District cars.

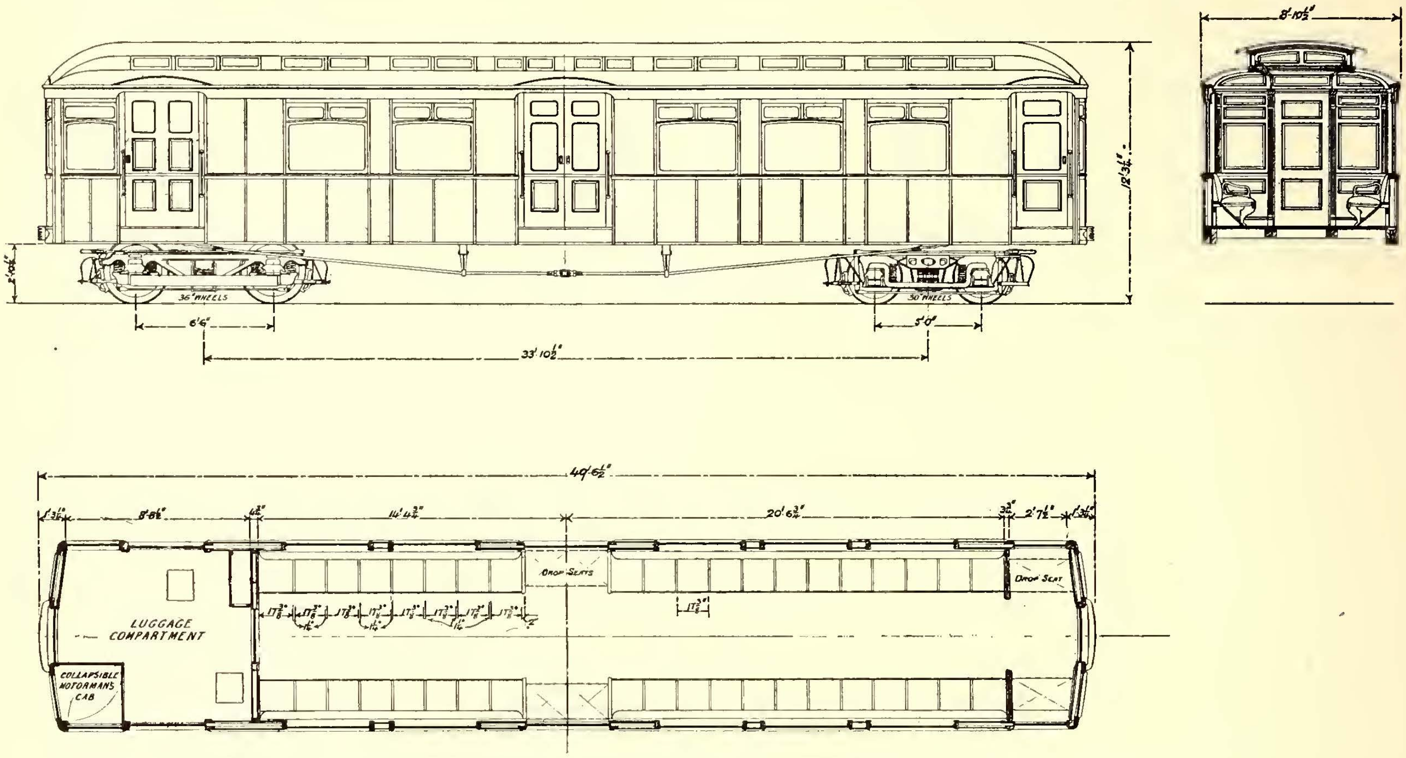


FIG. 67.—SIDE ELEVATION, PLAN AND CROSS-SECTION OF DISTRICT RAILWAY END MOTOR CAR

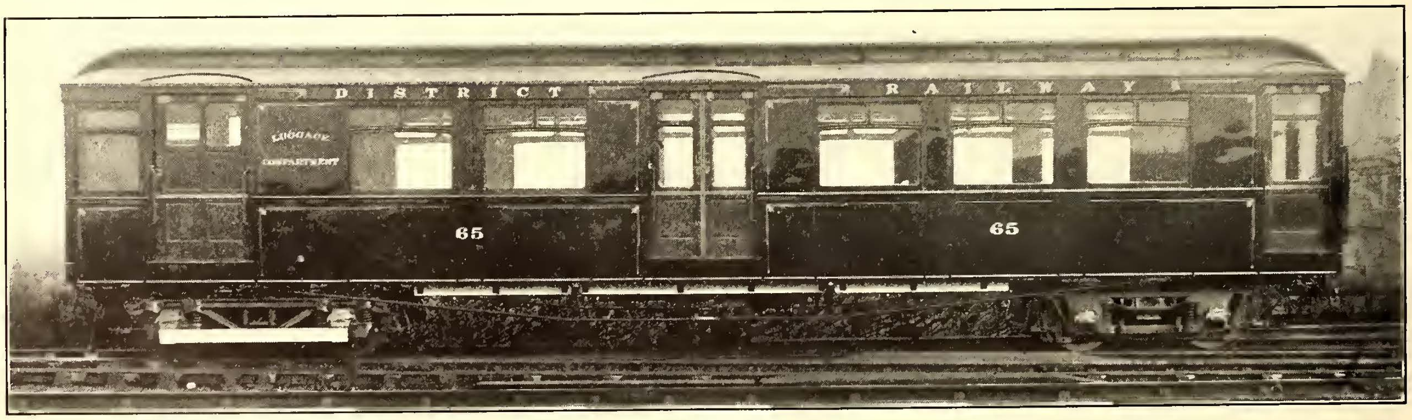


FIG. 68.—SIDE VIEW OF DISTRICT RAILWAY END MOTOR CAR WITH LUGGAGE COMPARTMENT

CAR EQUIPMENT

The main equipment for the trains is being supplied by the British Thomson-Houston Company, Limited, and consists of the standard 200-hp GE 69 motors and type "M" control. The motor frame is not split, but is of the well-known box frame type, with frame heads carrying the armature shaft bearings. The motors are mounted on a cast-steel struck of the Hedley type, with 6-ft. 6-in. wheel base and 36-in. wheels. The motor is arranged for nose suspension, and is also provided with safety lugs to prevent the motor from falling in case the nose should break. The motor is mounted on or removed from the truck from above when the truck is out from under the car, no pit being required. Each motor is provided with a suitable connection box, in which the motor leads are connected to the car wiring. The motor leads are protected by flexible metallic armouring, one end of which is sweated into a brass plug tapped into the motor frame, while the other end is secured to the connection box by standard pipe unions. This provides mechanical protection for the motor leads, and can be easily uncoupled when desirable to remove a motor. The gear is split in halves with a 7-in. bore and designed to go directly on the axle. Each motor car will be equipped with two motors, the weight of one motor complete, including gears and gear case, being about 6100 lbs.

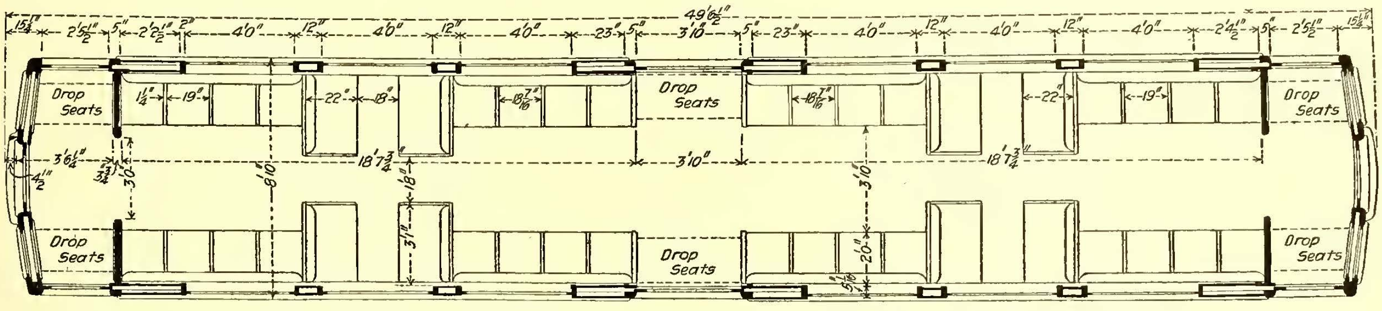


FIG. 70.—PLAN OF TRAIL CAR FOR THE LONDON UNDERGROUND DISTRICT RAILWAY

The type "M" system of control consists in general of two parts: First, a series-parallel motor controller composed of a number of electrically-operated switches called "contactors," and an electrically-operated reverse switch for the motors called the "reverser." The contactors make the different electrical combinations of the motors and regulate the starting resistance in circuit with them. Second, a master controller which operates the motor controlling contactors and reverser, this being located at one end of each end motor car and at both ends of each middle motor car. The control cable which connects each master controller with the contactors is extended the entire length of the train, connecting the control circuits of the several motor cars together by means of flexible couplers between the cars. The position of the master controller handle indicates to the operator the exact resistance and motor combinations on all of the motor cars. The master controller is manually operated and non-automatic. The motorman therefore has the train under his immediate control and can utilize the full power of the motors in either direction in an emergency. The master controller is designed so that in case the motorman removes his hand from the operating handle for any cause, the control circuit will be opened, thus shutting off all power from the train; releasing this knob at any position of the handle will also open the air valve in the controller and the air brakes will be applied on all the cars of the train. After applying the brakes by means of this device, they may be released by simply depressing the knob at the off position of the handle, and to render this air brake feature inoperative it is only necessary to move the reverse handle to the mid position. For reversing the motors the master controller is provided with a separate reversing handle, and a mechanical interlocking device prevents this reversing handle from being thrown unless the main handle is in the off position. The operating circuit is so arranged, that unless the reverser is thrown for the direction of car movement indicated by the master controller reverse handle, the contactors and motors on that particular car are inoperative. All current for the operation of the contactors on each of the different cars throughout the train passes through the single master controller under the immediate control of the motorman. This current may be taken directly from the collector shoes on the leading car or from the shoes on the following motor car by means of the bus line on the District trains, or by means of the lighting mains on the "tube" trains, but in either case it is controlled by the single master controller in use. Should the train break in two, the control current is automatically and instantly cut off from the detached rear portion of the train without affecting the ability of the motorman to control the front part of the train.

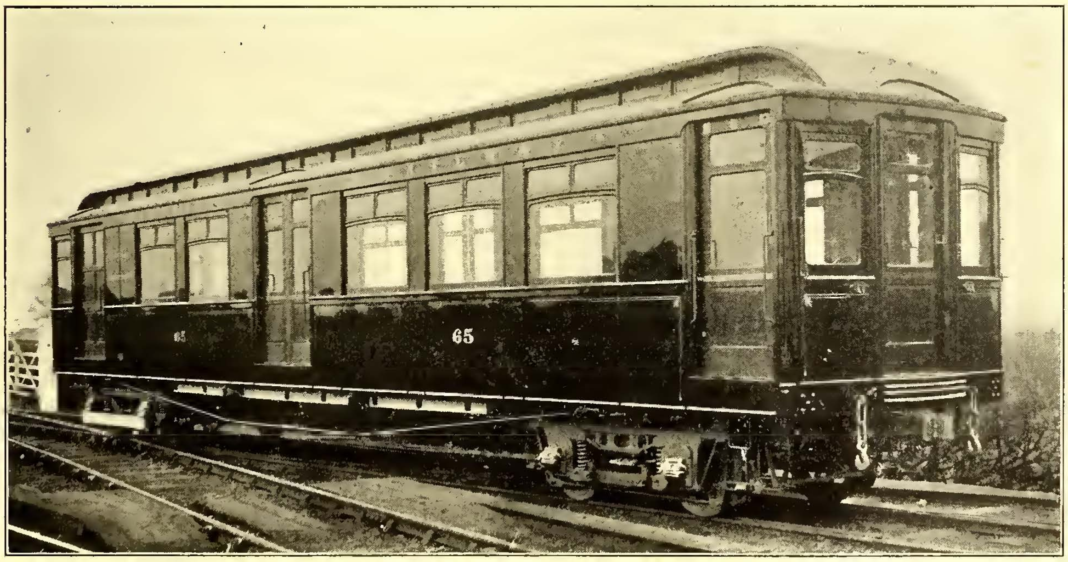


FIG. 69.—DISTRICT RAILWAY END MOTOR CAR WITH LUGGAGE COMPARTMENT

There are four rheostatic and one running point in series and three rheostatic and one running point in parallel, the relative resistance for each step being such as to insure smooth acceleration of the train. A smooth transition from series to parallel combination is insured by making the necessary circuit changes without short-circuiting or open-circuiting either motor. A series parallel arrangement of rheostats is used which produces the best possible proportioning of resistance sections, and at the same time gives uniform distribution of current per contactor. It is worthy of mention that these trains are the first in England to use the so-called bridge method of changing from series to parallel combination of motors. The change is effected by this method without interrupting the current in either motor, which is maintained at practically a constant value throughout the whole range of rheostatic acceleration. This eliminates entirely the somewhat unpleasant sag in speed which is noted when the motor current is interrupted while the motors are passing from series to parallel relations.

Another of the recently developed features with which these equipments are provided is the electrically-operated carbon break circuit breaker for the protection of the motor circuit on each motor car. Each circuit breaker is provided with a setting coil, by which it is closed; also a shunt and an overload tripping coil. Once closed by the setting coil the circuit breaker is held in the closed position by a mechanical lock. Either one of the tripping coils will open the circuit breaker by releasing the mechanical lock. The circuit breaker is built in the form of a contactor and is enclosed in a separate sheet-iron asbestos-lined cover. All circuit breakers throughout the train are closed by the setting coils energized from one of the control

FIG. 71.—INTERIOR OF MOTOR CAR WITHOUT BAGGAGE COMPARTMENT FOR DISTRICT RAILWAY

wires at the off position of the master controller, this wire being energized by the circuit breaker setting switch in the driving cab. All circuit breakers may be instantly tripped, irrespective of the position of the master controller, by merely closing the tripping switch in the cab, thus energizing the shunt trip coil of each circuit breaker. In addition, any circuit breaker may open automatically through an overload in the motor circuit without affecting the remaining circuit breakers in the train, merely cutting out of service the motors on that particular car. Magnetic blow-out, ribbon type fuses are used for the protection of the main circuits on the motor cars. Each positive collector shoe is protected by a shoe fuse mounted on the shoe beam. The motor circuit is protected by a positive and a negative fuse in addition to the circuit breaker, the negative fuse being considered advisable, as the negative conductor rail is not earthed. These fuses are of the ribbon type and are mounted beneath the car close to the contactors. The positive leads of the bus-line coupler sockets on the District trains are protected by coupler fuses, which prevent an abnormal flow of current through the bus line should the train run from a live to an earthed section of the conductor rail. These fuses are also of the ribbon type and are mounted beneath the car.

The copper strands of the heavy car wiring cables are first wrapped with paper tape, then rubber insulated, taped and served with one cotton and one asbestos braid. A slate-colored lead paint, containing very little oil and practically non-inflammable, is used to finish these cables. Standard Westinghouse automatic air-brake apparatus, with Christensen compressors, made by the National Electric Company, of Milwaukee, Wis., completes the train equipment.

ARRANGEMENT OF EQUIPMENT

On the District trains all of the controlling apparatus, air compressors and governors are installed under the car between the trucks. The control apparatus is all enclosed in well insulated metal covers supported from hard wooden beams. The main wiring is all run in drawn steel tubes, the rheostat and contactor leads being supported in wooden troughs lined with uralite. On the "tube" trains all the control apparatus, as well as the air compressors, is carried in a steel cab at the driving end of the car. Here the contactors and circuit breakers are hung from horizontal slate panels supported by rigid steel framework. This framework also carries the rheostats. This form of construction was adopted because the small diameter of the tunnel does not allow sufficient room for the apparatus to be carried under the car. It is also considered safer on the "tube" lines to have the apparatus enclosed in a steel cab in case of any fault developing in the equipment while a train is running in the tunnel.

CAR SHEDS

The District car sheds are located between the Mill Hill Park and Ealing Common stations parallel to the tracks, and cover a little over 4 acres. The building is divided into three equal bays by longitudinal fireproof walls, the over all length and width being 802.5 ft. and 216.5 ft., respectively. The structure is of steel construction with brick walls, each bay being spanned by a trussed monitor roof of corrugated iron and patent glazing. A total of eleven tracks, four in the paint shop, five in the inspection shop and two in the repair shop, are provided for housing the trains, inspection and repairs, entrance to the sheds being obtained from either end of the building. There is accommodation for about 150 cars under cover and 200 cars on the sidings. Working pits are provided under all tracks in the inspection and repair shops, the latter being equipped with the necessary machine tools and electrically-operated traveling cranes.

The writer is greatly indebted to the British Westinghouse Electric & Manufacturing Company, British Thomson-Houston Company, Babcock & Wilcox, Brush Electrical Engineering Company and Mayoh & Haley for photographs used to illustrate the text; also to F. T. Wright for assistance in the preparation of maps and drawings.

A RECORD OF COMPANIES AND MILEAGES CONSTITUTING THE PENNSYLVANIA RAILROAD

The Pennsylvania Railroad has recently published a record of the transportation lines owned and operated by, and associated in interest with it, for the year of 1904. This record forms a basis for a very interesting study, indicating, as it does, much of the organization of this great railroad system and its constituent lines. It is interesting to note that this great system now embraces a total length of lines of 10,588 miles, passing through twelve States of the Union and the District of Columbia. The State embracing the greatest mileage is Pennsylvania, in which there are 3900 miles of lines. Of this mileage, 5857 miles lie east of Pittsburg and Erie, embracing twelve different railroad companies, and 4731 miles west, embracing ten companies. It is interesting to note that it owns 66 miles of canal and operates seven ferry lines. The record is also of service in tracing the connection of the early railroad companies with the present organization; the pioneer roads which are of historic interest in the development of railroading in this country are separately enumerated. The record occupies 41 pages of a 9-in. x 12-in. pamphlet, which contains also a comprehensive map of the system.

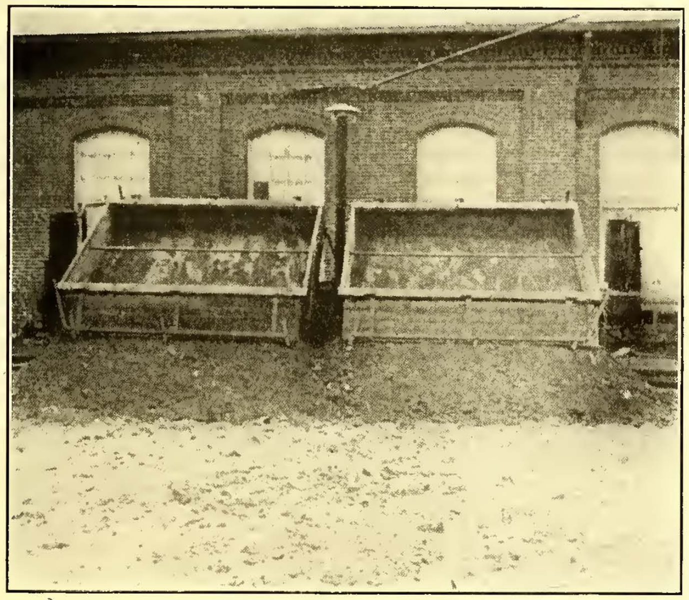
SIDE DUMPING CARS FOR BALLASTING TRACK IN BALTIMORE

The United Railways & Electric Company, of Baltimore, Md., is doing considerable reconstruction of track work and has found need for an efficient dump-car equipment to facilitate the handling and distribution of ballast. To fill this need a novel type of dump-car has been designed and built at the company's shops under the direction of H. H. Adams, master mechanic.

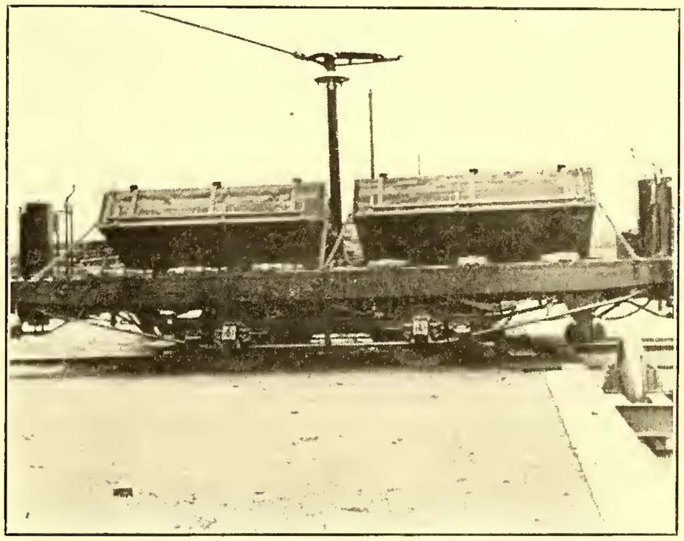
BALTIMORE DUMP CAR IN DIFFERENT POSITIONS

The car is illustrated in the accompanying engravings. The capacity of each car is about 8 cu. yds. and the weight of car, light, is 18,910 lbs. The cars are mounted on Lord Baltimore single trucks, with two Westinghouse 49 motors and K-10 controllers to each car.

The dumping feature of the car consists essentially of two boxes arranged with three channel irons on the bottom of each, these irons resting upon rollers, there being four rollers under each channel. The boxes may be dumped by pushing them upon the rollers toward the side of the car from which it is desired to unload. Each box has a chain fastened to each one of its lower corners, this chain being attached to the sides of the car as shown. On each end of the box there is also a chain, one end of which is fastened at the center of the box and the other end is fastened in the center of the car. This chain is just long enough to allow the box to pivot on the three outer rollers when it is in position to be dumped. The angle the box is allowed to take in dumping is regulated by the length of the check chains on the corners of the boxes.



SIDE VIEW, SHOWING BOTH BOXES TIPPED



BOTH BOXES TIPPED, SHOWING CHECK CHAINS

The doors on the side of the boxes are fastened at three points, and are so pivoted that when released they will swing outwardly and permit the contents of the boxes to slide to the ground when boxes are tipped. These doors are connected to a common lever at one end of the car and all the doors can be operated by this one lever.

The boxes are held in normal position upon the body of the car by a heavy latch, which is operated by a lever, shown in the end view of the box in one of the engravings. In addition to this latch, the center check chains on each side are drawn over a heavy forged hook, thus holding the box so that it cannot go either way until released.

The boxes can be operated easily by two men, who can readily push the loaded boxes to dump material. However, the floor of the car is arranged with two plates having holes in them to receive the end of a bar, in order to provide means for moving the boxes more easily. With the use of a bar one man can dump the boxes. One of these plates is placed across the car as near the center of each box as possible. After the load has been dumped, two men can readily place the box back in position again. It is stated that this type of car has been of the utmost service and convenience to the track department in distributing materials for ballast and filling.

INDIANA ELECTRIC RAILWAY GUIDE

A monthly publication of thirty-two pages bound in attractive cover is to be issued under the direction of a committee of three from the Indiana Electric Railway Association. It is to be known as "The Indiana Electric Railway Guide." The editor and manager is to be Paul Richey, for three years assistant in the office of the chief engineer of the Indiana Union Traction Company, and previous to that in the newspaper business. In addition to time-tables, etc., there will be printed in the Guide considerable reading matter of general interest.

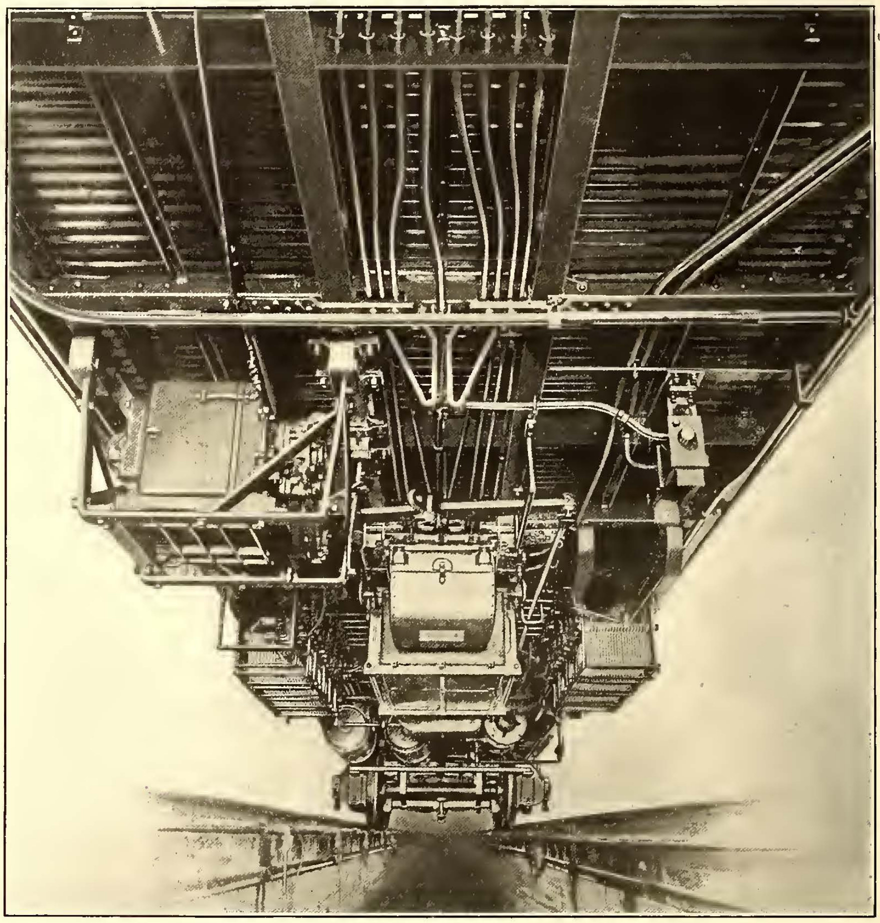
THE ELECTRICAL EQUIPMENT OF THE NEW STEEL CARS FOR THE NEW YORK SUBWAY

BY L. B. STILLWELL

Many engineers, especially those whose viewpoint is mechanical rather than electrical, have recognized the fact that in the remarkable development of electric traction systems the wiring of cars in general has by no means kept pace with the advance in motor construction and in systems of control. It has been repeatedly demonstrated in practice that insulation of rubber and cotton braid is not satisfactorily effective when subjected to abrasion or other mechanical injury, and that insulation of average quality as ordinarily installed deteriorates rapidly under the very severe conditions which it is called upon to meet in service. Even in cases where competent engineering advice has directed the car equipment and where skilful and faithful work has been done by the wiremen, the practical difficulties encountered in meeting the conditions imposed by the nature of the service have not always been satisfactorily and successfully met, and in the very many cases where short-sighted management has sought to economize by eliminating the engineer and purchasing cheap wire, rapid deterioration and frequent failure of the car wiring have been the natural and, indeed, inevitable consequences. A glance at the wiring of an average street car that has been in service for five years is sufficient to convince any practical man that this part of electric car equipment has been relatively neglected, and the frequent partial or even total destruction of electric cars by fire originating in the wiring has attracted general attention to the importance of radical improvement in respect to this important feature of the equipment.

In the equipment of the new steel cars of the Interborough Company, the organization, mechanical support and protection and electrical effectiveness of the car wiring have been the subject of careful investigation and much special study, with the result that improvements have been introduced which mark a distinct advance in the art of car wiring. The investigation by the electrical department of the company covered all classes of electric railway service, both here and abroad; the causes of difficulties encountered in actual service were carefully studied, in order to eliminate, so far as practicable, possibilities of similar troubles in the subway cars, and the results obtained as herein described are both interesting and highly commendable. This article will thus supplement the description presented in the recent "Souvenir" issue (Oct. 8, 1904) of the STREET RAILWAY JOURNAL, which contained interesting details of the mechanical construction of the steel cars.

The adoption of car bodies employing steel exclusively for not only framing, but also flooring, made it impossible to support the wiring beneath the car floor by any of the methods usually adopted. The use of wood, which more satisfactorily than any artificial substitute combines mechanical strength and "workableness" with good insulating properties, was prohibited by what was regarded as the primary consideration in the design and construction of these cars, viz., elimination of fire risk. Other methods of wiring, involving the carrying of wires above the floor of the car, were disapproved, as it was the aim of the company's engineers to keep all wiring and apparatus, so far as practicable, beneath the under framing; or in other words, outside the steel box which constitutes the car body. The problem presented, therefore, involved the construction of adequate mechanical supports for the large amount of wiring required by two motors of 200-hp each and a control system of twelve rheostatic steps, these supports to be attached to the steel under framing of the car; the protection of this wiring against abrasion and other mechanical damage; the use of insulation having an ample margin of safety with reference to the potential employed, and still the reduction of the amount of insulating material to an absolute minimum. This last particular requirement was emphasized by recognition of the fact that while actual risk to passengers inside the car which might result from any possible burning of wire insulation underneath the car was negligible; there remained risk of accident by reason of panic which might be caused by smoke from burning insulation. Obviously, since our best insulating materials are inflammable and in burning give off much smoke, it was necessary to balance against the requirement of insulation adequate from an electrical standpoint the equally obvious advantage of minimizing the insulation in view of the fire or smoke risk. In view of these considerations, the insulation selected for the wiring is of very high grade and moderate thickness, the insulation of conductors of larger sizes being 4-64 in., while that of the smaller conductors is 3-64 in. As to quality, the specifications of the company's engineers called for not less than 30 per cent pure Para rubber. This insulation is covered and protected by a single "weatherproof" braid, and in the case of all of the larger wires carrying comparatively heavy currents, this braid is in turn covered and protected by a heavy braid of asbestos. The thinnest insulation was subjected at the factory of the manufacturer to a test of 2500 volts for five minutes, the working potential in service being 570 volts. It may be mentioned here that it is the practice of the company to test the aggregate insulation of each car when completely equipped by applying

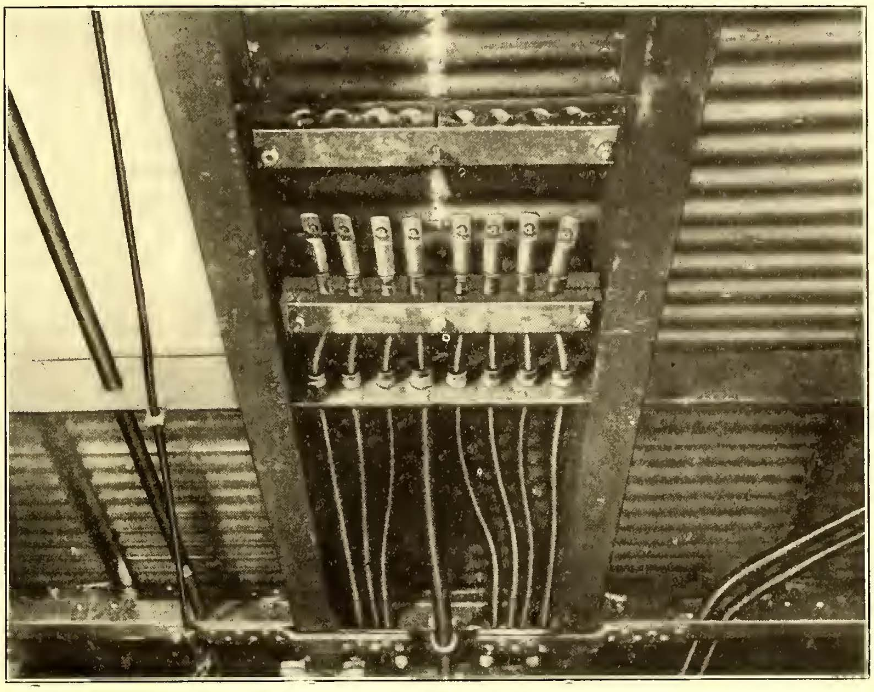


VIEW UNDERNEATH ONE OF THE STEEL CARS USED IN THE INTERBOROUGH SUBWAY IN NEW YORK CITY, SHOWING LARGE AMOUNT OF APPARATUS FOR THE MOTIVE POWER AND BRAKING SYSTEMS momentarily an alternating potential of 2000 volts between copper and ground. This test is repeated every time a car goes through the shop for a complete overhauling. I established this practice in connection with the equipment of the Manhattan Railway, and to it, together with the use of sheet asbestos between the electrical apparatus and the car floor, and the careful work done by the car equipment department, I attribute the immunity from fires which hitherto that company has enjoyed. This immunity is certainly remarkable in view of the fact that the equipment of the Manhattan division comprises over 1400 cars, of which more than 800 are motor cars, and that these cars are operated in a daily service exceeding 170,000 car-miles.

In equipping the steel cars, the method adopted conforms to the best approved principle of interior wiring of buildings, viz., the use of metal pipe conduits thoroughly grounded. This method has been used before in some cases. An obvious objection is the fact that it is not easy to provide effectively against abrasion of insulation where wires enter or leave the conduits. An apparent, though from some points of view not real, objection is the fact that the insulation of the wire itself is not reinforced, as in cases where wiring is cleated against wood undersheathing. Its principal advantages are ample mechanical strength, durability and consequently low cost of maintenance and effective protection of the wires against mechanical injury. Furthermore, in the opinion of the company's electrical advisers, the fact that a possible failure of the insulation will result in immediate and harmless grounding of the circuit and blowing of fuses is a valuable safeguard.

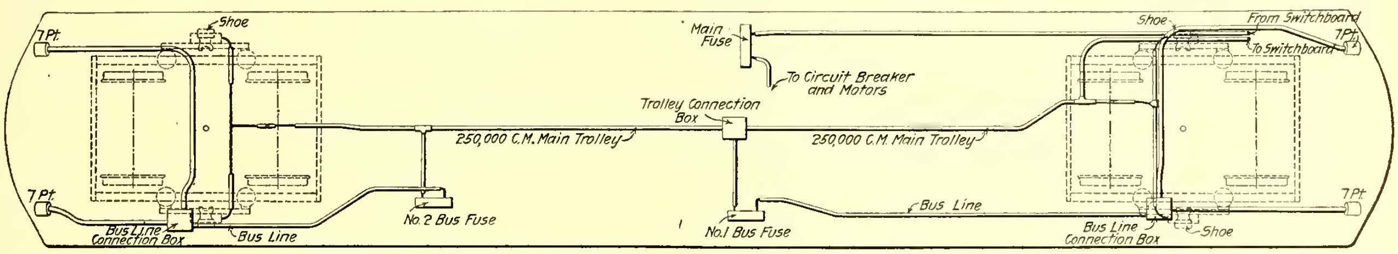
Study of the requirements of train operation led to the adoption of an equipment comprising for express trains five motor cars and three trail cars, and for local trains three motor cars and two trail cars, each motor car being equipped with two motors rated 200-hp each. The Sprague-General Electric multiple-unit system of train operation, employing twelve rheostatic steps, was chosen to regulate the supply of power to the motors. The problem presented, so far as wiring motor cars for power was concerned, was the determination of the best method of providing electrical connections for two motors mounted upon one truck, the multiple-unit control apparatus, together with the necessary circuit breakers, fuses, reverser, and the electrically-driven air compressor and its governor for the air-brake system. In addition to the power circuits, it was necessary also to provide circuits for heating and lighting the car, which circuits, as has been noted in a previous article, are arranged to be controlled from the switchboard in one of the platform vestibules of the car.

The multiple-unit system, as adopted for the subway, comprises a number of improvements upon its earlier forms. A description of the modified and improved system of control has been published in the March 14, 1903, issue of the STREET RAILWAY JOURNAL, and as the essential features of the system, together with the improvements introduced, were outlined in the above-mentioned article, they will not be referred to in detail in this connection. It may be noted, however, that the apparatus pertaining specifically to the power-control system which is placed beneath the car body, includes the following: A circuit breaker, sixteen contactors with rheostats, a reverser and the necessary connecting boxes for the multi-conductor cables. The cab equipment of each car comprises the master controller and its energizing switch, the circuit breaker resetting switch and the marker and cab heater switches. The multiple-unit control cut-out switch, as well as the main switch for connecting the motors to the trolley line, together with relay for automatically regulating the motors, is located upon the car switchboard in the vestibule, which switchboard also carries the lighting, heating, air compressor and governor control apparatus.

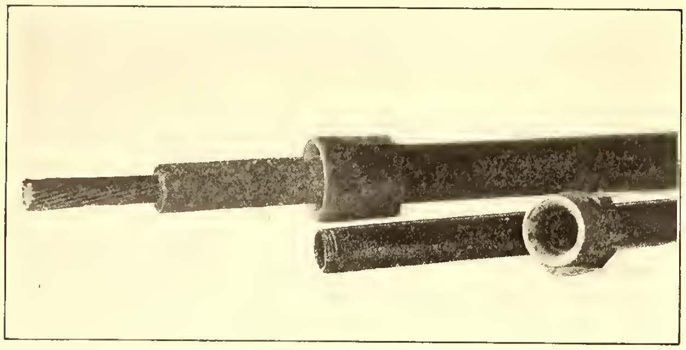


DETAIL VIEW OF CABLES LEADING TO THE MOTOR TRUCK, SHOWING METHOD OF SUPPORTING CONDUITS AND ARRANGEMENT OF "BELL-MOUTH" OUTLETS

The above engraving illustrates in a striking manner the fact that the amount of electrical apparatus required in the equipment of one of these motor cars is considerable, and no additional evidence is necessary to support the statement that the arrangement, electrical insulation and mechanical attachment of this apparatus beneath the car is a problem calling for skill and careful study in its solution. All inflammable material except wire insulation being eliminated in the construction of this apparatus, it is obviously important that the relative location of the various parts comprising the aggregate

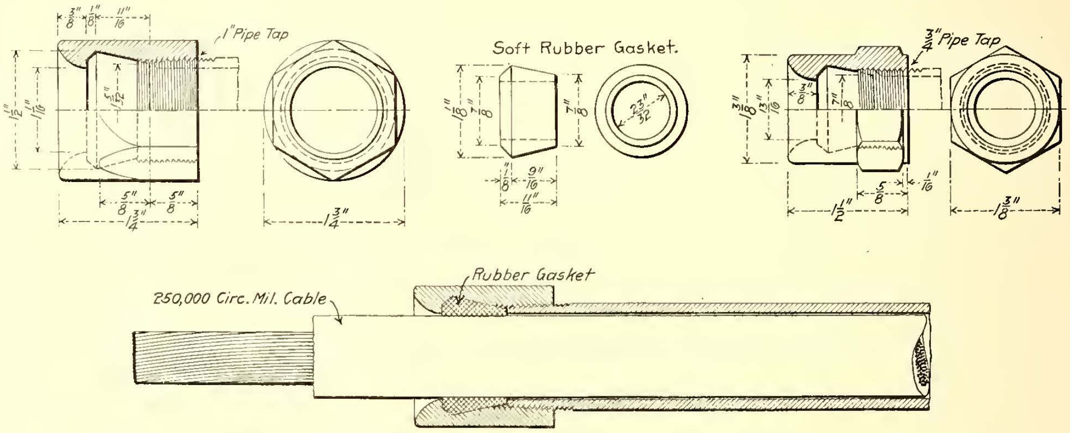


GENERAL PLAN OF THE STEEL CAR, TO SHOW ARRANGEMENT OF MAIN TROLLEY CONNECTIONS BETWEEN CONTACT SHOES AND OF BUS LINES TO JUMPER BOXES equipment should be such as to minimize the lengths of insulated connecting wires, thus minimizing the amount of insulation which may by any possibility burn and evolve smoke. At



VIEW OF A 1-IN. AND A ¾-IN. "BELL-MOUTH" OUTLET BUSHING, THE FORMER WITH A 250,000-CIRC. MIL CABLE IN PLACE

the same time it is obviously necessary that the apparatus be so arranged as to permit effective and reasonably convenient inspection and maintenance, which consideration prohibits undue crowding of the apparatus. With these considerations in mind, the engineers of the Interborough Company finally adopted an organization and arrangement of the apparatus which is believed to constitute a marked improvement upon previous practice.



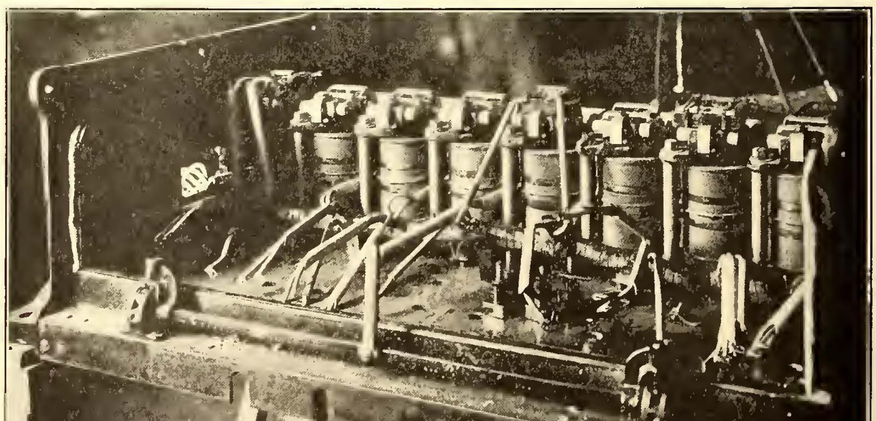
DETAILS OF TWO SIZES OF THE "BELL-MOUTH" OUTLET BUSHINGS AND OF ONE OF THE SOFT RUBBER GASKETS USED TO PREVENT ABRASION TO THE CABLE INSULATION

The arrangement of apparatus chosen is shown in the large drawing reproduced upon the accompanying inset, which is a complete drawing of arrangement of the apparatus and the conduit system beneath the car under framing. An excellent idea of conditions beneath the car and the locations of apparatus is also given in the accompanying photographs, which were taken looking upward from a pit in the repair shop. The innovation in respect to arrangement of apparatus lies mainly in the location of the resistances in relation to the contactors, and in the assembly of the contactors. It will be noticed that the contactors are enclosed in a protecting box located beneath the middle line of the car, and the resistances are located in two rows of four each on either side of the contactors. This arrangement results in bringing the resistances as close to their respective contactors as they can be placed without material sacrifice of effective inspection, the result being that the lengths of the leads between contactors and resistances is reduced to a minimum.

Another important feature of the wiring arrangement is to be noted in the scheme of connections between the main trolley and the bus lines: these connections are for clearness outlined in a separate sketch presented on page 423, which shows diagrammatically the connections between the four collector shoes upon the two trucks, the bus lines and the switchboard. The bus lines are connected directly to the main trolley through enclosed fuses furnished by the D. & W. Company, thus reducing the amount of insulated conductor as compared with the plan of carrying the bus line entirely through from one end of the car to the other, as has been done in some cases. It will also be noted that the connection from the main trolley to the switchboard is short.

The iron pipes in which the insulated conductors are enclosed are of the kind known as "Loricated" conduit, and were furnished by the Armorite Conduit Company, of Pittsburg, Pa. This conduit, which has of recent years been largely used in interior wiring for buildings, is a wrought iron tube heavily covered both inside and out with a hard and durable enamel, which not only serves as a protection against rust, but also tends to prevent abrasion of insulation of wires as they are drawn into place. The enamel is also of some value as insulation; the protection against rust, however, is itself a most valuable property.

The arrangement of the conduits for the various motor, control and light wiring leads beneath the cars is well shown in the drawing upon the accompanying inset. The main trolley and the two bus line connections are always alive when the collecting shoes are in contact with the third rail; the main leads from the collecting shoes upon each truck are connected together by the "main trolley," from which a branch is carried to the main cut-out switch located upon the vestibule switchboard through which the motor circuits are supplied. The bus lines which carry current through the seven-point jumper cables to adjacent cars are tapped off the main trolley as nearly as pos-

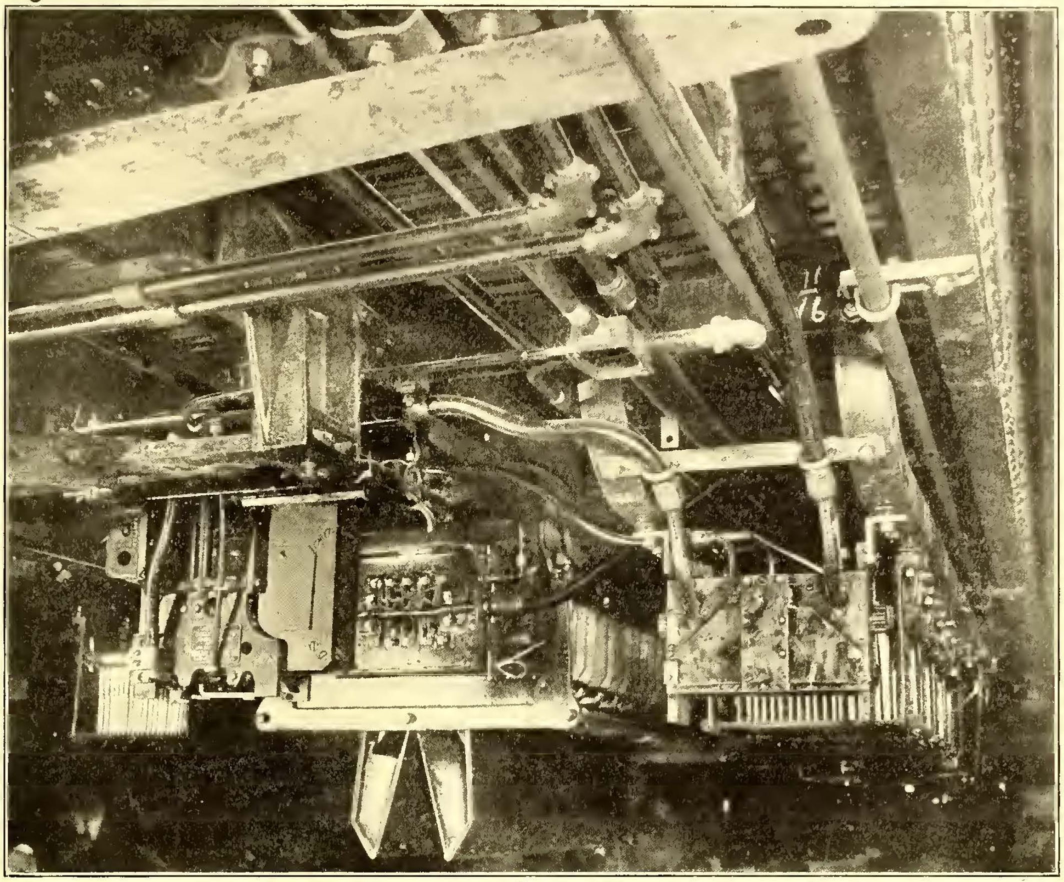


VIEW OF ONE OF THE NEW MULTIPLE-UNIT CONTROL CONTACTOR BOXES, PARTLY ASSEMBLED, TO SHOW METHOD OF WIRING

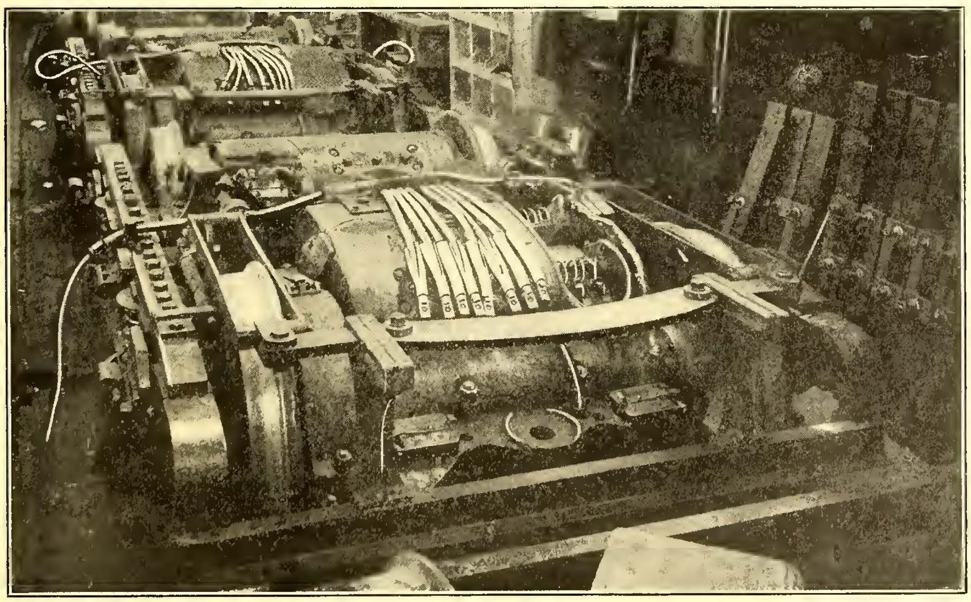
sible to the truck connections. Between them and the main trolley enclosed fuses are located, as shown. The general scheme of the auxiliary car wiring will be evident upon further reference to the large drawing on the inset supplement. The feeder cable leading from the switchboard to the motors passes first to the main fuse box, and from thence to the circuit breaker. After leaving the circuit breaker, this feeder passes directly to the contactor boxes through which, by connection in the various combinations formed by the contactors, current is supplied to the motors. Seven conductors are required to make the necessary connections between the contactors and the motors upon the motor truck. Connection is made from the main trolley connection box through a fuse beneath the car to the switchboard, supplying the current for operation of the air-brake compressor motor, light and heat circuits.

The other important series of connection is the set of control cables. The main train line control cable comprises ten wires, and is carried in a system of conduits easily traceable in the large drawing. Connections to this cable are made in a train line connection box near the body bolster at each end of the car, from which branch cables are run to ten-point jumper connections, and also to the switchboard for the cut-off switch and to the platform for the master controller. The heater circuits which are carried beneath the car are also shown in the engravings.

The particular location of each unit of the conduit system is, it is interesting to note, the result of careful investigation of the mechanical conditions to which it is subjected in service. A serious difficulty was encountered early in the development of plans for the new system of wiring, in spite of the proposed use of loricated conduits throughout, with the resulting effective mechanical protection to the insulation of the wires. It was foreseen that, unless some provision was made for holding the wires rigid at their outlets from the conduits, chafing and abrasion of the insulation would result at these points, due to the natural vibration and jarring of the cars when in service, even in spite of the use of the usual smooth-edge outlet bushings which are in common use in interior wiring of buildings. The solution of this difficulty which was worked out is interesting. A special type of outlet cap or bushing seemed to be necessary, and accordingly one was designed for covering the ends of all conduits, which should combine the advantages of gripping the wires so tightly that movement would be impossible, and at the same time furnishing additional insulating properties at the gripping point.



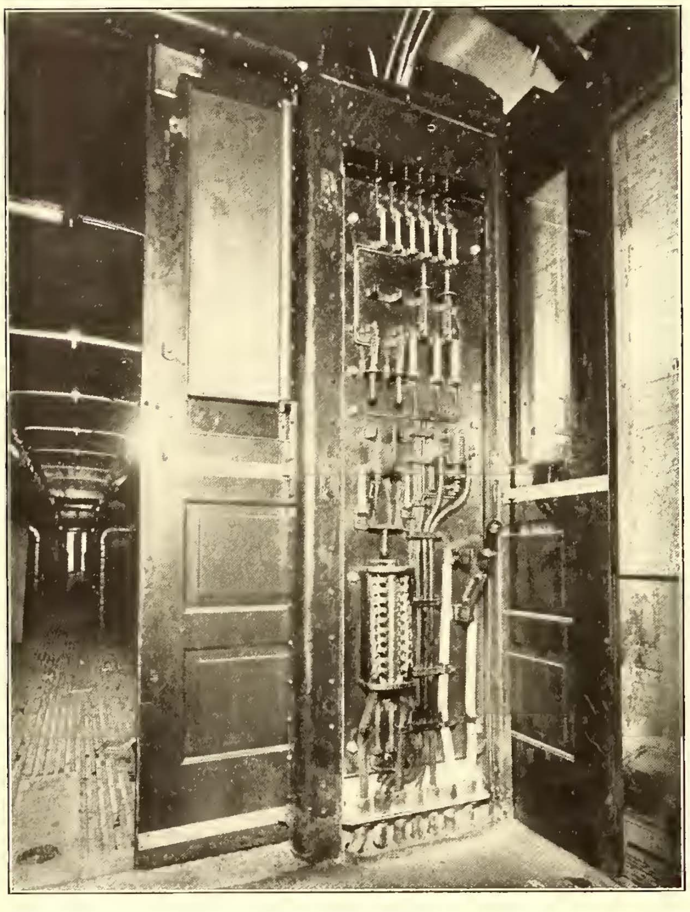
VIEW BENEATH THE STEEL CAR, LOOKING TOWARD THE CIRCUIT BREAKER AND CONTACTOR BOX, SHOWING TYPICAL ARRANGEMENT AND METHOD OF SUPPORTING WIRING CONDUITS



THE ARRANGEMENT OF WIRING FOR THE MOTOR LEADS AND CONTACT-SHOE CONNECTIONS, AS APPLIED TO THE MOTOR TRUCKS USED UNDER THE STEEL CARS

The style of outlet bushing adopted is similar in design to those used in marine wiring, this having a special "bell-mouth" shape of opening, the flaring edges of which favor the wire at its exit by compelling an easy curve. The details of one of these "bell-mouth" bushings as adopted for use upon the wiring of the steel cars is shown in an accompanying engraving. The body of the "bell-mouth" proper is made of malleable iron, with a hexagonal shoulder at one end. That end is threaded for the standard pipe sizes, as shown, so that in screwing the bushing upon the conduit the contained rubber ring or washer meets the end of the latter and is thereby compressed. It is evident from the accompanying views that no harm can possibly come to the wiring insulation from this source, yet the wires will be held rigidly, and vibration at this point, which might otherwise be particularly dangerous, will be effectually eliminated.

It will be noted that the means adopted to prevent mechanical injury of insulation at points where the wires leave the conduits involve also effective protection against access of moisture to the interior of the conduit. The construction in this respect is closely analagous to the best practice in marine wiring, in the installation of which it is necessary to provide not only rigid supports for the wiring, but also to secure effective protection against moisture.

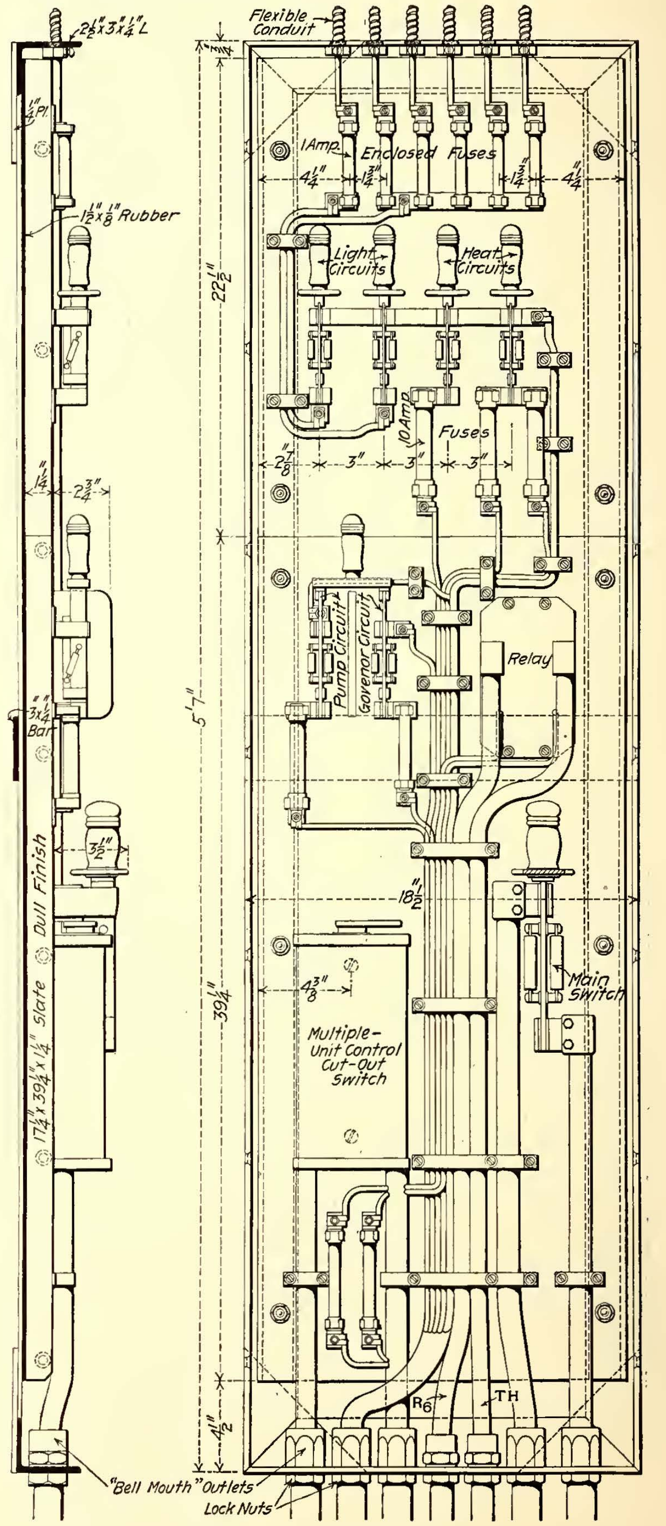


THE VESTIBULE SWITCHBOARD USED ON THE STEEL CARS FOR THE HEAT AND LIGHT CIRCUITS AND THE MOTOR-CONTROL SYSTEM

ARRANGEMENT OF CONDUITS

The methods of supporting the electric wiring conduits beneath the under framing varies, of course, with the location, but in general, it may be stated that supports of the most rigid and secure order are in all cases applied. In some cases the conduits are supported by passing through openings in needle beams or other beams or plates in the under framing structure which serve as very successful means of support. In other cases, the conduits are held up against the under frame members by strong clamps. This construction is clearly shown in the accompanying illustrations, taken beneath one of the steel subway cars, as well as also in the longitudinal section drawings in the inset.

One of the illustrations shows the outlets from which the motor leads and "trolley" connection pass down from their conduits to the truck below. An interesting construction is to be noted here; the eight conduits end in one of the cross buildings, each passing through a hole drilled for the purpose, and are rigidly secured in position there by a nut on the conduit side at the rear and the "bell-mouth" cap on the end. This forms a most rigid and secure means of support. At this point, moreover, a special construction is made use of to protect the cables where they leave the conduits to connect with the motor leads. As at this point they are inevitably subjected to a large amount of flexure, the protruding cables are arranged to be firmly carried in insulating clamps before and after connecting with the truck cables; these, which end in similar two-piece connectors to those shown upon the cables from the contactors, are swung up through the empty insulating (electrobestos) clamps in the foreground above in connecting up. They are bent to the shape of a letter S in dropping to the truck so as to provide most easily the flexure needed.

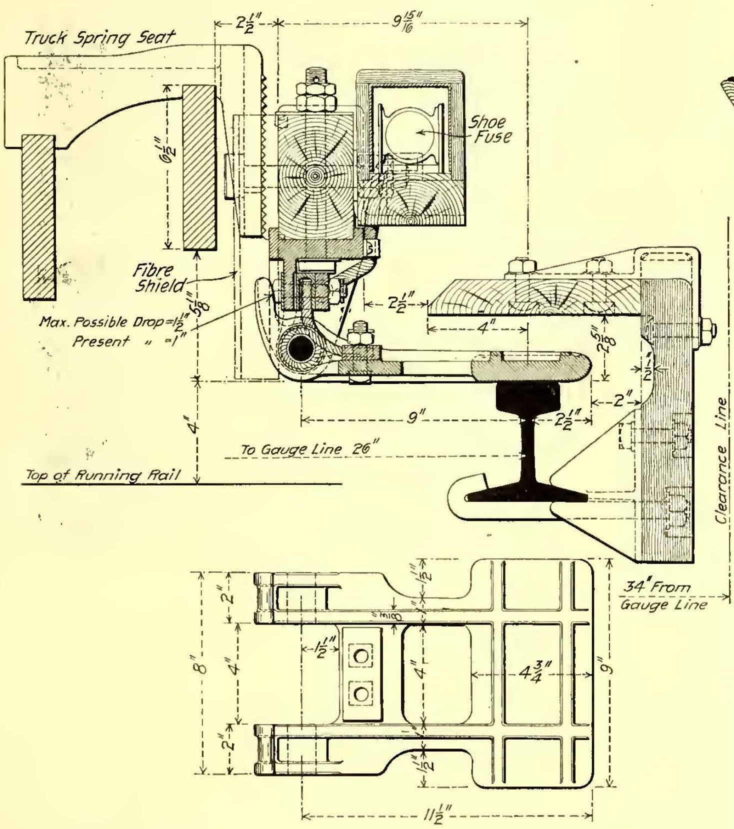


DETAILS OF THE SWITCHBOARD, SHOWING ALSO THE ARRANGEMENT OF APPARATUS

The truck connections are shown in a separate view. The eight leads which join those shown in the preceding view are each covered with a closely-wound helix or brass wire, which serves very effectively in protecting the insulation from the undesirable abrasion. After the leads from the truck have been connected with corresponding leads on the car, the connectors are insulated by means of rubber tubing, which, after being slipped on, are in turn carefully covered with several layers of adhesive tape. The only use of conduit upon the truck is for the cable connecting the two third-rail collecting shoes. The leads from No. 2 motor are carried across the truck bolster in a fibre trough suspended from the truck transoms. After leaving this trough the leads are carried on top of No. 1 motor, where they, together with the leads from this motor, are held firmly in position by means of electrobestos cleats reinforced by iron straps.

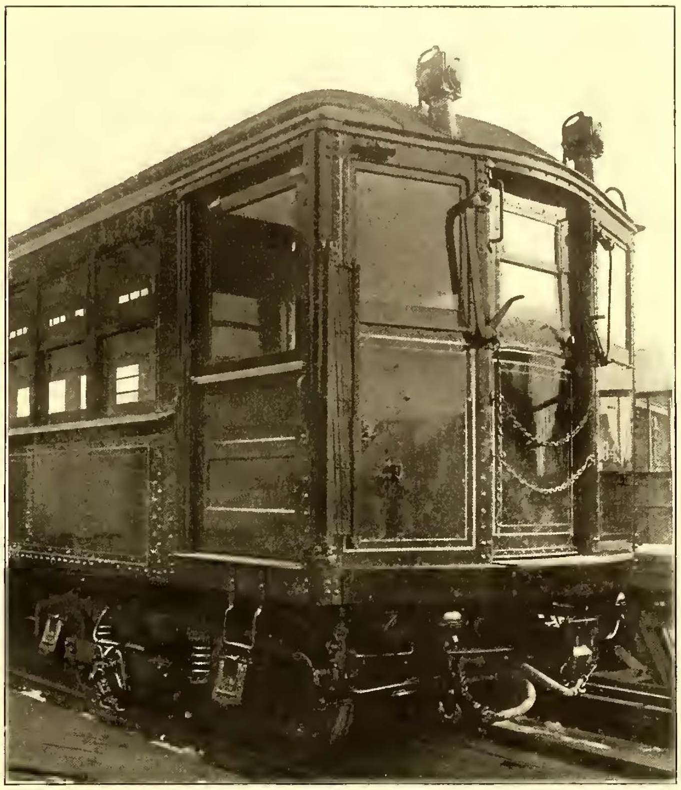
In the view beneath the steel car upon page 425 is shown the arrangement of conduits at the circuit breaker end of the contactor box. This view shows various methods of supporting conduits, and also shows the interesting scheme of using halved elbow fittings for the conduit where short bends have to be made. In the latter cases the wire is passed through one of the connecting conduits and then bent and introduced into the other, the exposed bend then being taped and covered with this two-piece elbow, as shown. These halved elbows are tapped and the threads fit upon those of the conduit when applied, so as to make a tight joint. In the latter view is also shown the use of the junction box in making interconnections in the system.

The vestibule switchboard used for the control of the car heater and lighting circuits and motor control circuits is well shown in an accompanying view and in detail in the drawing. This board is built up in two sections, as shown, the upper section 22 ins. high and the lower section 39 ins. high, both having a width of 17 ins. The upper panel is devoted to the heater and lighting circuits for use in the car, while the lower panel contains the switches for the control, motor and air- compressor circuits. The arrangement of the various instruments is indicated in the drawing. It will be noted that upon this switchboard is the only appearance of the main trolley connections

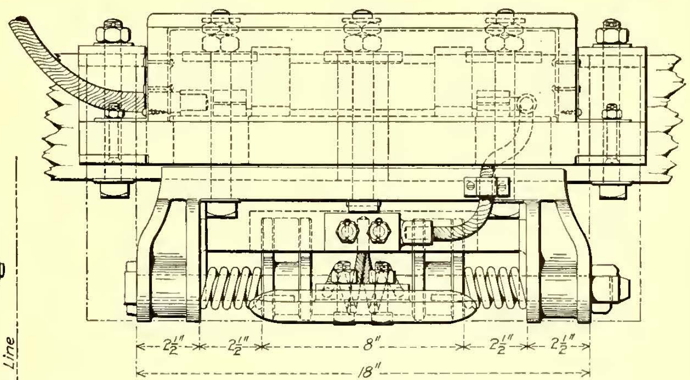


above the car floor, this circuit being necessarily brought at this point to the main switch through which current passes from the main trolley line to the motor circuits. This switch is located at the lower right-hand side of the board.

The two panels are carried in a special angle-iron frame which is bolted to the end framing of the car. In the space provided between the switchboard frame and that of the car, soft rubber washers are inserted to take up vibration. The panels are of slate, with dull finish, and no connections appear at the rear of the board, all bolt holes upon that side being



END VIEW OF ONE OF THE STEEL CARS, TO SHOW ARRANGEMENT OF COLLECTING-SHOE DETAILS AND OF JUMPER BOXES

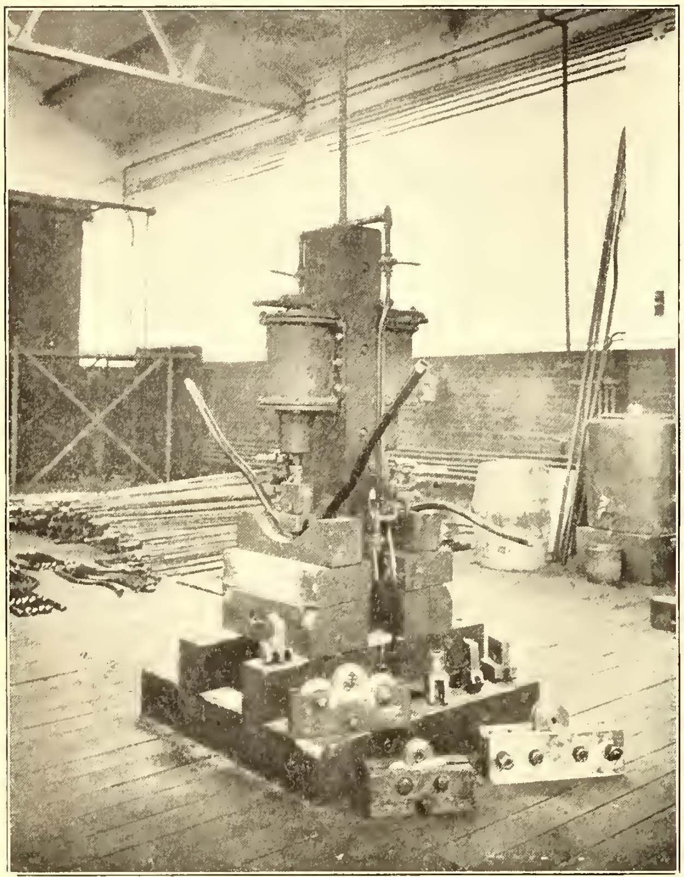


DETAILS OF NEW TYPE OF THIRD-RAIL COLLECTING SHOE AND ITS METHOD OF SUPPORT

filled with insulating compound. The wires and cables entering from beneath the floor of the car are carried up through sections of conduit of the type used beneath the car, and the methods of supporting the protruding ends of the same are clearly shown in the drawing. The "bell-mouth" outlet bushings with which each of the conduits are capped, together with the lock ends beneath the angle-iron frame, serve to hold them rigidly in position. The lighting circuits which leave the board at the top for distribution in the hood and roof of the car are carried in flexible conduits, as shown.

DETAILS OF COLLECTING SHOE

An important detail of the electrical equipment of the cars, which is in fact closely related to the wiring system, is the third-rail collecting shoe equipment. On account of important improvements embodied in the design of collecting shoe as adopted for use in the subway, it is illustrated herewith, both as applied to the car and in the detail drawing. As is well known, the third-rail arrangement in the subway consists of the use of a protected third rail, the rail being covered by a 2-in. plank 10 ins. wide, supported 2⅝ ins. above the contact rail throughout. The contact device is accordingly of the so-



THE DOUBLE PIPE AND CONDUIT BENDING MACHINE USED IN THE EQUIPPING SHOPS OF THE INTERBOROUGH COMPANY, FOR PRODUCING THE SPECIAL SHAPES REQUIRED

called slipper type, as indicated in the drawing. It is pivoted at a distance of 9 ins. from the contact rail center, being held normally in its lower position by a spring on the pivot shaft. As may be noted, the wearing surface of the shoe is carried from the hinged portion by two slender prongs, which are webbed as indicated. An improvement is embodied in this shoe in that these prongs are purposely made somewhat weaker than the balance of the casting, so that in case of meeting with an obstruction the breakage will occur at that point, throwing the shoe out of service, instead of breaking the supporting hanger and subjecting the contact-rail system to possible short-circuit.

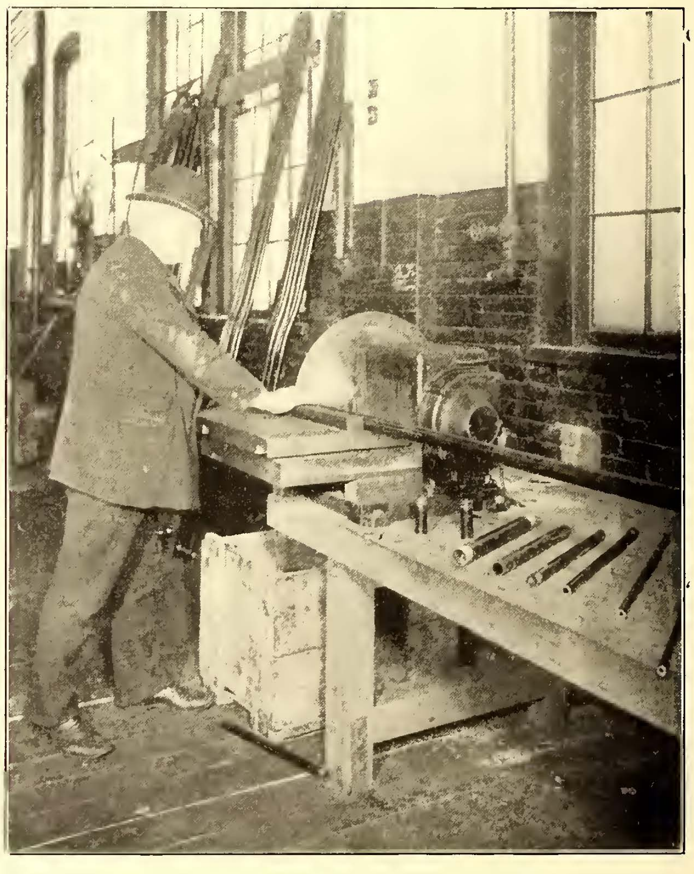
The method of pivoting the shoe is well shown in the cross section view. The shoe is arranged with limit stop, by which the downward movement of the shoe proper is limited and may be adjusted by means of shims. The maximum possible drop with the construction shown is 1½ ins., although a ⅛-in. shim is used to reduce the drop to approximately 1 in. Connections from the shoe to the supporting brackets are made through a flexible cable which is wound around the shaft, as shown; this method of winding is of importance, as the vertical movement of the slipper will not affect the connected cables. Other mechanical features of importance are to be noted in the mounting of the shoe, one of which is the arrangement of the pivoted shaft, which is fastened in place by a key for quick removal.

SHOP AND ERECTING METHODS

The methods employed in the shop in handling the important problem of conduit pipe cutting and bending, as well as the erection of the conduits beneath the cars, are of more than usual significance in relation to the general subject of conduit installation. In the first place the entire installation was seen to be a strictly mechanical work and demanded a mechanical treatment in order to secure the desired results of strength and permanency. Furthermore, as the installation of the conduit systems upon the steel cars involved the equipping of 300 cars, it was obvious that a large force of men would be necessary and that a systematic treatment of the problem would be essential. The result has been the equipment and organization of a large shop force and introduction of many labor-saving methods, which has not only kept the labor costs down to a minimum, but has also resulted in a great saving of time.

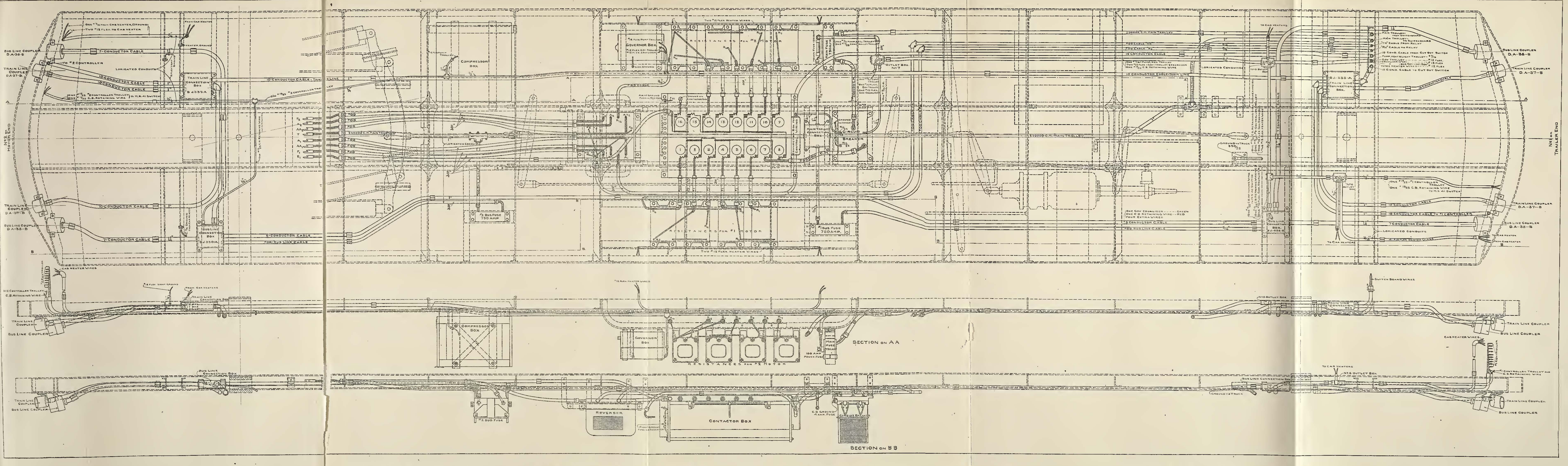
A shop was provided for the pipe bending and fitting work, including both the air-brake piping and the conduit work, while the electrical equipment was assembled in another shop. The assembling of the various details of the equipment upon the cars is carried out in one of the repair shop buildings of the elevated division of the company, where adequate facilities were to be had and excellent daylight qualities were available. This erecting shop is provided with four longitudinal tracks with pits, each track having a capacity for five of the steel cars. The view underneath the cars were obtained from points of vantage in pits in this shop.

The importance of the pipe shop is evident from the view of



THE NOVEL DISC-CUTTING MACHINE USED AT THE SHOPS FOR CUTTING PIPES AND CONDUITS TO LENGTHS

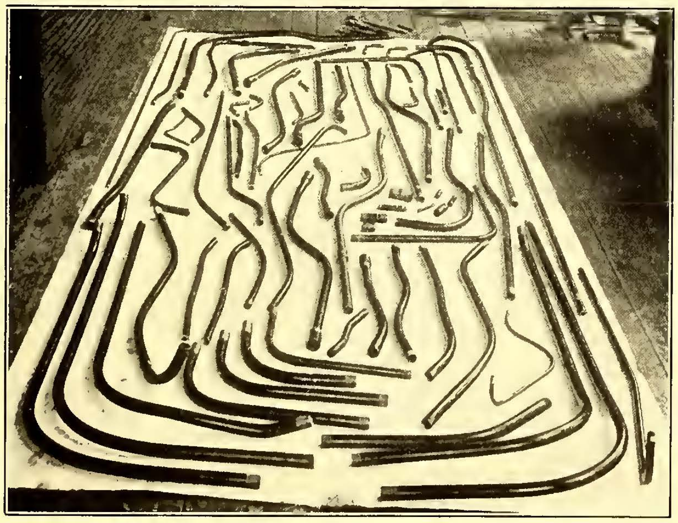
the various bends in the conduit and air-brake piping which are necessary in the equipment of the cars. It was arranged to bend the various pipes to templates and thus make them interchangeable, so that they might be made up in stock quantities, and consequently drawn out for use as required—this being, in fact, one of the most important features of the entire work in greatly reducing the cost of the labor. Templates were prepared for all of the various bends, and all the stock sections are made in quantities to fit the models, each section being an exact duplicate of the model or template section, so that they



PLAN AND LONGITUDINAL SECTIONS OF THE UNDERFRAMING FOR ONE OF THE NEW STEEL CARS OF THE INTERBOROUGH RAPID TRANSIT COMPANY (SUBWAY DIVISION), SHOWING ARRANGEMENT OF THE ELECTRICAL APPARATUS AND THE LORICATED CONDUITS FOR THE CAR WIRING may be placed on any car, thus reducing the cost of installation to a minimum.

The bending of both conduit and air-brake pipes is facilitated by the air bender illustrated herewith. This bender consists of two air-brake cylinders mounted upon a stand and fitted with forms by which all sizes of pipe and any style of bend may be quickly and cheaply made. The bender is illustrated in the act of making a very difficult bend. The air cylinders are controlled by motorman's brake valves for admitting air and holding or releasing. In accompanying views are shown the wide range of bends which are covered in this work.

VIEW IN THE INSPECTION AND STOCK ROOM DEPARTMENT OF THE EQUIPPING SHOPS, SHOWING TEMPLATES FOR STANDARDIZATION OF ALL SPECIAL HANGERS, FITTINGS, ETC., USED



A FEW OF THE SPECIAL SHAPES OF LORICATED CONDUIT WHICH ARE SHAPED IN THE BENDING MACHINE FOR THE STEEL CARS

An important accessory in the pipe shop is to be noted in the form of a novel type of pipe cutter which was devised for rapidly and efficiently cutting the conduit into sections of the desired length. It consists of a plain iron disc with smooth edge, which is mounted upon the end of a motor shaft for direct driving, and is operated at high speed in cutting, the pipe being merely held up against the edge of the rapidly revolving disc with moderate pressure. The effect in cutting is to be noted in a partial fusing of the portion of the pipe which is cut, as evidenced by the fact that large fins are produced, although they are readily removable and no harm results therefrom. One of the marked advantages of this type of cutter is that it cuts the conduit straight across without leaving the objectionable burr which results from many forms of pipe cutters.

This tool was made up in the shop from materials available, the motor having been removed from a Westinghouse air-compressor outfit as used on the subway cars, and was adapted to the work by the mounting of the cutter disc upon the extension of the armature shaft. The disc is of iron plate 24 ins. in diameter, mounted between heavy brass stiffening plates 20 ins. It may seem strange that iron is used for this purpose, but it is found that it is fully as serviceable as steel, and is in fact very efficient. The motor operates at a speed of 2500 r. p. m.

A feeding table is built up in front of the cutter disc, as shown in the accompanying view, upon which the pipe is held in, forcing it against the cutter. The table is arranged to move freely backward and forward directly against the cutter, so that in cutting it is merely necessary to press it against the disc. The guide block is arranged upon the table so as to bring the pipes against the cutter at right angles in all cases. It is to be noted that the action by this pipe cutter is very rapid and efficient. All of the pipe cutting which has been necessary in the equipping of the steel cars has been easily handled by this single cutter.

The further equipment of the pipe shop consists of a large equipment of power reamers, pipe-threading die-stocks, and also two automatic power threading machines. The two power thread cutters are of the Forbes type of automatic adjustable pipe die, which is built by Curtis & Curtis, Bridgeport, Conn. These machines have capacities for all sizes of pipe from 1/4 in. to 2 ins., and are very rapid and effective.

THE INSPECTION SYSTEM

Another important and essential feature of a work of this character, to be carried on in such large quantities, is the inspection department. The inspection of all parts entering into the equipment of the cars has been made an especial feature. In the same manner as applied to the bent sections of pipe, all hangers, brackets, braces, etc., used in connection with the equipment of the cars for service, are made in large quantities to templates, and are carefully inspected and gaged for absolute interchangeability. As above noted, this greatly facilitates the work.

The view in the inspection room illustrated herewith will give an idea of the method of carrying stock for the various classes of brackets, hangers, etc., and also shows the styles of templates used for gaging the various parts. The forms of the various brackets, hangers, etc., are laid out upon boards painted in various colors, to readily distinguish them, as indicated in the view. It is thus possible to compare each completed part with the form upon the template and ascertain if the holes are properly located, etc. All parts are required to compare with the templates within a very small limit of error, or they are thrown out.

The various parts, not only in sections of pipe, but also in hangers, brackets, etc., are made up in advance and kept in large quantities, so that they may be requisitioned for as needed. For the small brackets and clamps, bins of large capacity are provided, as shown at the right of the inspection room, while the other parts are stored at one side of the room. Furthermore, a careful record is kept of all parts made and delivered from this department, as well as drawings of details for ready reference. This system has proven of great assistance in the work of equipping the cars, particularly on account of the usual details that are almost inevitable where such large quantities of material are handled.

To J. S. Doyle, superintendent of car equipment, credit for the marked advance in methods and in workmanship described in this article is chiefly due. He has been effectively assisted in the work by Hjaimar Wallerstedt, engineer of car construction.

A SUBWAY SUGGESTED FOR CLEVELAND TO RELIEVE TRAFFIC CONGESTION AT THE PUBLIC SQUARE

A subway through the Public Square is the latest suggestion for the betterment of the street car system in Cleveland. It has long been contended that something should be done to relieve the congestion at the square. The delays that are occasioned there are such that the schedules all over the city are interfered with. The company has tried deviating a number of lines away from the square, but the public objects to this method.

The point of greatest trouble is in the center of the square, where a number of lines cross each other and where there are several loops. The city engineer and the engineers of the company believe that the trouble at this point could be relieved by depressing Superior Street, which runs through the square east and west. This would remove the surface crossing, enabling all through east and west cars to run under Ontario Street. The plan is looked upon with considerable favor.

BOOSTERS IN CAMDEN

The Public Service Corporation has just installed in its Camden & Suburban power station, at Camden, a 120-kw Westinghouse series booster, and has placed an order for four other boosters of the same size. In the use of these boosters the company is following out the policy of former General Manager W. E. Harrington in substituting a boosted feeder in many cases where additional copper might be installed by some other companies. One use of the booster equipment will be to maintain an equal voltage in the two stations of the company at Camden, 5 miles apart. One of these was the station formerly owned by the Camden, Gloucester & Woodbury Railway, while the other is the main power station of the Camden & Suburban division. The normal output of the Camden & Suburban station is 5000 amps., and that of the Camden, Gloucester & Woodbury, 1500 amps. It is now proposed to shut down the Gloucester station and to supply the railway feeders at that station through a tie from the Camden & Suburban station. This tie will consist of six 500,000-circ. mil cables.

The switchboard connections at the Camden & Suburban station differ radically from those in general use, and were described in detail on page 974 of the Street Railway Journal for Dec. 5, 1903. It will not be necessary to repeat this description here, except to state that the equalizer is on the negative side of the generators, that the board is of the single-pole type and that two positive bus-bars are used, one of higher potential than the other. This board is now being extended so that any one of the boosters now being installed can be thrown on any of the boostable lines. That is, each feeder is so arranged that it can be supplied off the regular bus-bar, or it can be thrown on to a higher voltage bus-bar, or can be fed independently through a separate booster, or if necessary it can be supplied through two boosters operated in series.

The company believes in the use of boosters for an indeterminate load, where the extra load does not exceed three hours out of the twenty-four, as is very often the case. A degree of safety can also be secured by the booster, because in case the feeder breaks down it is possible to put two boosters in series on a parallel feeder and raise the voltage up to 1000 if necessary for temporary service. A commentary on its use of boosters is the fact that the company has not had a single line tied up in four years by any station difficulty that could not be averted at the switchboard.

ELECTRICITY FOR DAMASCUS

It is reported from Constantinople that the syndicate associated with M. Empain, the Belgian financier, who is connected with the Paris Metropolitan Railway and other electrical enterprises, has acquired from Izzet Pasha the concession granted to the latter by the Sultan for the construction of electric light and power works and tramways at Damascus. The "Frankfurter Zeitung" states that the syndicate has paid for the transfer of the concession $130,000 in cash and $20,000 in shares of the company to be formed to carry out the scheme, with a shape capital of $1,250,000. The concession carries with it the right to utilize for the production of electrical power all the available water-power within 18 miles of Damascus.

The Northern Pacific Railway Company has announced that it proposes to equip with electricity its line between Spokane and Cœur d'Alene, Wash., 34 miles long. About a year ago an electric railway was opened between these cities. Since the building of this line, which was described in detail in the Street Railway Journal of Feb. 11, 1905, the steam railroad has done very little business between the cities.

THE QUESTION BOX

In this issue are published answers to questions pertaining to the protection and abolishing of steam and highway crossings; methods of attaching trolley rope to pole; treating car roofs; treating motor brushes; superheating steam; and proper weight and section of rails. Additional answers, suggestions or discussions on any of these topics are requested.

A—GENERAL

A 31.—On a high-speed interurban electric railway, what precautions should be taken to protect crossings where the line cuts a public highway? Please describe the precautions you take at such points.

On high-speed, interurban roads, such as we operate, we require motormen to slow down to 4 m. p. h. at all street crossings, blowing whistle 500 ft. before coming to such crossings, and ringing gong continually while going over and passing street.

H. C. Page, Gen. Mgr.,
Berkshire St. Ry. Co., Pittsfield, Mass.

Do not exceed 4 m. p. h. when approaching crossings. If necessary, put up stop signs.
W. T. Nary, Supt.,
Hoosac Valley St. Ry. Co., North Adams, Mass.

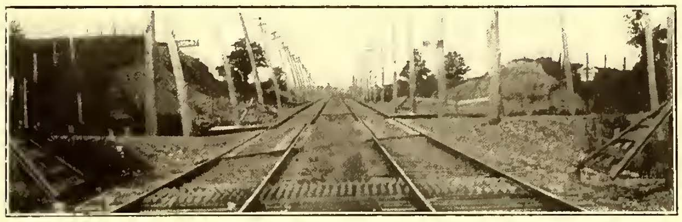
At each highway we put a cross-board sign reading, "Railroad Crossing," and on the post itself the words, "Stop, Look, Listen." Each approaching car is under orders to blow four blasts of the whistle, corresponding to steam railroad practice. I wish we had less whistling to do, and have considered the omission altogether of any whistling during full daylight hours at crossings where the view is unobstructed for some distance in both directions.

Theodore Stebbins, Gen. Mgr. for Receivers,
The Appleyard Lines in Ohio, Columbus, Ohio.

Cars should be made to slow down to 10 miles an hour and motorman required to blow whistle at the approach to such crossings.
J. R. Harrigan, Gen. Mgr.,
Columbus, Buckeye Lake & Newark Tract. Co.

Slowing down of cars to 8 or 10 miles per hour, blowing whistle and proper crossing signs.
H. A. Tiemann, New York City.

All highway crossings at grade on the Utica & Mohawk Valley Railway are planked 24 ft. in width with hardwood plank, next to and adjoining the rails of the track, and the space between the planks and for 50 ft. on either side of the crossing is filled with crushed stone rolled compact. This is done so as to give a good smooth approach to the crossing and make as level and smooth as possible the crossing itself for teams and pedestrians. Fifty feet on either side of the center line of the crossing and in line with the fence on either side of the right of way, are erected crossing signs bearing the legend "Railroad Crossing, Stop, Look, Listen." Cattle guards are placed between the rails, and for 4 ft. on either side of the outer rail. The cattle guards are made of tile. Immediately adjoining the cattle guards is erected a sloping fence, placed at an angle of 45 degrees, which in combination with a stretch of straight fence connects the cattle guards with the fence bounding the right of way. The cattle guards and the fences approaching the same are placed as nearly as possible to the line of the fence bounding the highway. All these are shown in the photographs. We are trying at crossings an automatic gong operated through a battery circuit actuated by a track instrument, which in turn is operated by a lever and pressure when cars are passing. To date its service has not been satisfactory. Our feeling is that all highway crossings should be protected by some device of this kind, if such device can be found that is positive and will work.



PROTECTING HIGHWAY CROSSINGS, UTICA & MOHAWK

C. Loomis Allen, Gen. Mgr.,
Utica & Mohawk Valley Ry. Co.

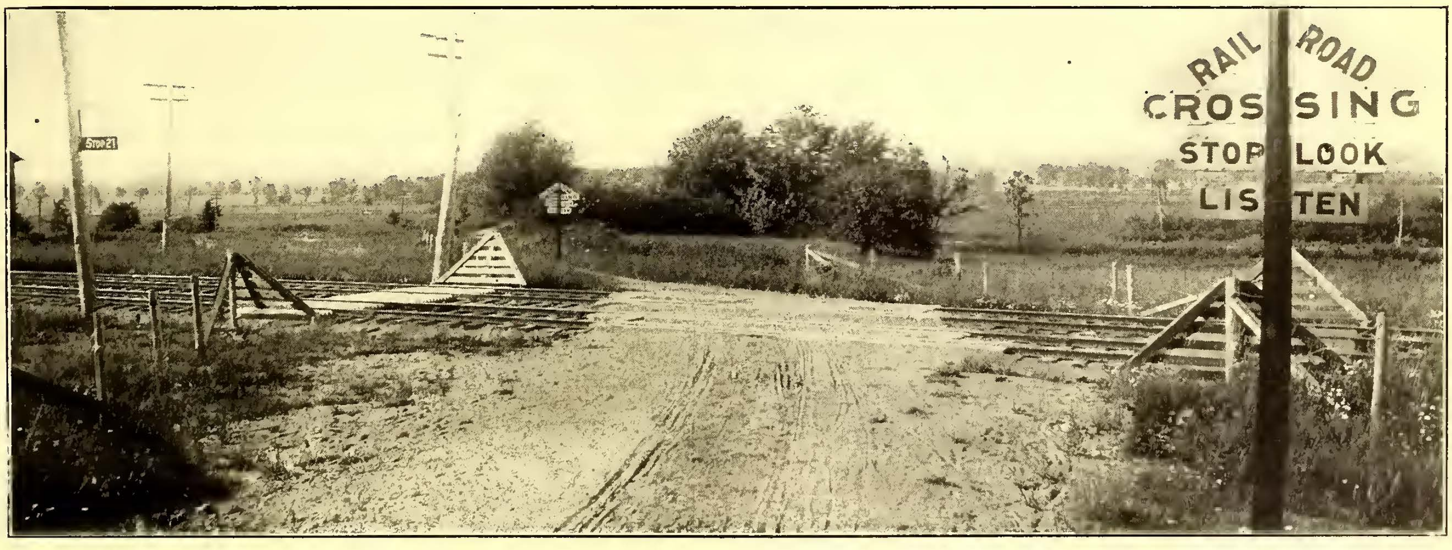
Standard steam-road crossing signs warning persons to "look out for the cars," and all cars give the crossing whistle 500 ft. from the crossing.
Francis G. Daniell, New York City.

A 32.—Where an electric railway crosses a steam road, what is the usual arrangement between the electric road and the steam road for the maintaining of a flagman at such points?

Each should have a flagman. W. T. Nary, Supt.
Hoosac Valley St. Ry. Co., North Adams, Mass.

Where an electric road crosses a steam road, in this State, if the steam railroad does not maintain a flagman, the Railroad Commissioners have made it a rule that the street railroad shall maintain a flagman and bear the total expense. If a flagman was maintained at the crossing before the street railway was built the steam railroad maintains the flagman who flags only the steam trains. We maintain a flagman at all steam railroad crossings where we cross the steam railroad, and the flagman flags all cars, the conductor staying on the rear end of the car, and the motorman starting (on a box car) with a signal from the flagman on the crossing, without receiving any bells. This puts all the responsibility onto the motorman and the flagman. On an open car we have the conductor give the usual signal of two bells to start as soon as the car comes to a full stop, and the flagman drops the white flag, indicating that it is all right for the motorman to proceed, he starting car on the signal of the flagman, rather than the conductor's signal, the conductor's signal only being used to indicate to the motorman that there is no one getting on or off the car.

H. C. Page, Gen. Mgr., Berkshire St. Ry. Co., Pittsfield, Mass.



SIGNS, PLANKING, FENCE AND CATTLE GUARDS FOR PROTECTING HIGHWAY CROSSINGS, UTICA & MOHAWK

In two cases, we have overway crossings, in another case an interlocking signal tower, and in about eight or ten other cases the car stops, the conductor proceeds to the steam railroad track and signals the car over.

THEODORE STEBBINS, Gen. Mgr. for Receivers,
The Appleyard Lines in Ohio, Columbus, Ohio.

We do not maintain flagmen at any steam railroad crossings, but in some cases we maintain a derailer which is maintained jointly by the steam road and the electric road.

J. R. HARRIGAN, Gen. Mgr.,
Columbus, Buckeye Lake & Newark Tract. Co.

Expense is usually borne by the second road built.

FRANCIS G. DANIELL, New York City.

A 33.—When grade crossings are to be abolished or avoided, what portion of the expense should be borne respectively by the electric railway company, the steam railroad and the municipal authorities?

When grade crossings are abolished in the State of Massachusetts the State law is that the street railroad shall bear not more than 15 per cent of the total expense of abolishing the grade crossing, the steam railroad bearing 65 per cent, and the State, town and cities interested bearing the balance.

H. C. PAGE, Gen. Mgr.,
Berkshire St. Ry. Co., Pittsfield, Mass.

It should be borne equally; in other words, a third of the expense to be borne by each.

J. R. HARRIGAN, Gen. Mgr.,
Columbus, Buckeye Lake & Newark Tract. Co.

A 34.—What have you done toward abolishing grade crossings on your system?

We had three grade crossings on our system, but have abolished two of them the past year, and expect to abolish the third one the coming season.

H. C. PAGE, Gen. Mgr.,
Berkshire St. Ry. Co., Pittsfield, Mass.

A 35.—What precautions do you take to avoid accident to persons getting on or off at points where it is necessary for conductors to go ahead to flag over crossings or other dangerous points?

We do not allow the conductor to go ahead of the car at any point.

H. C. PAGE, Gen. Mgr.,
Berkshire St. Ry. Co., Pittsfield, Mass.

The conductor does not signal the car to go ahead until he is absolutely sure that no passengers are getting on or off the car.

J. R. HARRIGAN, Gen. Mgr.,
Columbus, Buckeye Lake & Newark Tract. Co.

We maintain our own flagman at every grade crossing. We do not believe in having the conductor leave his place on the rear platform to go ahead and flag the car.

UNITED TRACTION CO., Albany.

Motorman must look back at rear platform before starting the car.

FRANCIS G. DANIELL, New York City.

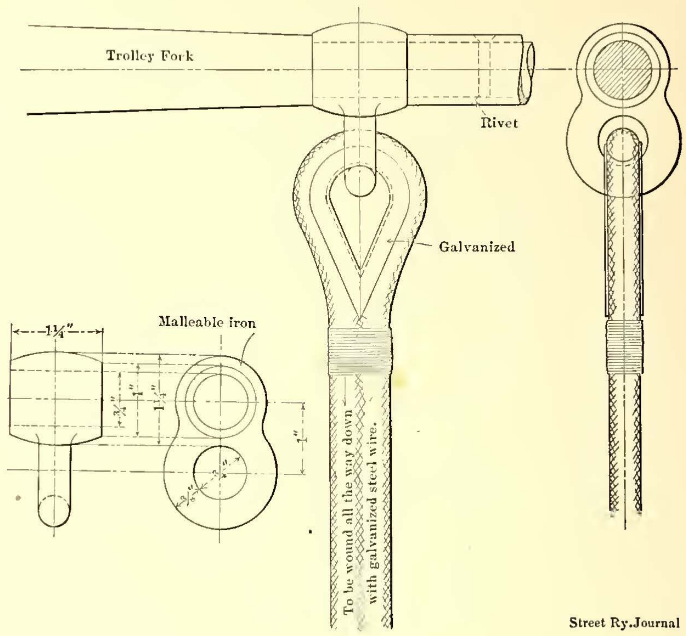
E—MASTER MECHANIC'S DEPARTMENT

E 70.—A road has had trouble with trolley rope leaking current when very wet; also with the trolley rope becoming detached from the pole. How can some of these trolley rope troubles be remedied?

We attach the trolley rope to the pole by a spring snap, but have had trouble when the trolley jumps the wire with the snaps unsnapping and thereby losing control of the pole. We issued a general order to the effect that on every car the trolley rope is to be wound once around the pole and then fastened with wire, so the snap cannot pull off. We have had no more trouble from this source.

Schenectady Ry. Co., Schenectady, N. Y.

To overcome trouble caused by the trolley rope pulling away from the pole, we are using the attachment shown in the drawings for connecting the rope to the pole. At the junction of the trolley fork there is a malleable-iron ring, which is slipped over the spindle of the fork before the fork is put on the pole. The malleable-iron ring thus has bearing against the end of the pole and the end of the fork, so that it cannot move up or down. This malleable iron ring has a projecting ring or eye through which the trolley rope passes, there being a galvanized thimble or cleat



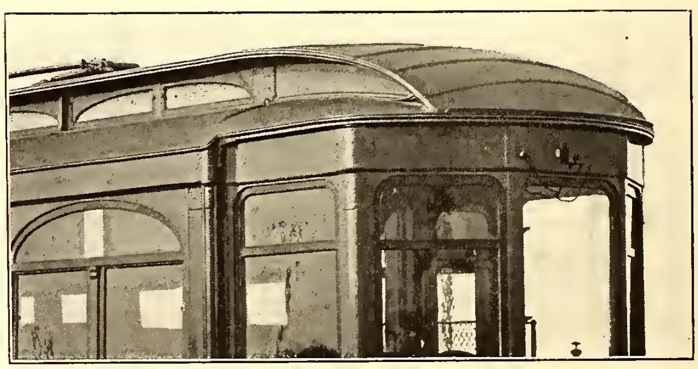
METHOD OF ATTACHING TROLLEY ROPE TO POLE, BROOKLYN

on the under side of the rope to prevent it from chafing. The end of the rope is brought down for about 8 ins., and the two strands are bound together with galvanized steel wire, wound in the manner shown on the drawing. The company is now trying a new metal clip or clamp for holding the end of the rope, and this promises to supplant the galvanized steel wire used for binding.

BROOKLYN RAPID TRANSIT CO.

E 99.—What is the best method of treating car roofs for securing tight roofs?

In order to strengthen car roofs and prevent possible injury to passengers of the car by reason of the trolley pole becoming detached and being forced down through the roof, the International Railway Company, of Buffalo, now reinforces the roofs of all cars by placing layers of No. 18 sheet steel over the hoods. The sheets of steel are curved to fit the contour of the hood, as shown in the engraving, and they are screwed into the carlines. In order



REINFORCED HOOD, BUFFALO

to exclude moisture, the steel plates are painted underneath and on top before they are placed in position. EDITORS.

It is not a painter's job to cover roofs, but he should paint the roof with a good thick mineral paint, made with slop varnish and slop turpentine before the canvas is put on. Canvas should be put on while the paint is wet, and pressed and smoothed. The canvas should then be painted with two or three coats of good paint—not pure linseed oil and white lead paint, however.

E. W. SELKIRK, Chicago, Ill.

E 129.—Have you found any scheme for securing better contact between motor commutators and the carbon brushes?

As an experiment we tried boiling two sets of motor carbon brushes in paraffine for eight hours, and then dried them out at a temperature of 85 degs. C., which is several degrees higher than the temperature of the motors in service. The brushes so treated after four weeks running showed but ¼-in. wear. The life of the same type of brushes untreated had been previously limited to six days. We now boil all carbon brushes in paraffine, and find not only that the brushes last about five times as long, but that the commutator wear is much less, and the commutator does not wear black. We have a large kettle in which we can boil about 200 brushes at a time. Schenectady Ry. Co.

F—STEAM ENGINEERING

F 41.—Can superheating be applied to existing electric railway power houses? What changes in piping, valves, engines, etc., are necessary? What advantages will follow? Cite instances.

Superheating can be applied to existing railway power houses with the greatest facility, and the case is exceptional where the application is not extremely advantageous. In case the boilers are installed the superheaters may be applied to one at a time without interrupting the operation of the others, or if the circumstances are favorable to a separately fired superheater, it would only be necessary to stop to make connection to the steam pipe. As to changes in piping, valves and engines, it is only necessary for moderate superheat, or say up to a total temperature of 500 degs., to make such changes as would be required for modern good construction for a pressure of 150 lbs. of saturated steam. The advantages which follow will be the increase in fuel economy of the station; a better regulation of the engine by the governor; the facilitating of starting up as the engine will move off promptly with thoroughly dry steam and be quickly warmed up and free from the nuisance of water in the cylinders; ability to straddle peaks without straining the boilers, and the general satisfaction and comfort of a dry, clean system of steam piping and engine cylinders free from dripping and petty leaks. Instances where superheat has been applied to existing power houses may be cited as follows: Power house of the Williamsport Passenger Railway Company, at Williamsport, Pa.; of the Jersey Shore Electric Railway Company, at Jersey Shore, Pa.; of the Omaha Electric Company, at Omaha, Neb.; of the Laclede Power Company, at St. Louis, Mo.; of the Milwaukee Electric Railway & Lighting Company, at Milwaukee, Wis.; of the Hartford Electric Light Company, at Hartford, Conn.

E. H. FOSTER, Vice-Pres.,
Power Specialty Co., New York City.

F 42.—What is the limit in size of station in which superheating can be used with economy?

The limit to stations in which superheating can be used with economy is not expressed in the size of the station. There certainly can be no limit so far as size is concerned where superheating is not economical. A small station is just as important in this respect as a large station, and the advantages of superheating must be classified under two distinct heads: First, the physical advantages such as the increase in power and improvement in operating features of the plant, which cannot be limited by the conditions; second, the financial consideration which places a limit on the economy of installing superheaters by the cost of fuel. With fuel at 50 cents to 75 cents per ton it is difficult to make out a strong argument in favor of the economy of installing superheaters, but as the cost of fuel increases from this point the economical advantage is very material, increasing in proportion to the cost of fuel. These considerations, however, are only to be taken in conjunction with the other advantages of superheating.

E. H. FOSTER, Vice-Pres.,
Power Specialty Co., New York City.

F 43.—Do you recommend separately fired or boiler contained superheaters for moderate size plants?

This question cannot be answered in a general way, and each case must be decided upon its merits. The points to be considered are the existing arrangements of boilers and engines, the steam piping, and the cost of making the necessary changes for either the boiler contained or separately fired superheater installations. There cannot be said to be any decided advantage so far as fuel economy is concerned in favor of either arrangement, nor is there a great difference in the cost. A separately fired apparatus must be protected so far as possible from heat radiation, and it is therefore advantageous to place it in between settings of boilers; frequently the side walls of the superheater are combined with the walls of the boiler setting. For power plants we should say that the decisions in favor of boiler contained superheaters, as compared with separately fired, are about as 3 is to 1.

E. H. FOSTER, Vice-Pres.,
Power Specialty Co., New York City.

I—TRACK DEPARTMENT

I 1.—In the construction of a suburban or interurban electric railway, what are the deciding factors in determining the weight and section of rail to be used? State what weight and section you prefer, and why.

The determining factors in selecting the weight and section of rail to be used on interurban or suburban roads are two, namely, the weight of the cars to be operated, and the character of the paving or other material used in filling in between the rails. With such cars as are being operated to-day on the interurban roads, I would not use a rail lighter than 70 lbs. per yard. If the roadbed is on private right of way where the track is exposed and can be well ballasted, I would recommend the A. S. C. E. section 70-lb. rail, for cars of 50 tons and under; and 80-lb. rail for cars over 50 tons. If the tracks are laid on streets that are unimproved, but where the top of the rails must be flush with the street so as to allow travel over them, I would recommend a T-rail 7 ins. high, with a 6-in. base, and weighing 80 lbs. per yard. This construction contemplates the track being filled in to top of rails with earth, broken stone, macadam, or some similar material. If the tracks are laid in paved streets, I would suggest a 9-in. 90-lb. semi-groove rail.

W. H. GLENN, Supt. Roadways,
Georgia Ry. & Elec. Co., Atlanta, Ga.

In determining the weight of rail, consideration must be given to the weight, speed and wheel base of car, the size and spacing of ties, the length and section of rails and the kind of rail joint. A rail weighing 70 lbs. to the yard, 30 ft. to 33 ft. in length, with ties spaced 24 ins. on centers, is considered best adapted for suburban cars weighing 30 tons. Many favor 80 lb. and 85-lb. rail for such service, but it would seem a better investment to expend the difference in a better joint and joint support. For present practice a 70-lb. T-rail, 33 ft. long with 36-in. joint having a base plate, laid with joints staggered, ties spaced 18 ins. centers at joints, and 24 ins. centers between, fulfills my idea of good construction. However, if 50-ton to 60-ton cars are to be expected in the near future nothing lighter than an 80-lb. rail would seem advisable.

M. J. FRENCH, JR., Roadmaster,
Syracuse Rapid Transit Ry. Co.

The deciding factors are amount of traffic, speed, schedules it is expected to maintain, and type of car to be used. We prefer a 70-lb. A. S. C. E. section. We believe 70-lb. rail is amply heavy for heavy interurban traffic.

GEO. H. HARRIS, Supt. Ry. Dept.,
Birmingham (Ala.) Ry. Lt. & Power Co.

The maximum weight of cars to be used. We prefer 70-lb. rail in 30 ft. or 33 ft. lengths.

Columbus, Buckeye Lake & Newark Trac. Co., and
Columbus, Newark & Zanesville Elec. Ry. Co.

I 2.—What is the best type of rail for city service in unimproved streets?

My idea is that the best rail for city service in unimproved streets is the 7-in. 80-lb. T, with 6-in. base.

W. H. GLENN, Supt. Roadways,
Georgia (Atlanta) Ry. & Elec. Co.

Ordinary T-rail. It is fair to presume that an "unpaved street" is one having natural earth or broken stone filling on the railroad strip. In such a case there would be no advantage in using a tramhead girder rail, as attempts to run heavily loaded wagons on the trams shortly make deep ruts along either side of the rail. The consequent exposure to the weather, the natural tendency of the side bearing rail to tip outward under the weight of the car, the liability of tie-rods becoming bent or broken, and the opportunity for water to readily reach and rot the ties, would all work to the detriment of girder rail. Where ordinary T-rail is used, a teamster has no inclination, opportunity or excuse for driving upon the rails, the gage remains permanent and maintenance is reduced to a minimum.

M. J. FRENCH, JR., Roadmaster,
Syracuse Rapid Transit Ry. Co.

Seven-in. T Lorain section in 60-ft. lengths, because it is the cheapest to maintain.

Geo. H. Harris, Supt. Ry. Dept.,
Birmingham (Ala.) Ry. Lt. & Power Co.

Nine-in. girder rail.

Columbus, Buckeye Lake & Newark Tract. Co., and
Columbus, Newark & Zanesville Elec. Ry. Co.

I 3.—What advantages, if any, does a 9-in. girder rail possess over a 7-in. girder?

The 9-in. girder rail has two advantages over a 7-in. girder. First, it is more rigid, if rigidity be desired; second, it will permit the usage of types of pavement which cannot be used with a 7-in-rail. For instance, in many cities the streets are paved with granite blocks 7 ins. deep. If these are used in connection with 7-in-rail, then some of the blocks must necessarily rest on the ties, and when subjected to wagon traffic the blocks between the ties will sink, while those on the ties will not. This will make the pavement present a very uneven appearance. If, however, a 9-in. rail be used, a 2-in. cushion of sand can be utilized, and the blocks will sink more uniformly.

W. H. Glenn, Supt. Roadways,
Georgia (Atlanta) Ry. & Elec. Co.

The greater depth of concrete above the base of rail, together with the additional vertical stiffness of a 9-in. rail, affords a more stable construction, but the same weight per yard of 7-in. rail, having a greater proportional depth of head and a wider base, should give longer life. So that where the depth of paving material, such as asphalt, does not exceed half the depth of the rail, the 7-in. rail would seem to be preferable; with paving block over 4 ins. deep the 9-in. rail should be used.

M. J. French, Jr., Roadmaster,
Syracuse Rapid Transit Ry. Co.

We prefer a 9-in. girder rail in city work, providing we are able to select the right kind of paving block.

Geo. H. Harris, Supt. Ry. Dept.,
Birmingham (Ala.) Ry. Lt. & Power Co.

The 9-in. rail gives less liability to heaving of paving from frost and longer life of the ties.

Columbus, Buckeye Lake & Newark Tract. Co., and
Columbus, Newark & Zanesville Elec. Ry. Co.

I 4.—If the conditions require a girder rail, which type would you prefer, semi-groove, full-groove, tram, center-bearing or Trilby section? Please state your reasons in full for the preference.

Either the semi-groove or Trilby section makes a first-class track. The full groove rail is harder to clean, consequently wears the wheel flanges. The tram rail allows a wheelway for wagons and thus prevents an opportunity for accidents. As a consequence of this wagon travel it will be found always that the pavement immediately on the inside of tram rails wears considerably. The center-bearing rail has this same fault doubled. A semi-groove rail with a heavy durable lip makes an ideal track.

W. H. Glenn, Supt. Roadways,
Georgia (Atlanta) Ry. & Elec. Co.

If the high T-rail be classed as a center-bearing high-girder rail, as it really should be, that type is preferable, as the tendency to spread under heavy traffic is reduced to a minimum. A longer life is afforded by a greater depth of head, and a greater proportion of metal is placed in essential parts. The shallow and narrow flangeway of the grooved types precludes the use of M. C. B. flanges upon suburban cars entering cities, except at considerable damage to both rails and wheels, and reduced life of rails results because the allowable wear is but 1/8 in. to 1/4 in. before the flange begins to cut the neck, and the rails are forced to wide gage through the car riding upon the flanges outside the center of gravity of the rail.

M. J. French, Jr., Roadmaster,
Syracuse Rapid Transit Ry. Co.

Semi-groove is preferable, because with this type of rail less power is required to move cars than with the full groove or Trilby sections. The semi-groove is also easier to keep clean than the other sections.

Geo. H. Harris, Supt. Ry. Dept.,
Birmingham (Ala.) Ry. Lt. & Power Co.

Our experience is in favor of the center-bearing rail.

Columbus, Buckeye Lake & Newark Tract. Co., and
Columbus, Newark & Zanesville Elec. Ry. Co.

I 5.—When laying tracks, what space should be left between the ends of the rails for contraction and expansion?

If the tracks are laid in permanent pavement, I would allow no space whatever, butting the rails closely together. If the tracks are exposed allow 1-16 in. for every change of 25 degs. F. in temperature of rail of 30-ft. lengths. The maximum variation, of course differs with the locality. If the track is laid during the lowest temperature, then the maximum spacing is left; if at the highest temperature, no spacing is left; at intermediate temperatures space proportionately.

W. H. Glenn, Supt. Roadways,
Georgia (Atlanta) Ry. & Elec. Co.

Where only the wearing face and gage are exposed to the weather, no space should be left. In T-rail construction the coefficient of expansion, together with the rail length and temperature at time of laying determine the open space at joint.

M. J. French, Jr., Roadmaster,
Syracuse Rapid Transit Ry. Co.

In city paved street would not leave any space between rails. In unpaved streets in extreme hot weather would leave 1-16 in. open. In Southern climates during the cold weather, joints should be laid 1/4 in. open.

Geo. H. Harris, Supt. Ry. Dept.,
Birmingham (Ala.) Ry. Lt. & Power Co.

This depends largely on the temperature of the air and the length of the rail.

Columbus, Buckeye Lake & Newark Tract. Co., and
Columbus, Newark & Zanesville Elec. Ry. Co.

At temperature of 96 degs., 1-16 in.; at 76 degs., 1/8 in.; at 8 degs., 1/4 in.

C. C. Wood, Mgr.,
Angola (Ind.) Ry. & Power Co.

ADDITIONAL QUESTIONS

The following questions have been received from correspondents during the past month. Replies to these from any reader of the paper who can supply the information requested will be heartily appreciated. Address answers to Question Box Department, Street Railway Journal:

A 5a.—Who are entitled to free tickets from street railway companies?

A 35a.—Can a fifteen-minute service be successfully given upon a single-track interurban road? What conditions are necessary to make this possible?

A 36a.—Based upon experience, what is a proper rate per mile for interurban passenger business, and to what extent should these rates be reduced by the sale of commutation tickets, monthly tickets, coupon books, etc.?

A 48.—Information is requested regarding the sprinkling of streets by street railway companies, and particularly the proportion of street usually sprinkled, and the amount paid by the cities and municipalities for this service. Does your company sprinkle streets? If so, on what terms?

A 49.—Information is requested relative to best ways of despatching cars on interurban roads.

(a) What is the proper method of numbering trains?

(b) Should odd and even numbers be used for opposing trains?

(c) How are train numbers changed at the end of the run?

A 50.—Please describe a simple board for despatcher's use, showing location of all trains at all times.

E 82a.—What is the best remedy for preventing sleet and ice forming on car windows, particularly on the vestibule windows?

MEETING OF THE OHIO INTERURBAN RAILWAY ASSOCIATION

About sixty members were present at the meeting of the Ohio Interurban Railway Association at Lima, Feb. 23.

The principal topic for discussion at the morning session was the baggage question, which had been discussed at previous meetings. F. G. Green, chairman of the committee on this subject, reported that the committee had corresponded with practically all the managers of the State and had found that, as reported at the previous meetings, there was a wide diversity of opinions as to the advisability of charging for baggage. Personally, Mr. Green said, he favored charging for baggage, but he had been forced to admit, by reason of figures obtained from other roads, that the free checking of baggage seemed to stimulate traffic. He said that the committee had decided that it would be almost impossible to make interline business a success unless this class of baggage at least was handled free of charge. It was the sense of the committee, therefore, that 150 lbs. of baggage should be checked free on interline tickets, with an excess fare of 25 cents per 100 lbs. or fraction thereof for pieces weighing over 150 lbs. Tickets upon which baggage was checked, to be properly stamped or punched. The baggage check to be a double card, containing the number, date, originating point, destination and route; one section for the passenger, the other to go with the baggage. Free checks to be white and excess fare checks to be blue. The form is illustrated. The baggage way-bill to consist of a uniform card, containing the date, train, time, shipping agent's name, receiving agent's name, initial point, number, destination and description of baggage. Conductors, messengers or motormen to make daily reports of baggage handled, and similar records to be kept by station agents, using the form illustrated on page 436. Where transfer of baggage is necessary, the transfer charge to be paid by the transferring road. This plan to apply only to interline baggage; baggage on individual lines to be handled as each road elects.

NAME RAILWAY
O Date
....
Original Check
From ....
To ....
State ....
Route Junction Pt.
Via to ....
.... to ....
.... to ....
.... to ....
.... to ....
No.
....
NAME RAILWAY
Passengers O Duplicate
From ....
To ....
State ....
Junction Pt.
....
Via to ....
.... to ....
.... to ....
.... to ....
.... to ....
No.

FORM ADOPTED FOR CHECKING BAGGAGE

The subject was then opened for discussion. Mr. Spring, of the Dayton, Covington & Piqua, said he was satisfied that some of the roads in the southern part of the State could not afford to carry all baggage free, not only on account of their lower rates, but because some of them have no competition and they can just as well as not make a little additional on baggage.

Mr. Morrell, of the Dayton & Western, said that the Indiana roads with which they connect are opposed to free checking, and he had found it impossible to change their views. While his company is able to handle through business to Indianapolis, it would be unable to check baggage free beyond Richmond.

Mr. Paxton, of the Dayton & Troy, inquired if the scheme of charging on one road for a short haul and carrying baggage free over several roads would not be contrary to interstate commerce laws.

Mr. Wilcoxon, of the Western Ohio Railway, thought the interstate commerce laws did not apply to traction lines, at least to those lying wholly within one State.

Mr. Green, of the Springfield, Troy & Piqua, said his road would not want to carry local baggage free because it had no competition and derived quite a little revenue from baggage. But to get the scheme started he was willing to carry interline baggage free. He said some difficulties might result from the fact that all roads do not have combination cars, but handled baggage on express cars. He urged the necessity of having baggage compartments on all cars, and in event that this could not be accomplished, he urged that connecting lines arrange their express runs so that they would make connections with as little delay as possible.

Mr. Carpenter, of the Western Ohio, which has always charged for baggage, urged the adoption of the scheme, as he said it would be impossible to get people to pay a charge to each road on a long trip covering several roads. He thought also that the plan must be uniform or it would be unsatisfactory.

Mr. Clegg, of the Dayton & Troy, said he could see how it would be possible for a passenger to defeat the scheme of charging on a local haul and carrying free on an interline ticket. For instance, a man going from Dayton to Piqua on their road could buy an interline ticket to a 5-cent point beyond their line on the Western Ohio, thus securing the free checking of his baggage and saving 20 cents.

Mr. Green, of the Springfield, Troy & Piqua, said that records kept for several weeks indicated that the average weight of each piece of baggage was 90 lbs., and that the money derived from excess amounted to very little.

Mr. Coen, of the Lake Shore Electric, urged the adoption of the report, as he said interline business could not be made satisfactory under present conditions. He thought the general sentiment was favorable, and that if adopted, pressure could be brought to bear to make the plan universal throughout Ohio at least.

Mr. Clegg, of the Dayton & Troy, said that he had always charged for baggage, but that he was willing to be coerced into going with the majority, and he moved the adoption of the report. It was passed without a dissenting vote.

Eight new members were elected.

Treasurer DeWeese reported that all expenses of the recent annual meeting had been paid and that the association was in good financial condition.

J. H. Merrill, of the transportation committee, reported on his recent conference with the Indiana Electric Railway Association on the subject of making the Ohio coupon books good throughout Indiana. He said an Indiana committee had been appointed to investigate the matter, but that it seemed to be the sense of the committee that the Ohio discount of 16⅔ per cent was greater than the Indiana roads could afford, in view of their lower rates of fare. He thought the committee would decide in favor of 10 per cent or possible a 12½ per cent discount. Two of the Indiana roads have authorized their conductors to accept the Ohio books. A resolution was adopted instructing the transportation committee to attend the next Indiana meeting and to use its best efforts to prevent another form of coupon book from being adopted, and the committee was given power to act.

Meetings for the spring season were announced as follows: March, Cincinnati; April, Springfield; May, Cleveland; June, Cedar Point (Sandusky). Committees for the year were announced as follows: On subjects, F. J. J. Sloat, H. C. Lang, J. W. Brown; transportation, Theodore Stebbins, J. H. Merrill, F. W. Coen, F. W. Adams; legislative, Dr. J. E. Lowes, C. H. Bosler, Warren M. Bicknell.

During the noon intermission representatives of the roads in the Ohio coupon book agreement met to discuss the plan suggested by some of making the books good for several persons to be named in the agreement, instead of good only for the individual owner. The general idea expressed was that a number of the roads desire to drop their present forms of commuter's mileage and adopt the Ohio book, which gives a somewhat better rate and would relieve the necessity of having several forms. The only objection to the change is that the local mileage books are usually good for several persons or for members of a family. In the discussion it was brought out the books were intended primarily for the use of traveling men, and that if the privilege was extended to cover several persons on one book, it would lead to dishonest use of the book and would render it possible for scalpers to buy the books and sell transportation at lower rates than the roads themselves. An informal vote indicated that the majority were in favor of limiting the book as at present. But the matter will be taken up fully with each road and a mail vote taken. It was developed at the meeting that more than a thousand of the books were in use.

AFTERNOON SESSION

The afternoon session was devoted to a discussion of the subject, "Uses and Abuses of Equipment." The discussion was opened with a paper by G. H. Kelsey, electrical engineer and master mechanic of the Western Ohio Railway. He spoke in part as follows:

USES AND ABUSES OF EQUIPMENT

The all day operation of a railway motor is one extremely varied in its requirements as imposed upon the motor, extending from conditions of rolling or coasting when the motor is practically inert, to the extreme condition of rapidly accelerating a heavy car when the motor is handling currents several times as large as its normal all day rating. The amount of work a railway motor will perform is limited by its mechanical strength, its commutation and heating. Its mechanical strength is governed by the chemical and physical properties and relative size of the various parts that go to make up the mechanical details of the machine. All machines, no matter for what purpose they are built, are designed with a factor of safety in view; thus a bridge will require six times its normal load to break it down. So it is with railway motors, the design must be amply strong. Take the condition which is one that sometimes happens, that a motorman is called upon to protect himself, car and passengers from the collision with some object. He acts quickly and sometimes without reason, he sets his brakes, and at the same time reverses his car. Possibly his circuit breaker will not stay in and he holds it in. This in turn will possibly open the power house breakers. The stress exerted in a motor under these conditions may be extremely severe.

I stated that he acts without reason, because I have seen time and again that he will apply his brakes and reverse his car. The common failure of a gear bolt, passing between the pinion and the gear, produces very heavy mechanical stresses on a motor. A case recently came under my observation where the shaft of a 50 to 60-hp motor was reduced at the end to receive the pinion. There was no excuse in having any more reduction than the taper to make a fit with the pinion; but as a result many shafts were bent and broken, and not necessarily by abuse to the equipment. The trouble was corrected by substituting a shaft that was not reduced so much at this position, but leaving one-half inch more stock.

A railway motor as a machine is possibly subjected to conditions in operation as far above normal rating as any class of machines made; so it is very important that its details should be carefully designed, and when machines are put in operation that they should receive extreme care in maintenance. Inspection of a most thorough nature is money well invested, Gears, pinions, bearings, brush holders and all bolts in and about the motor equipment should be inspected once each week when cars are subjected to hard service.

Motors may be designed to commutate their normal rated current without appreciable sparking or heating, but with lack of careful brush inspection and adjustment, excessive current due to various causes that come up in every day service will cause more or less sparking accompanied by flashing, and a dirty machine results in damaging commutator, brush holder and motor winding. Great stress should be laid upon careful inspection of brushes, brush holders and in maintaining a smooth and even commutator. It is foolish economy to operate a commutator with flat spots, on the theory that machining cuts off a useful lot of copper. Flat spots once started develop at an accelerating rate.

A very great proportion of our motor troubles are due to copper and carbon accumulating on all parts of the interior of the motor. The accumulation is augmented by rough commutators and poor brush and brush holder adjustment.

The operation of double-end equipments makes the question of commutation a much more severe one, as it is quite hard to maintain a contact the full width of the brush when cars run from either end. The brush holders have to be made a little larger than the brush, in order to let the brush go up and down freely. When the machine is reversed it goes against the other side; that twists the brush and it will wear two faced. That is not always the case if the brush holders are kept up in extra good condition and not allowed to wear. We should not let the brush have too much play in the brush holder, and it is a pretty hard proposition to remedy.

REPORT OF BAGGAGE. TRAIN NO. DATE, ..., 190

Initial	No.	Received	Time	Delivered	Time	Desc. Bg.	Final Dest.	Rec'd by Bg. Master

Conductor.

BAGGAGE WAY BILL

The third limitation to the work of a railway motor is its heating. The heating of a motor comes from six sources.

1. I^2 R in the fields.
2. I^2 R in the armature.
3. I^2 R from eddy currents.
4. Hysteresis.
5. Friction in bearing and commutator.
6. Friction in air.

A motor when starting in a day's service has a temperature the same as the surrounding air, but its temperature will begin to rise due to the six causes indicated, and will continue to increase until the difference of temperature between itself and the air is so high that the rate of radiation is equivalent to the rate of generation of heat in the motor. The final temperature then, at which a machine will run, depends on the magnitude of the losses, and they in turn depend on the mean current and voltage on which the machine is operated. In other words, there is a limit as to how warm a machine will get. It will keep increasing in temperature until the temperature is high enough above the surrounding air that the rate of radiation balances the rate of generation or the heat due to the losses. The rating of machines as now given by builders is hardly ever indicated by so many horse-power. To say a machine has so many horse-power, doesn't mean very much now.

I might illustrate a condition or two that came under my observation where the temperature got very high. We had a car that was about 50 miles from the shop, possibly not that far, and the motorman had trouble with one of the machines. His instructions were to get out two machines. He did so, but from some cause another machine broke down, throwing him on one machine. He ran from a point a few miles north of Sidney, south through Sidney to a heavy hill and back to Wapakoneta on the one machine. The weather conditions were dry. That machine got so hot that the solder began to run on the commutator.

The resistance losses in armature and field winding are equivalent to their ohmic resistance times the square of the current. The ohmic resistance of the motor is slightly variable, becoming a little greater as the motor gets warmer.

The iron losses vary as the 1.6 power of the magnetization, which in turn depends on the value of the current and the voltage at which the machine operates.

If it were possible to operate motors without their heating, the question of rewinding armatures and fields would be a small one.

The continued operation of machines at high temperature sooner or later weakens the insulation to such a point that its insulating qualities and dielectric strength are weakened, and the armature is much more susceptible to break-down from any electrical disturbances. Accumulation of copper and carbon dust all over the armature undoubtedly aids very materially in breaking down the armature.

A possible solution for a portion of this trouble may be in the use of asbestos insulated wire, for which great claims are made by the D. & W. Fuse Company, of Providence, Rhode Island. I have a little sample of this wire here, which I will pass around for inspection. This wire, they say, has been operated at 600 deg. C., without destroying the insulation.

Mr. Kelsey then gave the results of a test made with the "Theodore," one of the sleeping cars owned by the Holland Palace Car Company. Considerable interest attaches to these results, as the cars were until recently in operation on an Ohio road. Originally the cars were equipped with four 150-hp motors, and they weighed about 50 tons. Mr. Kelsey stated they had removed two of the motors, leaving one on the front of the front truck and one on the rear of the rear truck, reducing the weight to about 46 tons. On its first trial the car was run from Piqua to Lima, a distance of about 49 miles. Readings were taken on the car at intervals of fifteen seconds. The car was in regular service as a limited. It was fitted with heaters which used about 4 amps. The average current consumption was 134 amps. The voltage was maintained well up to 600. In accelerating, the current rise was very rapid, because there were no low points on the controller. The most severe pull was on a 4½ per cent grade, 1800 ft. long, where the voltage dropped to 475 and the current jumped to 460 amps.

On the return trips the average voltage was 482; average current, 151 amps.; average miles per hour, 25.2; kw-hour per car-mile, 3.06.

In reply to inquiries, Mr. Kelsey said they had 494,000 circ. mils of copper on portions of the line and 566,000 circ. mils on the balance, and the voltage is well maintained at all times. On their regular limited runs they use a 30-ton car fitted with four 50-hp motors. On tests covering two weeks, the average current consumption was 2.23 kw-hours per car-mile. He admitted that the larger car consumed less current per ton-mile than the regular car. He thought that the two-motor equipment was more efficient electrically, but that the four-motor equipment was superior from the mechanical standpoint.

W. E. Rolston, chief engineer of the Dayton & Troy Railway, urged the better education of motormen in the handling of controllers. Too many men feed up rapidly, which increases the temperature and reduces the efficiency of the motors. Such men invariably claim they cannot make schedules unless they accelerate rapidly. He had seen men use 420 amps. in accelerating, while other men used 320 amps. on the same track and under the same conditions. He had had men cover the distance from Dayton to Troy in forty minutes, and use less current and arrive with motors in a cooler condition than other men who required forty-eight to fifty minutes for the same distance, both having the same equipment and conditions. On a 4 per cent grade which he has watched, men that went up in series used 60 per cent less current than those that threw the controller into multiple. In instructing motormen, they turn the applicant over to old men and allow them to run under several different instructors. They have a class and use instruments on cars and show the men exactly what current they are taking. They use every precaution to keep their feeders up to the same capacity on all portions of the system. They use direct current and boost to the ends of the lines. He said the large majority of car troubles occurred near the ends of the lines, where the voltage is the lowest. On their limited car, which makes 95 miles in two hours and forty-five minutes, they have four Westinghouse No. 76 motors, with a car weight of 34 tons. On a recent test on this run they used 2.8 kw-hours per car-mile. On a test with the Holland car "Francis," a companion of the "Theodore," tested by Mr. Kelsey, they averaged 3.2-kw-hours per car-mile.

A. M. Frazee, superintendent of motive power of the Columbus, Buckeye Lake & Newark Traction Company, gave some figures on equipment. They use oil and waste lubrication for armature bearings, and the average wear is 160,000 miles and the diameter is reduced not to exceed 1-32 in. They use 240-lb. solid steel gears. They have been using steel-tired wheels, with tires 2½ ins. thick. These run from 30,000 miles to 50,000 miles before requiring re-turning, and their life has been about 140,000 miles. They are now putting on tires 3½ ins. thick, which will allow for five turnings. Flanges wear sharp on the gear side, and they frequently change wheels to match them up. They use Diamond S brake-shoes on steel tires and get 18,000 miles to 20,000 miles. Their lubricating oil is furnished by the Viscosity Oil Company, of Columbus. Their power station has a capacity of 3100 kw, and their average output is 15,000 kw-hours per day for 84 miles of city and interurban road. Their output figures 5.6 kw-hours per car-mile at bus-bar. This is higher than at present, because at that time they were operating the two Holland cars with the heavy equipment. They use natural gas as fuel, and for a recent month their current cost 0.41 cent per kw-hour at the station bus-bar, including labor, lubrication, fuel and repairs, but not interest or depreciation.

Mr. Hilton, of the Griffin Wheel Company, Chicago, said that steel-tired wheels were becoming very popular not only for interurban but for city service. He said that recently the Metropolitan Street Railway, of New York, had ordered 500 pairs for city service. He described a grinding outfit installed by the Boston Elevated with which they are now grinding wheels twice a month instead of turning them as heretofore.

President Bicknell, of the Lake Shore Electric Railway, said that new men were first sent to the shop for a week and given instruction about equipment under a foreman. Then they are sent out on the road for a week under an old motorman; on their own time in both cases. If either old or new men get careless and lay up cars where they should have been able to remedy the difficulty themselves, they are sent to the shop for a week on their own time. Illustrating the fact that many troubles come through lack of power, he said that a year ago they were attempting to run four 75-hp equipments on 100 miles of road with a power station that was designed for 65 miles of road cars using two 75-hp motors. They had numerous boiler troubles, and the boilers designed for 150 lbs. would drop to 75 lbs. or 100 lbs. The engines would slow down and the voltage would drop all along the line. For three months before they got in a new generator their car maintenance cost 5 cents per car-mile. Now with ample power it averages .028 cent per car-mile. They use a trolley wheel designed by F. Heckler, their master mechanic, and produced in their own foundry. It has a large oil chamber, which is filled with Dixon's graphite grease and does not require reoiling during its entire life.

C. O. Scranton, of the Stark Electric Railway, described his company's plan of giving every motorman his own car and making him responsible for unusual wear and tear on equipment. This plan was described in a recent issue of the STREET RAILWAY JOURNAL.

TWO-MOTOR VERSUS FOUR-MOTOR EQUIPMENTS*

BY N. MC D. CRAWFORD

It is manifestly impossible to consider judiciously the relative commercial efficiency of two-motor versus four-motor equipments, or to reach any absolute conclusion unless certain conditions under which the equipments are to be operated have first been determined. For the purpose of this paper a line was selected having light grades and reasonably small line losses, a line passing through the business center of a city and reaching the residential section, thus at all hours of the day calling for a fair average number of stops and therefore reasonably rapid acceleration, in order to make the time schedule.

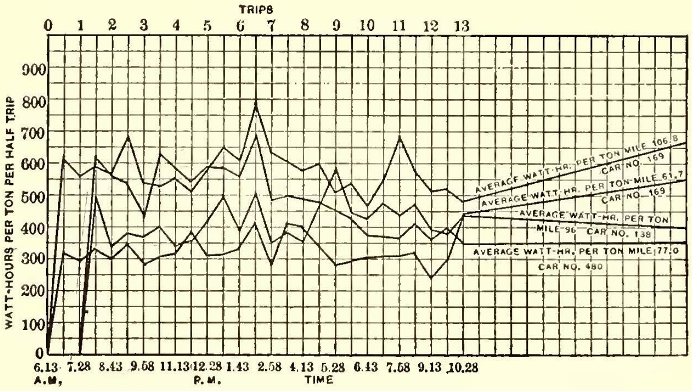


FIG. 1.—AVERAGE WATT-HOURS PER TON-MILE OF ALL CARS TESTED

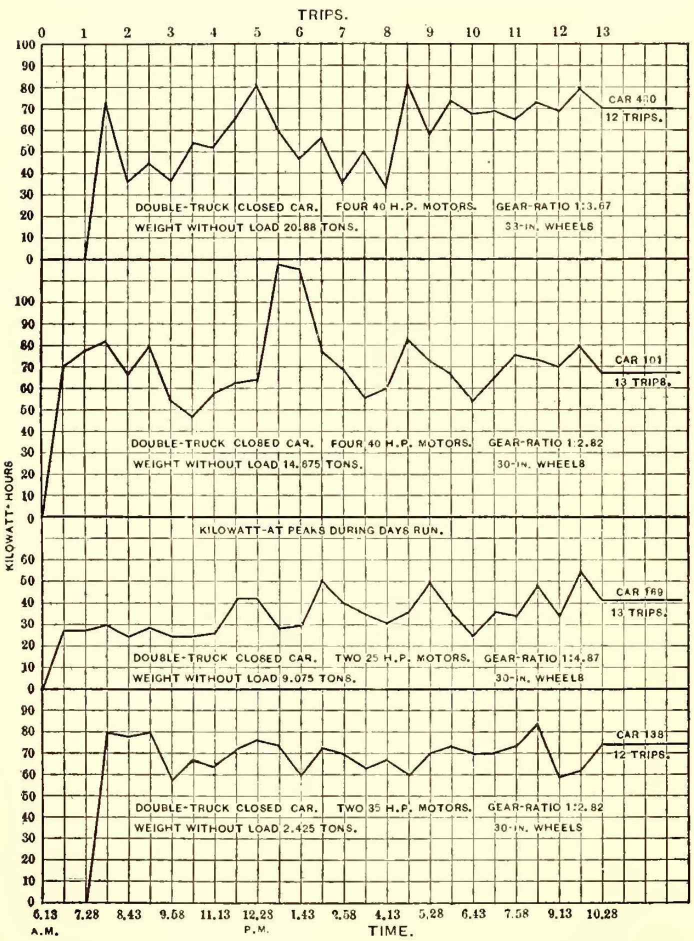


FIG. 2.—KILOWATTS AT PEAKS DURING DAY'S RUN

Four types of equipment were selected for this service, as follows: Car 169, having a 20-ft. body, single trucks, two 25-hp motors, and a gear ratio of 1 to 4.87; car 138, having a 26-ft. body, two trucks, two 35-hp motors, and a gear ratio of 1 to 2.82; car 101, having the same length of body and number of trucks as car 138, but having four 35-hp motors and a gear ratio of 1 to 2.82; car 480, having a 29-ft. body, two trucks, four 40-hp motors, and a gear ratio of 1 to 3.67.

The service required of these four equipments was exactly the same, namely, 136.5 miles per day at an average schedule of 8.45 m.p.h. The runs were made on succeeding speed days and during the same relative hours. Each car was equipped with a wattmeter, an ammeter and a voltmeter; the wattmeter readings at the end of each half trip were recorded, and at the end of the run checked by the ammeter and voltmeter readings. The wattmeter was also carefully calibrated with a standard meter, using a water rheostat as a load. The peaks were noted at times of acceleration and on grades. These tests have been tabulated as follows:

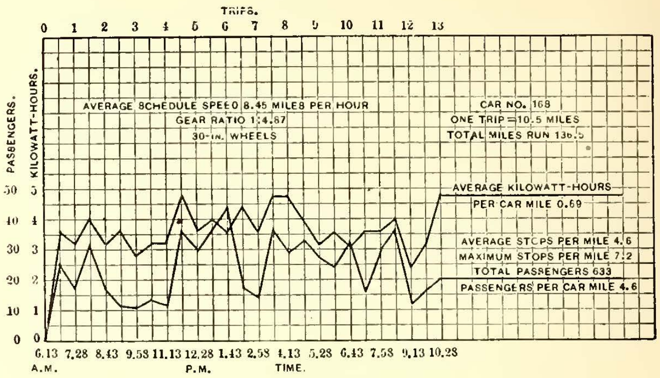


FIG. 3.—PASSENGERS AND KW-HOURS PER HALF TRIP, CAR NO. 169

Fig. 1, the average watt-hours per ton-mile.
Fig. 2, kilowatts at peaks during day's run.
Fig. 3, passengers and kw-hours per half trip.
Fig. 4, passengers and kw-hours per half trip.
Fig. 5, passengers and kw-hours per half trip.
Fig. 6, passengers and kw-hours per half trip.

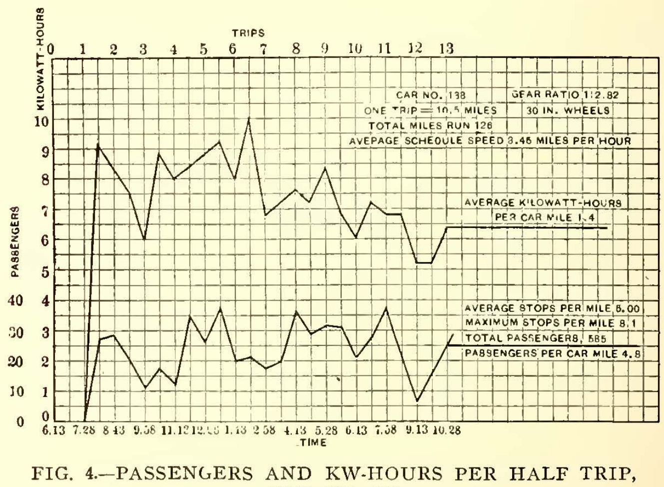


FIG. 4.—PASSENGERS AND KW-HOURS PER HALF TRIP, CAR NO. 138

Table 1 has been deduced from the sheets given.

TABLE I

Car No.	Capacity Seats.	Horse-power Motors.	Gear-ratio.	Total Tons.	Total Cost.	Cost per Seat.	Cost per Ton.	Commercial Efficiency.
					$	$	$	%
169	26	two 25	1:4.87	9.075	2710	104.23	298.62	17
138	34	two 35	1:2.82	12.425	3275	96.38	263.59	13.11
101	34	four 35	1:2.82	14.675	4360	128.23	297.10	12.53
480	42	four 40	1:3.67	20.680	5040	120.00	243.71	10.66

The commercial efficiency, E, was obtained as follows: $A + B + C + D = E$, and $\frac{H}{E}$ = commercial efficiency.

The same formula, substituting B for H, will give greatest

* Paper presented at a meeting of the American Institute of Electrical Engineers, New York, Feb. 24, 1905.

commercial efficiency. The letters used in the above formula represent the following:

A. Cost of current per watt-hour at station switchboard.

B. Value of seated load.

C. Platform labor per mile-run.

D. Interest and depreciation per mile-run, figured at 8 per cent.

H. Value of actual passengers carried per mile.

In obtaining the commercial efficiency, line losses and repairs of equipments and track have purposely been omitted, because it is almost impossible to determine what these values should be; the value of the standing load has been omitted for the same reason.

Applying the above formula and substituting values obtained during the test, the results are as follows:

CAR NO. 169

$$0.0006787 + 1.30 + 0.0475 + 0.0043 = 1.3525$$

$$\frac{0.23}{1.3525} = 0.1698 \text{ per cent}$$

$$0.0006787 + 1.30 + 0.0475 + 0.0043 = 1.3525$$

$$\frac{1.30}{1.3525} = 0.96 \text{ per cent}$$

CAR NO. 138

$$0.001056 + 1.70 + 0.0475 + 0.0056 = 1.7542$$

$$\frac{0.23}{1.7542} = 0.1310 \text{ per cent}$$

$$0.001056 + 1.70 + 0.0475 + 0.0056 = 1.7542$$

$$\frac{1.70}{1.7542} = 0.96 \text{ per cent}$$

CAR NO. 101

$$0.001174 + 1.70 + 0.0475 + 0.0070 = 1.7557$$

$$\frac{0.22}{1.7557} = 0.1253 \text{ per cent}$$

$$0.001174 + 1.70 + 0.0475 + 0.0070 = 1.7557$$

$$\frac{1.70}{1.7557} = 0.97 \text{ per cent}$$

CAR NO. 480

$$0.000847 + 2.10 + 0.0475 + 0.0087 = 2.1570$$

$$\frac{0.23}{2.1570} = 0.1065 \text{ per cent}$$

$$0.000847 + 2.10 + 0.0475 + 0.0087 = 2.1570$$

$$\frac{2.10}{2.1570} = 0.97 \text{ per cent}$$

An examination of Table 1 readily shows that car 169 is the most efficient for the service selected. This apparent efficiency must, however, be modified when the number of passengers carried, as shown in Fig. 3, is considered, because it will be seen that many times during the day's run the number of passengers was greater than twenty-six, the excess constituting a standing load.

Car 138, although showing a lower commercial efficiency, probably on account of its greater weight, yet accommodates the passengers much better throughout the entire day.

Car 480 was the least efficient of those tried, although there was only a short time when all the passengers could not be seated. This car was provided with 33-in. wheels and could have made the time schedule easily with a lower gear ratio.

Temperatures were taken at the end of each day's run; these were not excessive, except possibly in the case of car 138, due no doubt to the weight of the equipment and the greater number of stops to the mile, as shown in Fig. 4. (See appendix for record of temperatures.)

The tabulated records point to the superiority of the light two-motor, single-truck equipments for service on the line and

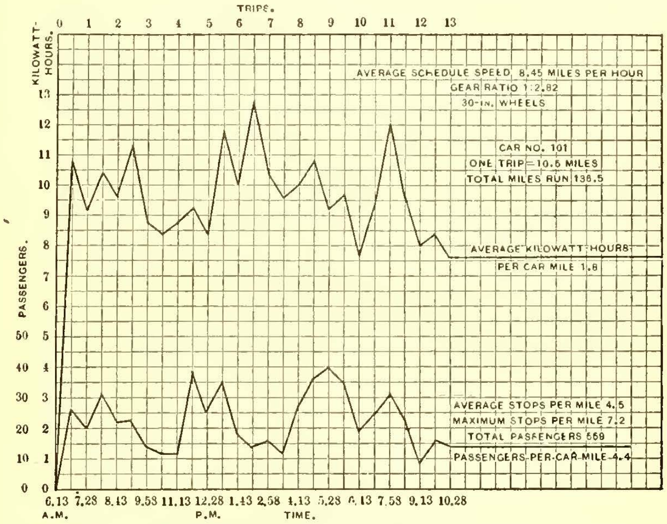


FIG. 5.—PASSENGERS AND KW-HOURS PER HALF TRIP, CAR NO. 101

under the conditions selected. With longer trips, heavier grades, greater speed in miles per hour and greater density of population, requiring more rapid acceleration, there is no doubt but that a car of the 480 type would show the greatest efficiency.

The operating manager is looking not only for an equipment

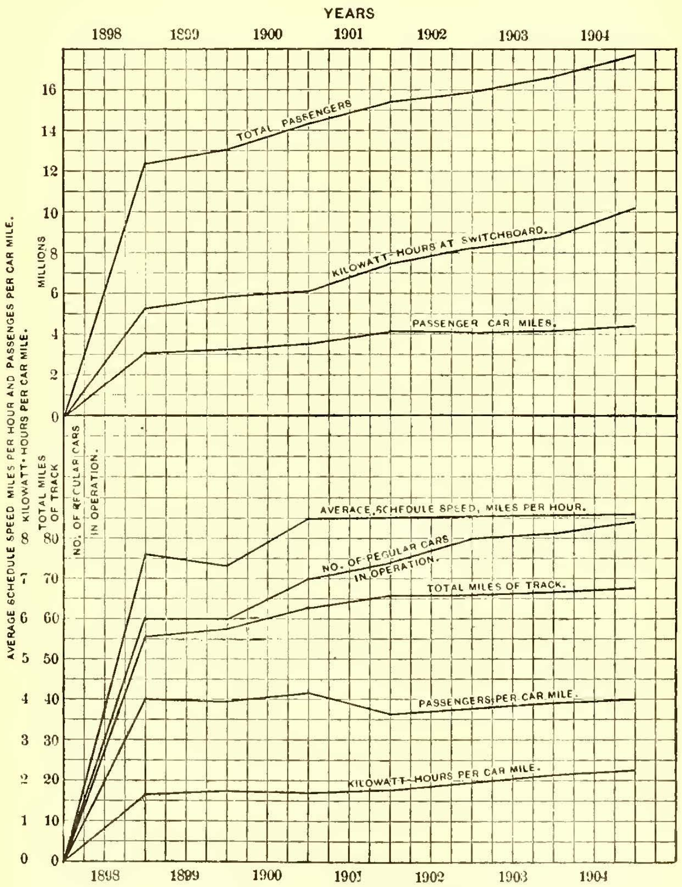


FIG. 8.—MISCELLANEOUS CURVES FOR SEVEN YEARS' OPERATION

that will fulfil all the requirements of any particular service with the least cost for repairs, and the minimum demand on the power station, but also for one that will combine these advantages at the greatest speed with safety to the public and the distance to be traveled per trip will allow. If the distance is, say, 6 miles per half trip, or 12 miles per round trip, requiring four cars for fifteen-minute service at 12 m.p.h., and three cars for the same headway at 16 m.p.h., the platform labor per mile in the first instance will be 0.0335 × 4 = 0.1340, and in the second instance 0.025 × 3 = 0.075, a saving in labor of 0.059 per mile, and 0.0085 per car-mile. This great saving in cost of operation appeals to the operator, but not so greatly if the operating costs are increased by excessive demand on power-station equipment and by added interest charges due to increased line copper and rail-bonds. In selecting motors and cars for a given run, it will be found necessary to consider the following:

Density of population, as governing the size and seating capacity of the car body; the number of stops per mile, and consequently the acceleration; the frequency of service; and the speed in miles per hour.

The number of trucks and motors, as determining the size and weight of cars selected; the tractive effort; and the acceleration.

The speed in miles per hour, as determining the number of cars in service; the platform labor; the demand upon power-plant equipment; the increased interest charge for line and power plant.

The gear ratio, as determining the size of motors; the acceleration; the number of stops per mile; the heating of motors, and consequent repairs; and additional power station and line requirements.

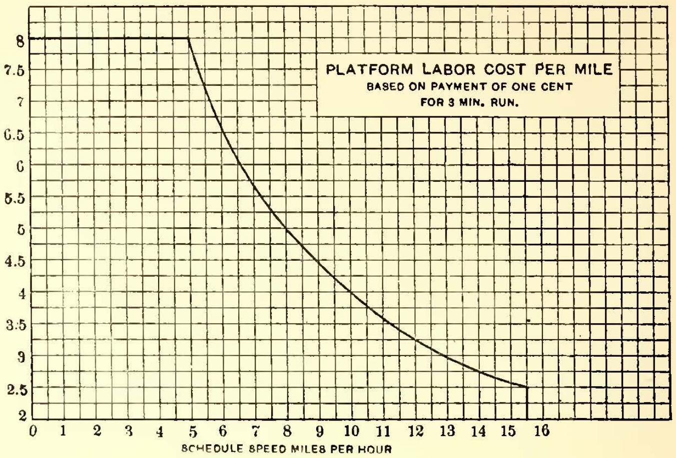


FIG. 7.—PLATFORM LABOR COST PER MILE

TABLE I

	1899	1900	1901	1902	1903	1904
Passenger-car miles, per cent increase	0.07	0.082	0.171	—0.0122	0.0247	0.051
Total passengers, per cent increase	0.06	0.021	0.0772	0.031	0.052	0.065
Passengers per car-mile, per cent increase	—0.009	0.058	—0.112	0.0375	0.0154	0.035
Kilowatt-hours at switchboard, per cent increase	0.012	0.051	0.222	0.094	0.081	0.146
Kilowatt-hours per car-mile, per cent increase	0.038	0.028	0.0462	0.105	0.085	0.06
Total miles of track, per cent increase	0.016	0.096	0.0408	0.0	0.0142	0.0153
Number regular cars operated, per cent increase	0.0	0.167	0.058	0.081	0.0125	0.037
Schedule speed, per cent increase	—0.021	0.142	0.0058	0.0	0.0116	0.0

TABLE J

	1904	1903	1902	1901	1900	1899	1898
Passenger-car miles	4,420,873	4,206,435	4,104,488	4,155,414	3,546,564	3,278,314	3,063,705
Total passengers	17,726,397	16,735,071	15,900,325	15,434,068	14,319,252	13,043,728	12,304,639
Passengers per car-mile	4.00	3.96	3.87	3.73	4.2	3.97	4.007
Kilowatt-hours, switchboard	10,204,480	8,896,924	8,226,905	7,520,852	6,148,588	5,849,584	5,225,010
Kilowatt-hours per car-mile	2.3	2.17	2.00	1.81	1.73	1.78	1.715
Total miles of track	67.573	66.546	65.614	65.614	63.045	57.533	56.638
Number regular cars operated	84	81	80	74	70	60	60

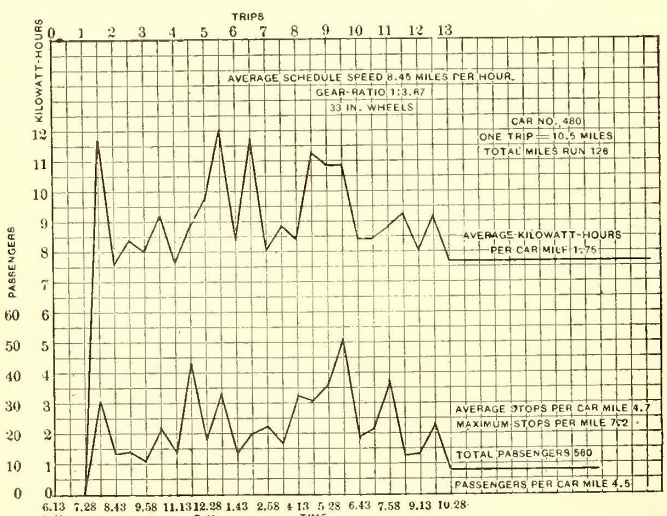


FIG. 6.—PASSENGERS AND KW-HOURS PER HALF TRIP, CAR NO. 480

Too much care cannot be exercised in determining the gear ratio for given service, for there can be no doubt that in many cases lack of power-station equipment and excessive motor repairs can be traced to the use of wrong gear ratio. In the first place, cars should be selected of ample capacity for the service requirements, and then motors should be selected with a rating only slightly greater than the service requires, and with a gear ratio so designed that the schedule may be made without resorting to rapid acceleration on starting, and, as a consequence, running the motors on low-efficiency points in order to kill time. The additional tables contained in this report show the various conditions existing in Hartford, and may be of general interest.

AVERAGE SCHEDULE SPEED MILES PER HOUR

1898	7.6
1899	7.44
1900	8.5
1901	8.55
1902	8.55
1903	8.56
1904	8.56

APPENDIX

Car No.	Motor No.	Car in at	Temperature in Degrees C.			
			Of Air.	Of Armature Iron.	Of Field.	Of Barn at 6 a.m.
138	1	10.35 p. m.	0	68	63	..
101	1	10.35 p. m.	1	70	46	17
480	4	10.35 p. m.	1.5	29	25	23
169	1	10 35 p. m.	5	5	27.5	20

In all the above temperature readings the temperature of the field coils was obtained by placing a thermometer on the top right-hand field coil at about the same point. The armature temperature was obtained by placing the thermometer on the iron core.

The following letter was received from Mr. Crawford relative to the term *A* mentioned in his paper:

MR. CRAWFORD'S LETTER

HARTFORD, CONN., Feb. 24, 1905.

In looking over my paper to be read to-night, I desire to explain term *A* in the submitted efficiency formula. The definition of term *A* may be misleading; its value is obtained by multiplying the average watt-hours per ton-mile by ton weight of car, and the result by the cost of power per watt-hour at the switchboard.

It has also seemed to me important to use the cost of current per ton-mile at switchboard; the value of seated load; the platform labor per mile run, and the interest and depreciation per mile run; considering these terms as input, and the returns per mile as output in determining this efficiency.

It is manifestly true that it would be extravagant practice to run a heavy, high speed, expensive car of large seating capacity over a line from which—due to the density of population and other causes—a small earning would be returned, when a lighter, slower speed, less expensive car with smaller seating capacity would fully accommodate the travel and produce an efficiency more nearly ideal—100 per cent.

I have endeavored, possibly erroneously, to name the efficiency obtained "commercial efficiency." It has been suggested that possibly "load factor" or "earning efficiency" would be better. I am looking at this matter, however, from the standpoint of a street railway manager, and not from an engineering standpoint.

Yours truly,

NORMAN McD. CRAWFORD.

DISCUSSION

A. H. Armstrong, being called upon, said that the contest between two-motor and four-motor equipments was one of long standing, but that it seemed to have settled itself rather definitely in the majority of cases in favor of the four-motor equipment. Mr. Crawford had brought out the fact that each case must be considered by itself, the local conditions being the governing element. Perhaps the fundamental reason for adopting four-motor equipments, assuming a double-truck car, is the need of increased traction. This is felt in a number of different ways, in the North largely to climatic conditions, the presence of excessive grades and an exacting schedule calling for rapid acceleration. In the latter class might be included all city railways. The frequency of stops in a densely traveled district is very great, and the schedule called for is also very high, especially in towns not favored with the rapid transit facilities given by underground and elevated lines. In these cases it is necessary to resort to as high an acceleration as the comfort of passengers will permit. This can be secured only by the adoption of motors on every axle, making all driving axles. In such cases there is no dispute of the superiority of four-motor over two-motor equipments. On elevated, subway or other city roads enjoying especially good conditions as regards rail surface, the adoption of either type of equipment is open to discussion. In the case of the subway, sufficient traction can be obtained with two motors before reaching the limit of comfort of passengers—that is, without equipping all axles. Suburban work presents different conditions, as we have single cars and infrequent headway. We have hills that would not be tolerated in steam railroad practice, and in the North climatic conditions made more severe through the infrequency of cars. The high speed often required and the resulting large power demand can be met in many cases only by resorting to four-motor equipments. The modern high-speed road, running 50 m.p.h. to 60 m.p.h. with cars from 35 tons up, can only be accommodated by having every axle equipped. The total power in such cases is from 500 hp up, and to design two motors of 250-hp each is impracticable with the limitations imposed by the standard gage of 4 ft. 8½ ins. and a wheel base which can negotiate the sharp curves of city streets. The two-motor equipment seems to be relegated to light city traffic lines (of the type mentioned by Mr. Crawford) with fairly level profile, having a schedule which can be accommodated with a moderate amount of acceleration, and where the climatic conditions are not too severe to destroy the tractive effort available with two-motor equipments.

He noted in the paper one or two discrepancies, or perhaps different ways of looking at the same subject. It seems that in arriving at the efficiency, the numerator is taken as the actual nickels earned per mile, while the denominator is largely made up of the possible earnings per mile—that is, the author assumes that at the end of every mile an entirely new set of passengers is taken on board with a new set of nickels. If instead of a 1-mile basis a 2-mile basis had been taken, the 17 per cent in the case of car No. 169 would have been nearly doubled without in any way changing the factors entering into the case. Again, in Figs. 3, 4, 5 and 6 it is shown that the energy consumption (in kw-hours per car-mile) of the two-motor equipments is somewhat less than for the four-motor equipments. To make an absolutely satisfactory comparison, the same schedule and the same total horse-power per car should be taken in each case. What should be done is to compare, for instance, two 70-hp motors with four 35-hp motors. In any other comparison it is obvious that one set of motors would be either underloaded or overloaded. The watt-hours per ton-mile assumed in any given service are independent of the motor-power of the car—that is, they are practically independent and only affect the situation when there is a considerable amount of free running, viz., when a very heavy motor car is permitted to run on the very light load efficiency part of the motor curve. The service in question does not take up any considerable amount of free running, and therefore the results given in Figs. 3, 4, 5 and 6 should coincide more nearly than they do. The reason they do not is perhaps because only one or two cases were taken instead of the average of a large number of trials. All those who have had anything to do with railway tests know the unreliability of the results of one or two tests. Reliable results can be obtained only by correlating the data of many tests.

S. T. Dodd took the floor after Mr. Armstrong. He said that Mr. Crawford in writing about the term commercial efficiency did not mean efficiency in the ordinary engineering sense, but that he desired to get a general term which would express the carrying value of different cars. The criticism that Mr. Dodd desired to make in regard to Mr. Crawford's method of deriving the quantity called commercial efficiency was his introduction of the seat value. If the author had gone a step further by dividing up the seating capacity of the car, and had given the cost per seat-mile instead of the cost per car-mile, he would have shown that the cost of operation per seat-mile with a four-motor equipment was less than that with a two-motor equipment. If Mr. Crawford wished to introduce, in addition, this question of earning capacity as compared with earnings, he could have introduced a separate formula, dividing the earnings by the possible earning capacity, and he would have given a clearer idea by making a distinction between the different types than by attempting to combine results in one formula. Regarding the cost of repairs, considerable data are needed. We have more or less data on the cost of repairs per car-mile, but not on the cost of repairs per motor, and if operating men would watch more closely the cost from this standpoint it would tend to give more definite information. Referring to the belief that under similar conditions, two-motor equipments will heat up more than four-motor equipments, on account of their less radiating surface, he said that the ordinary designer, when designing a motor of any size, designs it along the same general lines, so that the radiation of different motors is proportional to their size. In a stand test which he had made on eight motors taken at random, he added up the carrying capacity for one hour and the carrying capacity for two hours. Calling the carrying capacity of each motor for one hour 100 per cent, he ascertained what the capacity of the motors would be for two hours, and compared the average carrying capacity of four 35-hp motors with that of four 75-hp motors for one hour and two hours. The difference between the average carrying capacity for two hours of both sets of motors was only 0.7 per cent. On this question of heating, he had examined with interest the tables in the paper to see if there were any differences in the heating of the two-motor and four-motor equipments. He found that cars Nos. 138 and 101 were running at an armature temperature of approximately 70 degs., while cars Nos. 480 and 169 were running at armature temperatures of approximately 30 degs. and 40 degs. These differences must arise from some other cause than those due to the use of two-motor or four-motor equipments. An examination of Figs. 4 and 5 for the two-motor and four-motor cars Nos. 138 and 101 show that their average kw-hours per car-mile is far in excess of the other two, and the curves in Fig. 2 show again that the two-motor equipment of car No. 138 takes a maximum input of 80 kw several times, which is also true of car No. 480, which has an equipment of four motors of nearly the same capacity, makes the same schedule and seats forty-two passengers as against thirty-four. This difference is in the gearing, because the equipments on cars Nos. 138 and 101 are geared with the ratio 1:2.82, while cars Nos. 169 and 480 are geared 1:4.87 and 1:3.67. In other words, two of the sets are geared too high. If the two 35-hp motors of car No. 138 had been geared 1:3.94 instead of 1:2.82, they would have been perfectly capable of carrying 7 tons per motor with perfectly reasonable and economical heating.

Calvert Townley, assistant to the president of the New York, New Haven & Hartford Railroad, was the next speaker. He said that the question as to which was the best car to use for city railway work was not so much a question of two-motor or four-motor equipments as it was on the local topographical conditions and density of traffic. Having determined the proper carrying capacity, the question of two or four motors can be treated as a separate thing. Within ordinary limits any gear ratio can be applied to either size of motor. As Mr. Dodd pointed out, the motors having the greatest reduction consume the smallest amount of energy per ton-mile, which is to be expected in a service with frequent stops and low schedule. As a previous speaker had pointed out, no fair comparisons could be made unless the total horse-power of the motors was the same for similar service. Assuming, then, exactly the same capacity on a car, the four-motor equipment will be slightly heavier and additional energy must be taken in proportion to this extra weight. Similarly, the first cost of the four-motor equipment must be greater. The maintenance charges will also be greater, as more units must be provided for. All this being admitted, the unmistakable tendency toward four-motor equipments must be due to their increased traction. For interurban roads, as Mr. Armstrong had pointed out, four motors were necessary. Admitting the value of increased traction, let us see to what extent it is needed. The two-motor equipment will have from 55 per cent to 60 per cent of the total weight of the car on the drivers; 60 per cent will give 1200 lbs. on the drivers for every ton in the weight of the car. This would give, with 20 per cent adhesion, which is safe for the conditions, an available tractive effort of 240 lbs. per ton to provide for acceleration. Taking a car up a grade as severe as 8 per cent would require 180 lbs., leaving 60 lbs. for acceleration. Coming to winter service with its attendant ice and slush, we are likely to reach a point where instead of 1200 lbs. on the drivers we have only 600 lbs. and 10 per cent adhesion instead of 20 per cent, and it is under such conditions that the two-motor equipment falls down.

Bearing in mind these two extremes, it is important that we should not be carried away by the trend or fads of the time. It was his observation that engineers were not entirely free from the weakness of following the fashion. With ordinary conditions of summer service—no snow, greasy rails from mist or severe grades—there are few places where a two-motor equipment will not give all the traction which can possibly be used. We should draw our conclusions after studying the limiting conditions of the locality.

ON TRACK BONDING*

BY C. W. RICKER

In the earliest days of electric railway work with crude apparatus and light loads, track resistance was neglected. As the need became evident, auxiliary return wires were run and connected to the rails at frequent intervals, but of a size which now seems absurdly small. Joint bonds were first of small iron wire like railroad signal system bonds, then pieces of copper wire with the ends riveted in holes in the rail-web, then pieces of trolley wire with channel pins and so on, until specially designed terminals were developed.

About eight or ten years ago the real usefulness of high track conductance began to be understood. The work of F. H. Farnham regarding the electrolysis of buried metals called attention strongly to the return circuit losses in what was then a well equipped electric railway system. Since then the progress has been along the general direction of utilizing the track metal to best advantage for the return circuit, and except in the case of rather complex city networks and single lines fed from a power plant unfavorably situated, this course has proved more economical than the installation of copper return cables. In the special case of elevated railways using steel structures, the metal of the latter has been used to excellent advantage, though this presents some peculiar problems in bonding and a serious risk of electrolysis of anchor bolts.

With the prospective use of alternating currents and the six to sevenfold increase of apparent track resistance, an increased use of copper may become necessary; but with all direct-current operation the engineering problem is to use the rails to best advantage, and this is largely a matter of the selection and installation of track bonds

The first condition to determine the character of the bonding is the rail-joint, which in turn is determined by the roadbed. Track joints are of two general types, rigid and flexible. The first is applicable only to track laid on continuous rock or concrete foundation, with the rails buried in hard pavement, and includes electrically-welded, cast-welded and riveted joints. Electrically-welded joints require no secondary electrical connection, but their availability is limited and they have not attained great use. Cast-welded joints are widely used in large cities, and unless the current density is high need no additional bonding. Riveted joints, used somewhat abroad, are similar to cast-welded. The majority of all track, including all not buried in pavement, must have flexible joints of either bolted or wedge types, and the electrical conductivity must depend upon bonds installed for that sole purpose, that of the rail-joint itself being slight.

Conditions Governing Material, Form and Structure of

* Abstract of paper presented at a meeting of the American Institute of Electrical Engineers, New York, Feb. 24, 1905.

Bonds.—To get the necessary conductivity, bonds are nearly always of copper, about the only exception being those of tin amalgam. To reduce cost and resistance, they must be as short as practicable, and the manufacturing cost must be kept low, to preserve the scrap value as near the first cost as possible. For durability they must be flexible enough so as not to break or lose contact by the allowable relative motion of the rails. They must be formed so they may be applied to the types of rails in ordinary use, in such position as to be protected from accidental damage and from theft. They should be readily accessible for inspection and repair. The cost of application must be kept low, and to this end it is very important that the process shall be so simple and easy that no highly skilled labor or extraordinary care is required to install them with certain and uniform results. The bond that satisfies all these conditions has not yet been devised.

The ordinary process of selection has developed a form of bond made of annealed copper and consisting of a flexible stranded or laminated shank about 8 ins. to 12 ins. long, welded to solid terminals of considerable mass, which are attached to the rail-web under the joint plates, or less frequently under the base of the rail. Accessibility for inspection and repair, however, is almost wholly sacrificed, and the importance of good work in manufacture and application is thereby greatly increased.

Pure copper is a very plastic material of low strength and elastic limit, and under moderate pressures behaves almost like a liquid. The surface oxidizes slowly at ordinary atmospheric temperatures, but very readily at high temperatures, and so it is very difficult to weld. The result is that the union between the shank and terminals of a composite bond is always subject to suspicion, and not the less so that the outside of the same and all the welds that show at or near the surface may be very nice and neat to look at and the resistance moderate, as the unwelded interior contacts are still bright when the bond is new. Under the smooth exterior may be defective welds that will corrode, and weakened strands that will soon be broken by the motion of the rails, either of which will materially diminish the utility of the bond.

It is a common practice to saw partly through a terminal and split the copper with a wedge. In some cases this will open up defective welds, in other cases the soft metal will tear close to a bad joint without showing the same. The writer has seen some bonds of excellent appearance that when compressed much harder than in ordinary practice developed open cracks in the upper parts of the terminals. Perhaps the most satisfactory inspection of the workmanship is made by sectioning the terminals in various planes, polishing the cut surfaces with a smooth file, emery and crocus, to remove all burrs, and then etching with a mixture of strong sulphuric and nitric acids, when the defective welds will show as fine black lines, and the actual welds and the form of the various component parts of the bond at that surface can be traced by the different colors of the metal after etching.

With a good process carefully followed out, bonds of good and uniform quality can be produced, but the material is delicate and a little carelessness may spoil many bonds. Considering the cost of copper bonds and the importance of their function, it would seem worth while to have their material and manufacture inspected in the shop, in much the same manner as is done with structural steel and machinery, by the engineering inspection bureaus. The writer has not heard of any great amount of inspection of electrical apparatus by these bureaus, but the quality of their work in other directions would suggest their probable usefulness in this one.

Area of Contact.—Discussion of the ratio of contact area to cross section of bond has not lead to the adoption of any standard. Practice seems to be to get as large contact area as convenient and make the best of that. The ratio increased as the size of bonds increased, till with No. 0000 short bonds with 0.875-in. cylindrical terminals it became about 9.33, while with 500,000-circ. mil bonds of later design it is only 4.5. The smaller ratio seems ample to secure a negligible contact resistance, if the contact is only close enough. Unfortunately, the full possible contact area is seldom realized, because of rough or dirty surfaces and insufficient compression or soldering.

Failure of Bonds in Service.—The failure of a bond is that condition in which the resistance of the joint made by the same is seriously increased, which may occur without interruption of the continuity of the bond itself. The general cases are: 1. Breakage of bonds; 2. Disintegration of the bonds; 3. Impairment of contacts.

Breakage of Bonds.—Breakage may occur because of defects in manufacture, as in copper bonds with welded terminals, the strands may be weakened by overheating where they enter the terminals, and a slight but continuous motion of the joint will cause them to break, one by one, at this place. Long continued jar and repeated flexures will produce fatigue in the metal (what has been called the Bauschinger effect in steel). Such breakage in the case of either welded or solid bonds is, of course, most frequent where the flexure of the bond due to rail movements is too great for its flexibility, which means ill-selected bonds or badly-kept track.

A less common manner of breakage occurs in laminated under-plate bonds which are too large for the space between the joint-plate and the rail, the bond shank is pinched and the working of the joint under passing wheels tears off the outer strands by a kind of ratchet effect, working them into the narrowing space at top or bottom of the rail-web, and sometimes squeezing them out of the joint in thin ribbons. Bonds secured under the base of the rail may be frozen in the ballast and torn off by the movement of the rail.

Disintegration.—The surfaces at the imperfect welds in composite bonds corrode, increasing the resistance greatly and loosening and weakening the bonds so that they may be pulled apart.

Tin amalgam used at contacts or in masses, hardens and shrinks, losing flexibility and contact with the bonded surfaces. In the case of amalgam plugs enclosed in cork boxes, the cork sometimes breaks, allowing the soft amalgam to run out.

Impairment of Contact.—By far the most important cause of impaired contact is oxidation. This is greatly facilitated by the presence of moisture, so that the slightest crevice into which moisture may penetrate and lodge is dangerous. Soft-soldered contacts underground are not to be trusted, especially on track laid in streets, which is sure to be wet with dirty water, though there is no apparent reason why soldered contact entirely above ground should not be durable, if all traces of corrosive flux are removed. Brazed joints seem to give no trouble. Amalgamated steel surfaces are not durable and soon rust in track exposed to dampness. Expanded or compressed terminal bonds, which have not been properly applied, may be loosened by the movement of the rail, and well soldered bonds may be loosened or torn off by the same means if they are too rigid. No mention has been made of accidental breakage of bonds. Of course, bonds which are improperly located may be knocked off by rolling stock and various local external conditions may operate to destroy any kind of bonds.

Importance of Good Contacts.—The rapid deterioration and general unreliability of track bonding has been a favorite subject of complaint. Impairment of contacts and breakage are the most common grievances, and while the latter is easily traced to improper selection or ill-kept track, the former is no less due to poor work in applying the bonds, which too often is left to cheap workmen; with poor supervision, and as the work is usually covered up as soon as done and is seldom tested at all, it gets no more attention till trouble develops. The writer knows of one case in which the suprintendent of a rather notable electric railway made public a letter praising the performance of a certain kind of bond used on his road, and in less than three months careful tests showed the condition of the bonding to be so poor that it had to be completely renewed.

The importance of clean and tight contact between bond and rail cannot be insisted upon too strongly, both for immediate effect upon track conductivity and for its still greater effect upon deterioration, yet the importance of this is not generally enough understood. The apparatus most commonly used for applying bonds throws light upon this. In two recent jobs using compressed terminal bonds, the screw presses for applying which were got from large and highly reputable makers and were selected for the bonds used, the writer was able to get reasonably good contact only by overworking the presses to such an extent that two presses were always being repaired for each one on the work. A press would seldom do 200 terminals without breaking down. The makers of the presses said merely that the presses were used too hard.

The resistance at the terminal of a bond depends upon the area and intimacy of the actual contact; with good bonds of ordinary design this may be made negligible if proper care is taken. If contact by pressure is to be used, both copper and steel surfaces must be smooth, clean and dry; if soldered, they must be clean, well tinned and free from corrosion flux when the operation is finished. As large a proportion as possible of the surfaces must be brought into contact and kept there.

The writer has inspected many compressed terminals, some applied with ordinary care, some with greater care, and usually a considerable part of the copper surface, sometimes more than one-half, shows plainly that it has never touched the steel. In a short time that part of the contact surface becomes oxidized and is of little further use. A film of oil, such as is left in holes in which oil is used to lubricate the drills, decreases the conductivity seriously and increases the deterioration. Such holes show in time a black deposit from the decomposed oil, and ultimately rust. Rough surfaces require greater pressure to get good contact and allow more crevices into which moisture may penetrate with resulting corrosion. In the case of soldered bonds complete contact between the terminal surface and the rail is seldom obtained, no matter how carefully the work is done.

The heat capacity of the rail is so great that it is difficult to get any considerable part of it to soldering temperature by external heat application, without excessive expense and possibly damage to the rail, so the edges of the terminal surface are usually well soldered and the middle portion but imperfectly.

Large flat surfaces held in contact by bolts have been tried, though they have never attained great vogue. The cost and bulk of any arrangement of bolts and plates which could maintain intimacy of contact similar to that of an ordinary compressed terminal, together with the cost of finishing and fitting the flat surfaces, would be prohibitive. In some cases such bonds have been used in joints where there is supposed to be enough motion to keep the surfaces rubbed bright, but here there would seem to be little advantage in using copper, as the joint-plates fill the same office. The following data illustrating the foregoing may be of interest:

A track laid with 87-lb., 60-ft. girder rails on concrete base in unusually substantial manner, with joints driven tight and made as rigid as possible, was bonded with two 0000 bonds with 0.875-in. terminals expanded with a steel drift left in the hole. On account of the rigidity of the joints the bonds were very short, of horseshoe type, 4 ins. and 2.5 ins. between terminals. Bond holes were punched at the mill and reamed bright with taper reamers just before applying the bonds, which were set with the shank at the small ends of the taper holes. Measurements of fifteen joints by comparison of fall of pressure through the joint with that in 10 ft. of rail made with a millivoltmeter, showed the mean joint resistance equal to that of 1 ft. of rail. The same joint measured in the same manner with the same instruments one year later showed no perceptible increase in resistance.

A double-track railway laid with 60-lb. T-rails, rock ballasted and maintained unusually well for an electric railway, was bonded with masses of tin amalgam enclosed in washers of treated cork, pinched between the rail-web and joint-plates. After the road had been in operation about four and a half years and parts of it one and two years less, measurements were made upon joints in the various sections by the same method as the preceding test.

Number of Joints.	Years in Service.	Mean Resistance of Joints		Res. too High to Read (Over 500 Ft. of Rail)
		No. Measured	Equiv. Ft. of Rail	
13	4.5	8	15.7	5
6	3.5	5	12.4	1
18	2.5	17	8.4	1

About forty joints of various ages were opened for inspection, and in none of them were the amalgamated surfaces unimpaired, while the older joints were nearly or completely rusted over. The amalgam masses were (with one exception) either dry and crumbly or hard and brittle. The cork washers were generally intact, though a few were broken.

In a single-track interurban electric railway laid with 70-lb. T-rails on private right of way, the joints were each bonded with one 0000 copper bond 10 ins. long with 0.875-in. welded terminals. In the earlier part of the work, the bond holes were drilled with oil lubrication and the bond terminals were upset with a screw compressor by one man using a wrench about 36 ins. long. To estimate the improvement possible, the resistance of 633 ft. of one rail containing twenty joints was determined in the condition described, then the bond terminals were thoroughly compressed with a similar compressor using a wrench about 66 ins. long, with a heavy man on the end applying the pressure slowly and steadily. Then a similar section of one rail 425 ft. long, containing fourteen joints, was drilled with soda-water lubrication, the holes carefully wiped and the bonds compressed thoroughly as above. The sections of rail when measured were disconnected at both ends and the ballast scraped clear. The readings were taken at night in dry weather and very nearly uniform temperature. Pressure readings were taken with a low reading voltmeter. Only switchboard ammeters were available for current measurements, but they were new, and three were connected in series and the mean readings used. They checked very closely and were reliable enough for comparative measurements.

	Ohms per Ft. Rail	% Increase R
Drilling with water, bonds well compressed,	1.29×10^{-5}	0
" " oil, " " "	1.47×10^{-5}	14
" " " " poorly "	1.96×10^{-5}	33

Cost of Applying Bonds.—Two cases are presented in detail, as it is proposed to try to derive from them some conclusions regarding the most economical expenditure for bonding in two typical roads.

On a single-track interurban railway quoted herein, it was necessary to organize a bonding gang of entirely green men, none of whom had ever seen a bond before. It contained twelve men at $1.75 per day and a foreman at $3, total of $25 per day. The work consisted in unplating the joints which were half bolted up, drilling two 0.875-in. holes in the rail-web, compressing one bond per joint, and replating and bolting up the joints in permanent shape with four bolts each. The equipment consisted of three portable rotary track drills, three screw compressors, about sixty 0.875-in. twist drills and the necessary track tools, costing altogether about $350, in which the salvage was about $150. The capacity was 100 bonds per day, making a labor cost of 25 cents per bond. Grinding drills cost about $1 per day, and repairs to compressors about $1.50, making total cost 27.5 cents per bond, of which 5 cents was chargeable to plating and 22.5 cents to bonding. The work was continually interrupted by construction trains, and the temperature was so high that several men were overcome by heat. With clear track and decent temperature the daily output could be increased 20 per cent at the same total cost.

On a larger installation in somewhat more favorable conditions, the bonding gang consisted of ten or eleven men and a foreman, with a total pay-roll of $23 to $25 per day. The drilling apparatus consisted of a gang drill driven by an electric motor which made two 0.875-in. holes at once, piercing the rail-web in one minute and drilling an average of thirty joints per hour when smartly handled. The position of the drills was determined by a jig, so that no time was lost in adjustment. The machine used an average of 2000 watts when drilling, derived from the trolley wire used by the construction trains. It weighed about 1500 lbs. and had to be removed from the track by the bonding gang about four times per day to allow construction trains to pass. The capacity of this gang was 200 bonds daily, making the labor cost about 12 cents each, of which 3 cents was chargeable to plating and 9 cents to bonding. The machine contained a drill grinder, so there was no additional expense for sharpening drills. The equipment included six screw compressors of the best type obtainable, but they were too light, and three or four were always crippled, adding 1 cent to 2 cents for repairs to the cost per bond. The drilling machine was built especially for this job and required considerable changes after work was begun, so the cost of tools was rather large, about $2,000, on which the salvage was probably $1,000.

Economical Bonding.—It is at once evident that the proportion of the resistance of the rail circuit due to the bonds is small; in the first case cited, using 60-ft. rails, it is a little less than 2 per cent; in the third case it is about 13 per cent, and as the resistance of the rail circuit is usually not over 25 per cent of the whole resistance, the saving by a considerable increase in bonding is relatively small.

In order to reach some general conclusions regarding the economical expenditure for bonding in cases similar to the two described, by means of Kelvin's law, it is necessary, in order to make the law apply, to make certain assumptions, which are not strictly true, but which, if carefully adjusted to the case taen up, may be near enough for the purpose.

The following data of equipment may be taken as typical of the interurban electric railways of moderate size and capacity built extensively in the Middle Western States. The 0000 copper bond, 12 ins. long, with solid 0.875-in. terminals, is selected as a unit, because it is a convenient market size and well adapted for use with the rails assumed:

Single track	two 75-lb. T-rails
Cost of power in line	0.02 cents per kw-hour
Mean current in track	200 amps.
1 joint bond (based on No. 0000 × 12-in. bond at 40 cents)	0.19 cents per 1000 circ. mil
Applying same (based on 20 cents per bond)	0.094 cent per 1000 circ. mil
Scrap value of bond	0.056 cent per 1000 circ. mil
Net cost of bond	0.23 cents per 1000 circ. mil
Useful life of bond	10 years
Annual cost of bond at 15 per cent.	0.034 cent per 1000 circ. mil
Resistance of bond (12-in. 0000 copper + 8 per cent for contacts)	0.0116 ohms per 1000 circ. mil
Annual (7300 hours) loss in one bond.	847 kw-hour per 1000 circ. mil
Cost of same at 2 cents	$16.94 per 1000 circ. mil

$$\frac{0.00034 \text{ circ. mil}}{1000} = \frac{16.94 \times 1000}{\text{circ. mil}}$$

$$\text{circ. mils} = 223000$$

The equipment described would correspond to that of a road operated by rotary converter sub-stations having an average traffic of two 40-ft. cars per section. Such a road would usually have one 0000 bond per track joint, which would seem to be a little too small.

For a road of somewhat heavier construction and traffic, and operated at high speed, the following data may be assumed; items which are the same as in preceding case are not repeated:

Double track	four 80-lb. T-rails
Mean current in track	800 amps.
1 joint bond	0.19 c. per circ. mil
Applying same (based on 12 cents per bond)	0.057 cent per 1000 circ. mil
Scrap value of bond	0.056 cent per 1000 circ. mil
Net cost of bond	0.203 cent per 1000 circ. mil
Annual cost of bond at 15 per cent.	0.0304 cent per 1000 circ. mil
Annual (7300 hours) loss in bond	3.387 kw-hour per 1000 circ. mil
Cost of same at 2 cents	$67.76

$$\frac{.000304}{1000} = \frac{67.76 \times 1000}{\text{circ. mil}}$$

$$\text{circ. mil} = 472000$$

This case is fairly comparable with the Aurora, Elgin & Chicago Railway, which is bonded with two 250,000-circ. mil bonds per joint.

If this method indicates a cross section of bonding varying greatly from a multiple of the typical bond selected, a second approximation will be necessary, as the cost of bonding will not vary with the cross section unless the unit size is practically adhered to. In a more precise solution the square root of the mean square of the current should be used instead of the mean current. It would be interesting to compare the results obtained by this method, carefully carried out, with those obtained by the summation of annual cost and annual loss curves covering all the elements of the conducting circuit in the above typical cases, but the brief time at the writer's command does not permit.

The cost of applying bonds stated by the writer may be criticised as unduly low, and is intentionally very close, but in work of great enough size to permit of a good organization, such costs are practicable for compressed or expanded terminal bonds. Of course, delay by interference of other work will increase the cost. The use of reliable hydraulic compressors might reduce the figures a little, but the amount would not be great, as the copper must be compressed rather slowly, and the hydraulic machines are heavier and more difficult to handle; so the net saving of labor cost is probably small, though the quality of work is probably improved by their use.

The expression for the economical cross section of bonding may be stated conveniently:

$$\text{C M} = 1000 \sqrt{\frac{\text{annual loss}}{\text{annual cost}}}$$

or the economical cross section varies inversely as the square root of the annual cost. In the first case considered, the net cost per 1000-circ. mil of bond was 0.33 cents, of which 0.09 cents was for application, about .4 of the whole (based on cost of application of 20 cents per bond). It is evident that any considerable increase in the cost per 1000 circ. mil of applying bonds will decrease the economic section of the same rapidly, and much more so than a proportionate increase in the price of the bond.

In this case, increasing the cost of application 50 per cent would decrease the economical cross section 10.4 per cent, and doubling the cost of application would decrease the economical cross section 19 per cent. This is worthy of attention in view of the increased cost of application of various soldered bonds for which lower contact resistance is claimed. Unless a considerably greater saving is made than the 8 per cent herein allowed for contact resistance of compressed terminal bonds, which seems also to accord with the results of tests by Mr. Burton, of J. G. White & Company, the greater cost of soldering to the rails would seem a rather doubtful investment.

DISCUSSION ON BONDS

Mr. Lardner opened the discussion by congratulating Mr. Ricker on the thoroughness of his paper, stating that his only regret was that after Mr. Ricker had stated so well the qualities of the ideal bond he had not presented one which filled the requirements. The difficulties were certainly very great, and they seemed so largely due to the difficulty in obtaining good contact between the bond terminal and the rail that he believed some radically different method of bonding will have to be devised. The proper welding of the bonding strip to the terminal can be worked out, and he believed that it could be done with proper inspection. The attainment of good contact depends largely on the individual applying the bond. It is practically essential that all rails be drilled or reamed, and it is a question whether or not the bond terminals themselves should not be actually machined so as to give a much more accurate fit and require less expanding than is possible with the bonds now on the market. If this fit is not very close, the bond must be expanded to such an extent that the copper in some instances may become as hard as the rail itself. He believed that, especially with the heavier traction we are approaching, the plugged or expanded bond must be replaced by some form that will insure better contact. This is especially true in the case of heavy traction where the bonds must be installed under the plates of an existing track. The placing of bonds under these conditions becomes very serious, owing to the lack of time for properly drilling or reaming holes in the rails and installing the bonds with all the care and attention necessary. It is also a matter of great expense where nut locks or special bolts are used for keeping the joint tight, practically meaning the throwing away of the old bolts and providing new ones. Unless some radical change is introduced, he believed that it would be essential to utilize the splice bars themselves in some way with connections to the rail which can be made outside and without the removal of the bolts or splice bars.

Mr. Knudson, the next speaker, gave some instances of electrolysis caused by poor bonding.

Mr. Pestell, following Mr. Knudson, spoke of the use of the expanded or compressed terminal bond under different conditions. Deterioration is much more rapid where a track is exposed to moisture or where streets are paved than where the bonds are on private right of way and not subject to moisture.

Calvert Townley, when called upon, said that one point had not been considered in Mr. Ricker's paper, namely, the effect of an increased bond on the reduction of electrolysis. He had the feeling that the electrical engineer of the future, and his client, the street railway company, will have to make a considerable change on the question of electrolysis, so that in calculating the value of a bond, account should be taken of the electrolytic action, which, of course, makes it difficult to present the problem in mathematical shape, depending so largely on the number of water pipes, etc., along the line.

R. D. Mershon asked Mr. Ricker as to data bearing on the contact resistance itself in relation to the bond.

Mr. Ricker, who closed the proceedings, said in reply to Mr. Mershon's question, that in some cases where he had tried to compute the probable contact resistance of compressed or terminal bonds by measuring the actual resistance of the length of track and subtracting from that the resistance of the rail and the length of the copper between the centers of terminals, the resistance per contact averaged in a considerable number of contacts, in the case of 0000 bonds with 7/8-in. terminals (with the contacts in good condition), about 1/2 in. of the copper shank of the bond.

The Indianapolis & Eastern Interurban Company has been selected by the United States postal authorities as the line on which trial postal cars will be placed this season. The new service will begin soon after March 4.

LOS ANGELES-PACIFIC RAILWAY

Owing to the greatly increased traffic on the interurban railway system of the Los Angeles-Pacific Railway Company, the officers of that company have decided to increase the capacity of their central power house at Vineyard and to install an additional sub-station in Los Angeles. The new electrical equipment has recently been contracted for with the Crocker-Wheeler Company through its Pacific Coast managers, the Abner Doble Company, of San Francisco. The contract comprises one 1200-kw, three-phase, 50-cycle, 2300-volt, engine-type generator with a speed of 125 r. p. m.; one 300-kw motor-generator set; one 400-kw motor-generator set; three 400-kw transformers; three 160-kw transformers; three 120-kw transformers, and a 60-kw engine-type exciter. The 1200-kw alternator will be of the Crocker-Wheeler Company's new revolving field type, similar in construction to the three 4000-kw alternators recently ordered by the California Gas & Electric Corporation. The Los Angeles generator will be driven by a 2000-hp compound-condensing McIntosh & Seymour engine. The motor-generator sets will consist of 2300-volt synchronous motors driving 600-volt direct-current railway generators. The transformers will be built for 15,000 volts on the primary and 2300 volts on the secondary, and will be of the water-cooled, oil-insulated type.

The interurban railway system of the Los Angeles-Pacific Railway Company is one of the most extensive in the country, embracing as it does nearly 200 miles of up-to-date lines. The company owes its growth largely to the energetic and untiring work of the president and manager, E. P. Clark, who was one of the pioneer railway men of Southern California, and who has seen his system develop from a very small beginning to its present commanding position in the traction field. The system extends from Los Angeles in a fan shape to Santa Monica, Ocean Park, Playa del Rey, Hermosa, Manhattan Beach and Redondo on the ocean, and passes through the intermediate towns of Hollywood, Colegrove, Sawtelle, Sherman and Palms. In other words, the lines cover thoroughly the territory lying south of the Santa Monica Mountains and between Los Angeles and the ocean. Most of the lines have been double-tracked and are constructed in conformity with the best steam railroad practice. About a year ago a new central steam plant was installed at Vineyard, about 5 miles west of Los Angeles, and from this station transmission lines at 15,000 volts carry the power to several sub-stations located at intervals over the system. It is to increase the capacity of this central station and to supply additional power for the operation of the lines in Los Angeles that make necessary the additional machinery named.

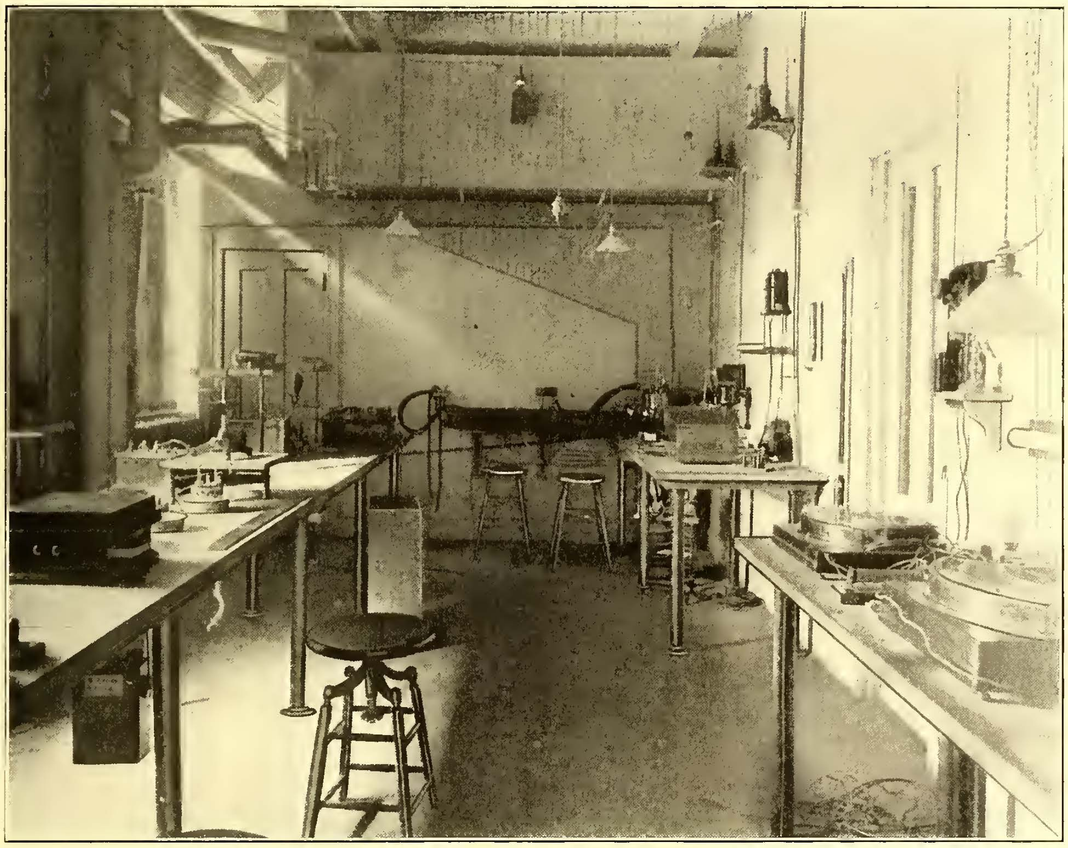
HANDLING CAR ADVERTISING IN CAMDEN

The South Jersey Division of the Public Service Corporation and its predecessor, the Camden & Suburban Railway Company, have differed from most companies in handling their own car advertising. As most of the advertisers are local mercantile houses, it seems quite as easy and even more efficacious to approach them through local agents than through an outside house. In Camden, the advertising solicitor for the display cards works on a commission and, with the assistance of one boy, attends to all the work of placing the cards in the cars, changing them, etc. The solicitor reports directly to the general manager and hands him a statement each day of the cars in service and of the number of spaces available, their rate and the total amount received, and the same figures for the spaces to rent, with totals and grand totals for each class of space sold on the cars. There are five such spaces, viz.: Main compartments, smoking compartments, end frames, end roof signs and side roof signs. The advertisers supply their own cards, and the net receipts to the railway company have averaged for some time $55 annually per car.

AN IMPORTANT ACQUISITION TO THE ELECTRICAL INDUSTRY—THE ELECTRICAL TESTING LABORATORIES

The history of every phase of the electrical industry, and particularly that of the electric railway field, is one of constant and comparatively rapid improvement. Apparatus has been constructed and tested in the laboratory and work shop, or in actual service. Its weaknesses have been discovered and crudity in manufacture has given place to refinement. But the rapidity with which improvements have taken place has depended very largely upon the testing which has been done. Before remedies could be applied weaknesses had to be discovered; this could be done only through tests. After weaknesses were found, the remedies which were applied may have been insufficient or they may have been entirely effectual; the results could be known only through tests.

In the past, improvements in electrical apparatus have been due very largely to the efforts of large manufacturers, who could afford to maintain expensive testing laboratories for carrying out investigations and testing models of new and improved apparatus. The small manufacturer has been greatly handicapped, having to rely largely upon tests which were made while his apparatus was in actual service. Small purchasers of electrical apparatus and supplies have suffered in a similar manner because of the lack of testing facilities; such purchasers have been obliged to rely entirely upon manufacturers' statements, until by actual experience they could come to some conclusion concerning the merits of the supplies purchased. Some few far-sighted large purchasers have, on the other hand, established testing laboratories and have purchased all their supplies subject to strict tests. In this manner they have secured the cream of the product of the various manufacturers, and the small purchasers have been obliged to take what the manufacturer offered them, which might represent his first-class product, or might represent material which had been discarded by a larger purchaser having testing facilities, as the case might be.



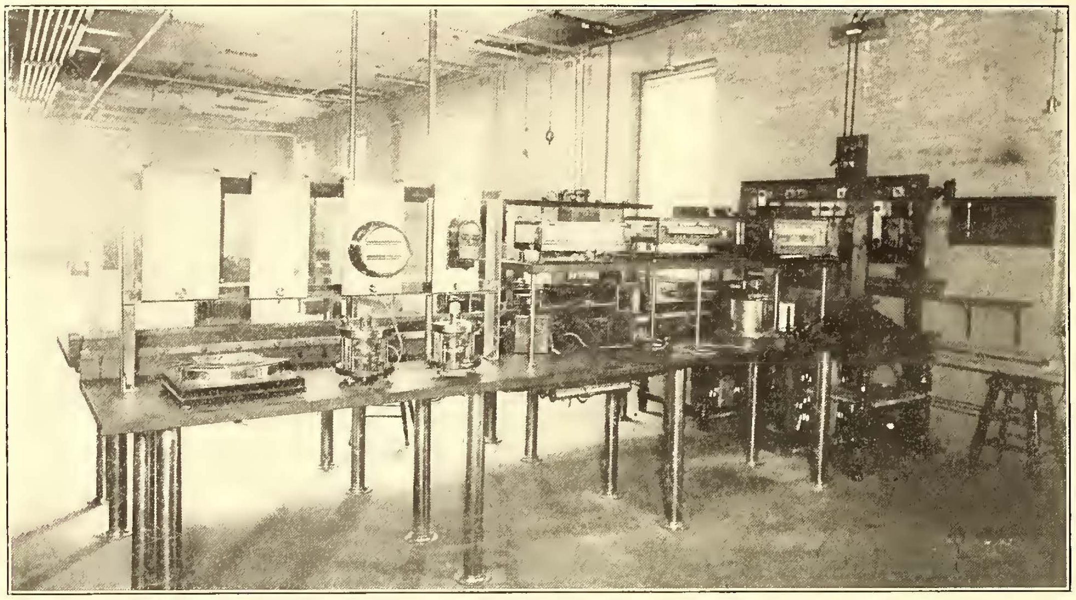
THE STANDARDIZING LABORATORY WHERE HIGH PRECISION TESTS OF RESISTANCE, CONDUCTIVITY, ETC., ARE CARRIED OUT

As a remedy for the evils which underlie these conditions, the establishment of commercial testing laboratories, under the name of the Electrical Testing Laboratories, comes as a boon to all, manufacturers and purchasers alike. In these laboratories electrical tests of any description can be made for anyone. To purchasers they afford a means of protection against unscrupulous manufacturers, of whom there are always a number ready to work off inferior goods. Purchasers, both large and small, can now have the products of various competing manufacturers tested at a moderate cost, and can thereby insure the securing of the best apparatus and supplies which the market affords, and furthermore, after having placed a contract, as the result of careful consideration of the results of accurate and impartial tests, may provide against deterioration in manufacture, and may be assured concerning the quality of the material delivered under the contract, by purchasing under intelligently drawn specifications subject to periodical tests. That such assurance is well worth the proportionally small expenditure involved cannot be doubted.

The Electrical Testing Laboratories are an outgrowth of the Lamp Testing Bureau, which formerly maintained a laboratory at 14 Jay Street, New York, for the commercial testing of incandescent lamps. With the rapid development of the electrical industry, however, the scope of its work continually increased, and it soon became necessary to enlarge its equipment and provide apparatus for every conceivable kind of electrical test. It also became necessary to have a corporate name more in keeping with the work done by the company and a building large enough to house the apparatus, leave room for expansion and provide comfortable quarters. Accordingly, the name of the company was changed to the Electrical Testing Laboratories, and large quarters were obtained at Eightieth Street and East End Avenue, New York City, where the work is now carried on.

The building occupied, fortunately, combines fireproof construction with the strength and solidity so advantageous in this class of work, as it was built primarily as a power plant for one of the early lighting companies in New York. Its location is also very favorable in being well removed from the external disturbing influences of electric cars, heavy street traffic or adjacent heavy machinery. The main portion of the building is 50 ft. x 120 ft., three stories high, while the rear addition, two stories in height, is 30 ft. x 120 ft. in size. The top floor of the three-story section is devoted to office and general electrical testing work, the second floor of both sections to the incandescent-lamp life-test racks and general photometry of all kinds of lamps, and the lower floors to the generating and transforming apparatus and storage-battery equipment for the current supplies. The primary electrical supply is secured from the New York Edison Company, current being delivered through direct cables; this obviates the disturbing factor of a local generating plant.

In the arrangement and equipment of the laboratories, the purpose for which they are intended was kept strictly in view. The work for which they are designed primarily is commercial testing, not research in pure science. The requirements of commercial testing demand that such work shall be carried out with promptness, at low cost and with a degree of accuracy sufficient to meet the needs of each special case. Having in view the minimizing of the labor cost of testing, the plan has been followed of laying out all the frequently recurring tests in advance. All requisite apparatus for such tests is put permanently in position and all electrical connections made, so that it is necessary only to connect the material or instrument to be tested into the circuit, close a switch or two and proceed to make measurements. In cases were tests are required less frequently, so that it is not found possible to set apart all the necessary apparatus for their exclusive use, a place has been assigned to the tests and the electrical connections have been made, so that but little preliminary work remains to be done.



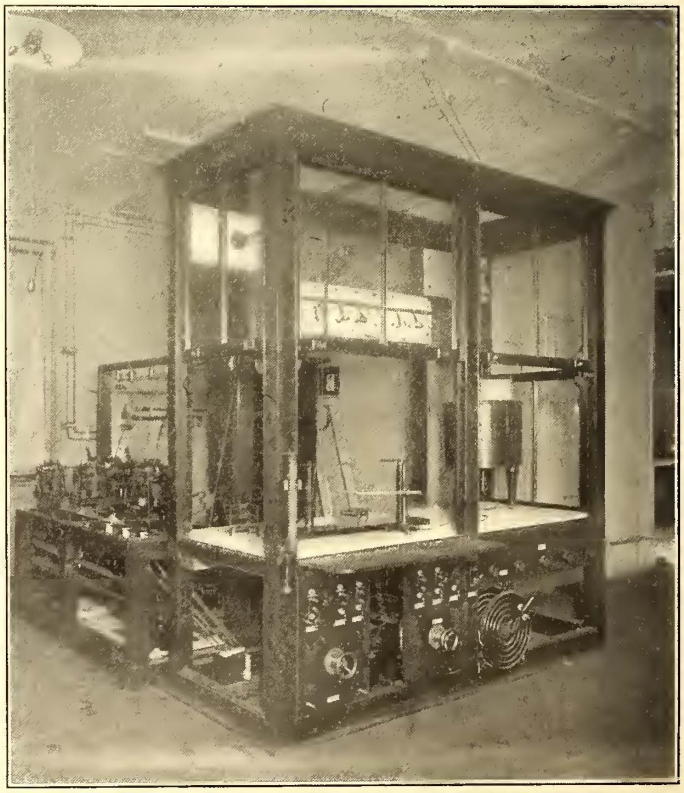
THE AMMETER AND WATTMETER TESTING TABLE IN THE ELECTRICAL TESTING LABORATORIES

Most of the work of delicate electric testing is carried out in the elaborately equipped laboratories upon the third floor of the building. In one of the rooms upon this floor, known as the "standardizing laboratory," which is illustrated in the engraving on page 447, work of high precision is provided for, including frequent intercomparisons of standards and the checking of instruments used as working standards. This room is equipped with special refrigerating apparatus for reducing the relative humidity of the air within it, which greatly facilitates the delicate testing work, by preventing the inevitable formation of imperceptible conducting films of moisture upon all portions of the apparatus.

The purpose of the standardizing laboratory is chiefly for the measuring of resistance and electromotive force, the electrical equipment provided embracing the best and most accurate standards known to electrical science. Here also the conductivity of samples of wire, bonds, etc., may be tested in a specially designed apparatus by which the greatest accuracy is obtainable. The latter measuring apparatus is arranged to be emersed in an oil bath when in operation, the oil for which can be warmed or cooled as desired, so that the temperature of the wire may be brought to any desired point and maintained during the measurements; the results are obtained in terms of percentage conductivity. Measurements of the resistance of insulating materials of cables, etc., are made here by the usual galvanometer method. For special cases where the usual high-resistance d'Arsonval galvanometer is not adaptable, a high-resistance duBois armored galvanometer is used, which cuts out the effects of outside magnetic disturbances to the greatest possible degree.

Another important feature of the laboratory equipment is the special arrangement of testing tables, as illustrated in an engraving below, for the checking up of ammeters and wattmeters. The current supply is derived from special large cells of storage battery which can be connected in any combination, and are capable of delivering 5000 amps. By this equipment, stationary as well as portable ammeters may be tested by comparison with the most delicate apparatus. This facility will be of importance to power plant operators, as by this equipment all classes of commercial electrical measuring instruments may be tested and recalibrated with the least possible delay.

Another interesting equipment is that for the high-tension tests. An equipment consisting of a 10-kw transformer and five direct-current dynamos is provided, by which voltages up to 10,000 volts direct current and 120,000 volts alternating current may be delivered for testing purposes, the actual application of which in testing is made in a closed glass cabinet provided for this work, as illustrated in the engraving above. An important feature of this equipment is the arrangement for measuring the high-tension current directly; the ordinary practice in such testing is to determine the high secondary voltage from



THE HIGH-VOLTAGE TESTING CABINET, WITH ITS EQUIPMENT OF GENERATORS, TRANSFORMERS, CONTROL AND MEASURING APPARATUS the primary voltage, which may be a source of considerable error. Here a Kelvin electrostatic voltmeter is used, which measures the high tension directly. A spark gap is also provided when it is desired to use that method of high-tension measurement. This latter point illustrates the predominating feature of the equipment of the laboratories, in that apparatus is provided for all possible variations of electrical testing so that all known methods may be utilized for the accurate determination of measurements.

Among some of the tests which may be made here that will be of interest to those engaged in electric railway work are: Resistance and conductivity tests of samples of wire, bonds, etc.; checks of indicating, recording and integrating instruments over a wide range of frequencies, power factors, volts and amperes; high-potential and break-down tests with alternating current or direct current; tests of fuses and circuit breakers; permeability and hysteresis measurements; measurements of distribution of light and illumination; photometric and life tests upon incandescent lamps, arc lamp carbons and gas mantles.

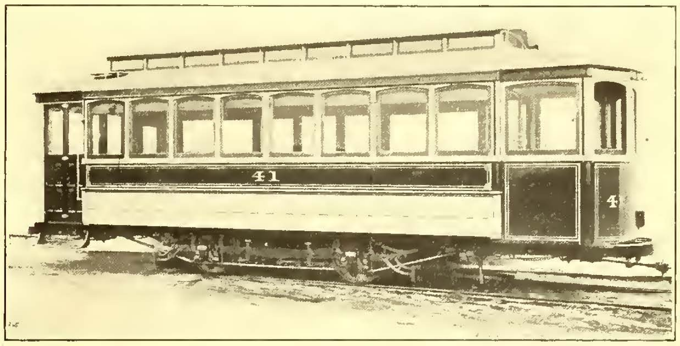
An innovation which will no doubt be of considerable convenience to the electrical public is the setting aside of three rooms as private laboratories, to be leased to responsible and competent persons for conducting private tests and researches. These rooms are equipped with tables, with gas and with wires leading to the distribution switchboard. Having leased one of these rooms an electrical engineer has all the facilities of the laboratories at his disposal. Electric currents of various descriptions and abundant apparatus are at hand for carrying out any such researches as he prefers to conduct personally. Of the nature of the work which he is doing no one but himself need have any knowledge. Researches of this sort are, of course, not necessarily confined to these rooms, but may by special arrangement be made in any available part of the building.

The electrical public is to be congratulated upon the establishment in this country of these testing laboratories devoted to commercial testing work. Community of interest on the part of a number of manufacturers and purchasers of electrical supplies and apparatus has led to a demand which the establishment of this institution has recognized, and has made possible the establishment on a basis of moderate charges. Increase in this demand which is sure to follow will make possible a still further decrease in the charges which it is necessary to make in order to provide for the maintenance of the laboratories.

The effect of such an institution upon the electrical industry in this country cannot be but beneficial. This has been found to be the case in European countries, and may be readily observed in this country in those phases of the electrical industry in which the influence of the Electrical Testing Laboratories has been felt. Continual testing must result in improvement in quality and in the elimination of inferior goods. Every careful test which is made must therefore, either directly or indirectly, result in raising the standard of quality, and the laboratories should receive a hearty welcome and consistent support from the electrical public.

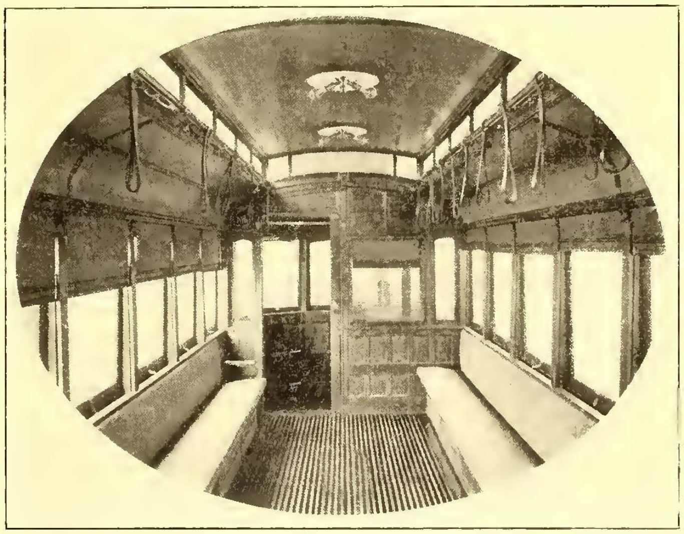
ROLLING STOCK FOR URBANA AND CHAMPAIGN, ILLINOIS

The American Car Company has delivered a number of substantially built and well finished single-truck cars with 22-ft. bodies to the Urbana & Champaign Railway, Gas & Electric Company. The lines at Urbana and Champaign are a part of the extensive system operated by the McKinley Syndicate, extending across the central part of Illinois, and are connected with the high-speed lines operated by the syndicate between Danville, Decatur, Springfield and other principal cities. Though comparatively small (Champaign has a population of 10,000, and Urbana, 6000), they are important railway and commercial centers. The interior illustration shows the seating arrangement and the type of doors used in the ends, known as the Brownell "semi-accelerator." The advantage claimed for this style of door, in connection with entrance from one side of platform, is the great facility with which passengers may enter and leave the car, both as to position—being close to the platform step—and the fact that the arrangement prevents, in a large measure, passengers from standing upon the platforms in such a way as to obstruct the passageway. A large amount of standing space is afforded in these cars and on their platforms, the platforms being 5 ft. long over end panels from vestibule sheathing. The interiors are finished in cherry, and the ceilings are birch, tinted a light green.



SINGLE-TRUCK CAR FOR URBANA & CHAMPAIGN RAILWAY, GAS & ELECTRIC COMPANY

The general dimensions of the cars are as follows: Length over the end panels, 22 ft., and over the vestibules, 32 ft. The width over the sills is 8 ft. 1 in., and over the posts at the belt, 3 ft. 3½ ins. The sweep of the posts is 1¾ ins.; centers of posts, 32½ ins.; size of side and end sills, 4 ins. x 7 ins. The sill plates are 7 ins. x ½ in.; thickness of the side posts, 2¾ ins., and of the corner posts, 3¾ ins. Height of the platform steps from the trucks, 16 ins., and height of the risers, 14 ins. The wheel base of the No. 21-E trucks is 8 ft., and the wheel diameter, 33 ins. One 50-hp motor is used to each truck.

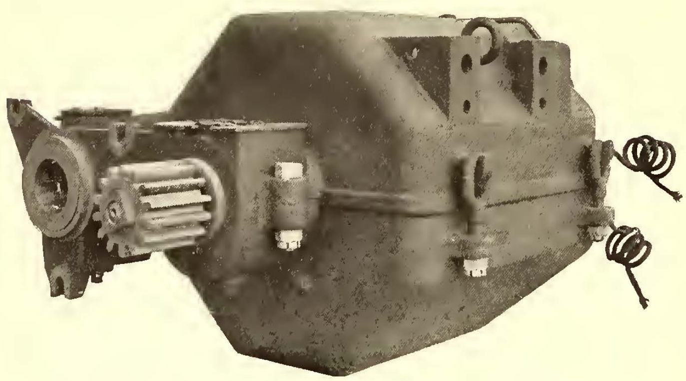


INTERIOR OF CAR, SHOWING SEMI-ACCELERATOR DOOR

The electric tramways at Colombo, India, are to relay their rails. The weight of the present rail is 67 lbs. per yard, and for this it is proposed to substitute one of 95 lbs. per yard. For the curves a special heavy section will be used, weighing 101 lbs. per yard. It is proposed to adopt the Thermit process in welding the rail-joints.

PEEBLES (TYPE S) TRAMWAY MOTOR AND CONTROLLER

The Peebles (type S) tramway motor, manufactured by Bruce Peebles & Company, Limited, Edinburgh, is a good example of the more powerful class of motor used on British tramway systems, being adapted for use either with medium weight cars making fast schedules over hilly routes or for heavy cars on easier systems. It will be seen from the performance curves that on a one hour's rating, tested stationary and totally enclosed, the output of the motor is 35 hp, measured at the car axle, the efficiency with gears at this load being about 85 per cent. Of course, the rating of the tramway motor by horse-power in this manner does not give complete information with regard to its service capacity as the loads are continually fluctuating through such wide limits, but an examination of the curves shows excellent characteristics in the motor. The efficiency, which reaches 85.5 per cent as a maximum, is maintained very high over an unusually long range.



MOTOR COMPLETE, SHOWING OCTAGONAL FRAME

In external form and in the arrangements for suspension, etc., this motor is in conformity with the best modern practice such as has been practically standardized. The frame is of cast dynamo steel of the best quality, of octagonal form divided horizontally, the upper half of the frame carrying the journals both for the motor bearings and the car axle bearings. Large doors both in the upper and lower half provide access to the commutator and brush gear. By loosening one or two bolts the lower half of the field frame may be swung away from the upper half, and the motor is thus completely opened out for inspection over the pits in the car shed. It is, further, a simple matter to remove the lower half field and also the armature in its bearings if required.

Each of the motor bearing journals is provided with two lubricant boxes fitted with spring lids and gaskets, and thus either oil or grease can be used, or both. The motor bearings are of gun metal, each 7½ ins. length x 3¾ ins. in diameter, the maximum diameter of the motor shaft being 4⅛ ins. The axle bearings are babbitted, and are 4 ins. x 7½ ins. in standard motors, but the axle boxes are so arranged that a different size of shaft can readily be taken. The motor bearings are made of gun metal on account of the desirability of avoiding wear in these bearings, so as to prevent any liability of the armature touching the fields. The bearing surface is very long and the lubrication has been skilfully arranged; carefully designed oil-thrower rings on the shaft within the bearings prevent any possibility of oil getting on to the armature of the motor and injuring the insulation.

The leads are as usual brought out independently through insulating bushings from the lower halves of the field, in order to avoid trouble when opening up the motor. The motor has inwardly projecting solid poles fitted with long extended pole-shoes of a form which absolutely prevents sparking, except at the very heaviest overloads. The field coils are of copper, of ample section, carefully wound, taped and varnished, baked several times and insulated from the frame with press-spahn and mica. The weight is kept off the pole tips by the use of substantial cast-iron clamps. It will be noticed that laminated poles are not used. Bruce Peebles & Company have never believed in the lamination of field circuits for continuous-current machines, regarding this practice as a survival from the days when continuous-current armatures were made with a small number of teeth and large slots, and when in consequence the eddy currents caused in a solid pole face were quite considerable. With such armatures, however, as are used with this motor, having a large number of slots, these eddy currents are reduced to a negligible quantity. From a commercial point of view the use of solid poles has the advantage of making a somewhat more liberal design of the other portions of the motor possible, and thus improving the output commutation and efficiency of the motor. The armature has forty-nine slots, and there are 147 segments in the commutator. The commutator is of ample depth and allows about ¾ in. reduction in diameter; owing to the special form of pole pieces which is adopted with the solid poles, the sparking is reduced to a minimum, which greatly prolongs the life of the commutator.

The armature core plates are clamped between end plates of the form usual in traction motors, and the windings are held in place by four bands insulated from the core and windings by mica. Additional bands over the ends of the conductors, both at the commutator and at the other end of the armature, prevents spreading of the coils should the armature attain an undue speed. The armature has further been designed with very small fly-wheel action, thus reducing the amount of energy dissipated at every stop and reducing the amount again stored up in the armature at starting. The brushes, which are of carbon, slide off machined surfaces in substantial box type brush holders and are pressed down on the commutator by suitable trig-

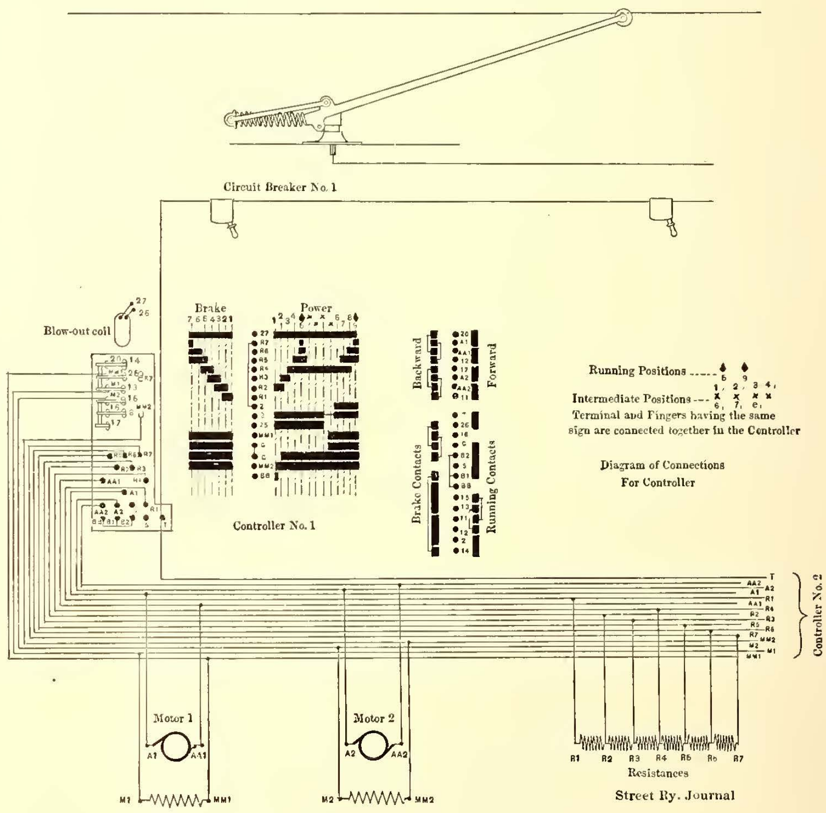
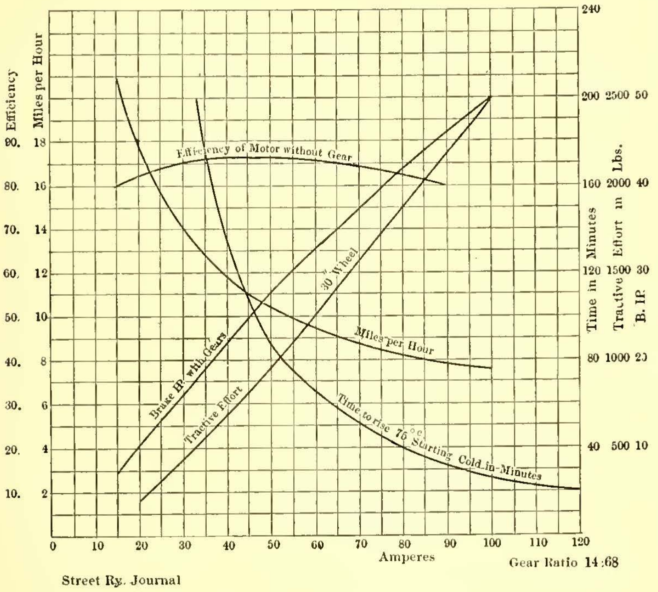


DIAGRAM OF CONNECTIONS FOR CONTROLLER

gers. The brushes are very easily removed, the type of brush holder being the simplest possible.

The weight of the motor complete, together with bearings, brasses and pinion gear and gear case, is approximately 1 ton. Any type of suspension can be arranged for if required. As a

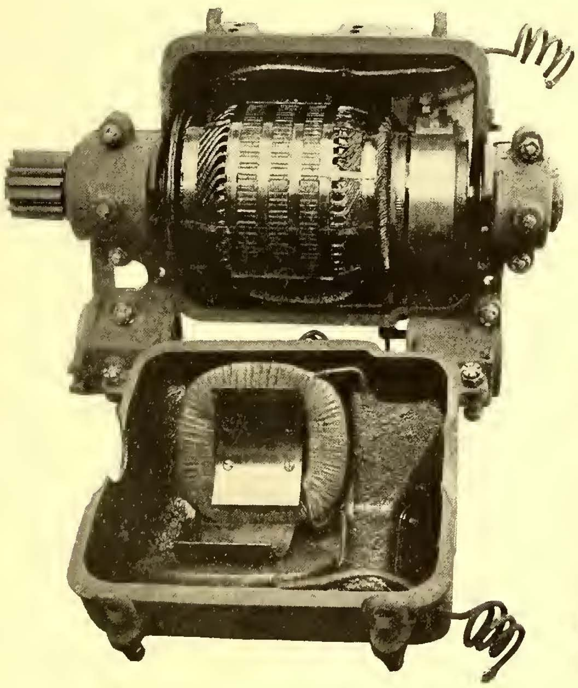


APPROXIMATE PERFORMANCE CURVES

general rule, however, the "nose" type of suspension is found most satisfactory.

The controller used is of the magnetic blow-out type, and has in all three drums, namely, a main drum, at which the breaking of the circuit in service always takes place; a reversing drum, and a further small drum actuated by a rack from the main drum, the position of the contacts on which to determine whether the motors are connected for braking or running. The controller has five series and four parallel running positions, besides four positions intermediate between the first parallel and the last series notch, and there are also seven braking positions for use with the ordinary service, rheostating braking or with an electromagnetic brake.

The diagram of connections will clearly indicate the connections of the controller, which can readily be traced out, remembering the fact that all contacts, fingers and leads having the same symbol are permanently connected in the controller. A large blow-out coil is fitted to reduce sparking at the contacts, and a number of breaks in series are arranged for when a heavy current has to be broken; for instance, in turning from the first series notch to the "off" position, the current is broken at six points in series under the influence of the magnetic blow-out. Provision is made for cutting out either motor should it be injured, and with one motor cut out it is impossible to move the main handle of the controller beyond the last series position with no resistance in circuit.

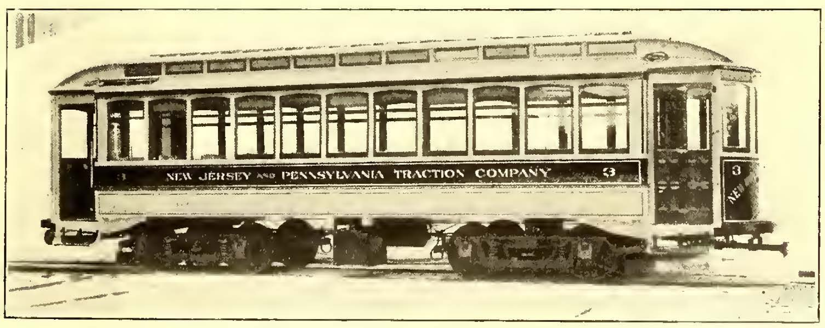


MOTOR OPEN, SHOWING ARRANGEMENT OF ARMATURE AND FIELD

CARS FOR THE NEW HOPE & LAMBERTVILLE RAILWAY, NEW JERSEY

The New Jersey & Pennsylvania Traction Company has just placed in commission four handsome cars built by the J. G. Brill Company on a division of its system extending between Lambertville, a thriving manufacturing town and commercial center in Western New Jersey, and New Hope, Pa. A large amount of the traffic between these points is due to the fact that New Hope is the terminus of a branch of the Philadelphia & Reading Railway, and Lambertville, the other side of the river, is at the junction of two divisions of the Pennsylvania Railroad.

The cars are of the vestibuled suburban type, with eleven windows to each side, and are mounted on the American Car Company's No. 23-A type of M. C. B. trucks. The upper sashes of the windows are stationary, the lower drop into pockets in the side walls, and the openings have hinged covers. A transverse seating arrangement with longitudinal seats at corners provides for forty-four passengers. The seats are of the builder's type, upholstered in cane, and have step-over backs. The interior woodwork and the doors and sash frames are of cherry, and the ceilings are three-ply birch veneer, decorated. The framing of bodies and vestibules is substantial, and includes inside trusses shouldered high upon the posts, and 6-in. x ½-in. plates on the insides of the side sills. The platform timbers are re-inforced with angle irons and capped with angle-iron bumpers. The vestibule sashes are composed of single lights and are arranged to drop into pockets. Tongued and grooved poplar boards constitute the outside sheathing of the vestibules. The cars are furnished with platform gongs, signal bells and



VESTIBULED SUBURBAN CAR FOR THE NEW JERSEY & PENNSYLVANIA TRACTION COMPANY

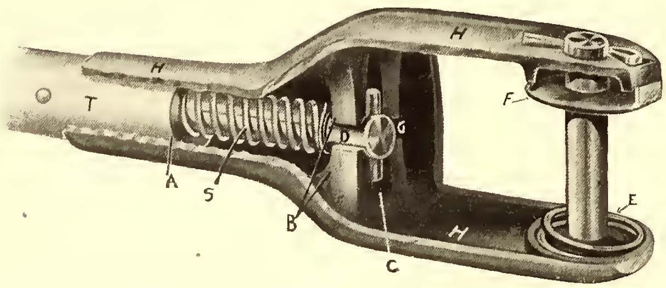
vestibule door controlling devices of the builder's manufacture.

The length of the cars over the end panels is 30 ft. 8 ins., and over the vestibules, 40 ft. 1 in.; length of the platforms, 4 ft. 8½ ins.; width over the sills, including the panels, 7 ft. 10½ ins., and over the posts at the belt, 8 ft. 2 ins.; sweep of the posts, 1¾ ins. The long leaf yellow pine side sills are 4¾ ins. x 7¾ ins.; white oak end sills, 5¼ ins. x 6⅞ ins. The corner posts are 3¾ ins. thick, and side posts, 2¾ ins.; from center to center of the window posts, 2 ft. 8 ins.

DETACHABLE TROLLEY HARP

Within the last two years the "Bayonet" detachable trolley harp, made by the Bayonet Trolley Harp Company, of Springfield, Ohio, has become so popular for all classes of electric railway service that a description of its construction and operation may prove beneficial to those who have not yet had the opportunity to try this harp on their own lines.

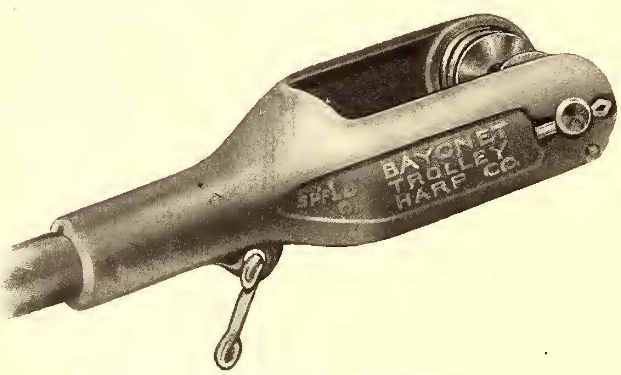
As shown in the accompanying sectional view, the complete harp consists of the head *H* and the stem *D*, the latter being firmly riveted in the pole. The pole extends 1 in. into the sleeve of the head, and the end is flush with the slight shoulder *A* in the middle of the stem. The lower end of the lock spring *S*, coiled about the stem, rests against the end of the pole and



SECTIONAL VIEW, ILLUSTRATING CONSTRUCTION OF HARP

shoulder at *E*. The upper end of the lock spring *S* rests against the under side of the flange *B* at the upper end of the sleeve. This flange has a central aperture of the same diameter as the reduced extension of the stem. At *C* is shown the lock pin in the end of the stem, resting in the locking recess after the lock pin has been passed up through the vertical internal grooves *G*, which are diametrically opposite and at right angles to the locking recess, and the head has been given a quarter turn either to right or left. The lock spring keeps the lock pin firmly seated in the recess. To change heads it is simply necessary to compress the lock spring until the lock pin disengages the locking recess, give a quarter turn until the pin engages the grooves and remove the head. By reversing the operation, the head can be put on again.

At the point *E* is shown a protected centering spring seated



DETACHABLE HARP IN SERVICE

in its groove around the axle, and at *F* a contact washer, showing the extended lip in perfect contact with the end of the head. When the wheel and the washer are in position the spring is completely protected from all injury. The stems are made to fit all standard poles.

The simple, reliable construction of this detachable harp results in many important advantages. Only ten seconds are required to change or replace a damaged wheel either in the daytime or at night. To do this work even while the car is moving, no tools other than human hands are required—hence there is no loss of schedule time on account of broken wheels or harps. By carrying on the car an extra head properly fitted with wheel, axle and washers, it is possible to replace quickly any that may become broken. The claim is made for this harp that it wears longer than others, because all axles are a driving fit, the centering springs are protected from all damage, the washers are extra heavy and all repair work and adjustments are made in the repair shop by experienced mechanics—hence there is no opportunity for patchwork on the top of the car by an inexperienced motorman. With this harp the wheels should therefore wear longer and jump less frequently than with others.

The detachable head is fitted with a sleet wheel or cutter, which is instantly interchangeable with head with the regular wheel. There is no loss of time in icy weather or on account of stopping to bolt on a sleet cutter or change to a sleet wheel.

The adaptability of this detachable harp to both urban and interurban work is well shown by reference to the following partial list of railway companies, most of whom are reported to be using it exclusively: Columbus (Ohio), Newark & Zanesville Railway; Washington Railway & Electric Company; Pennsylvania & Mahoning Valley Railway, New Castle, Pa.; Jamestown (N. Y.) Street Railway; Lexington (Ky.) Railway Company; Salem (Ohio) Electric Railway Company, and the Oklahoma City Railway Company.

THE MAGNET WIRE COMPANY TO MANUFACTURE FIELD AND ARMATURE COILS

An important departure has recently been made by the Magnet Wire Company, of New York, in the establishment of a department for the manufacture of field and armature coils for electric railway motors. The magnet wire manufactured by this company has become well and favorably known, and in consequence, the company has found that there is a large market for complete coils, not only among the smaller roads which do not have large shop facilities, but also among the large systems whose coil winding facilities are often inadequate for the demands made upon them. Excellent facilities for electrical repair work and the manufacture of field coils have been secured through the recent purchase by the Magnet Wire Company of the business and plant of a large electrical manufacturing and repair company, which has been consolidated with that of the already large plant of the company. The company was also fortunate in securing the services of H. S. Williston, who will take charge of this new manufacturing department. Mr. Williston, who is a technical graduate and a member of the American Institute of Electrical Engineers, had five years experience with the General Electric Company in charge of the manufacture of railway motor armature and field coils, and is therefore especially fitted for this class of work.

The new department of the company is prepared to manufacture both field and armature coils for all existing types of railway motors. Those for the motors which are in more general use in electric railway work will be manufactured in advance, in accordance with the usual specifications for this class of work, and kept in stock so that they may be shipped without delay upon emergency orders. The company will also, of course, be prepared to build coils to order upon all classes of specifications with special requirements. It is now building large quantities of field coils to special specifications for several of the largest city railway systems in the East, and is also supplying coils to numerous smaller systems. It has also considerably enlarged its present manufacturing facilities, in addition to the new department added. The former president, Mr. Valentine, is succeeded by Edwin W. Moore as president. F. H. Cowles is now secretary, and J. Nelson Shreve, treasurer of the company. These young men are well and favorably known in the street railway field. It is the intention of the company to meet the ever-increasing demand for and, at the same time, maintain the present high-grade standard of the magnet wire manufactured.

LONDON LETTER

[*From Our Regular Correspondent.*]

In this column last month I mentioned that there was a great and growing development of the petrol omnibus in London, and it is interesting to note that during the past month there have been aroused the most interesting discussions, pro and con, as to whether petrol omnibuses will succeed in driving out the electric tramway. The daily newspapers, and even the technical press, have printed columns on the subject, and most of the tramway magnates have been interviewed and their opinions carefully published. There is not the slightest doubt that there will be in the next year a tremendous accession in the numbers of petrol omnibuses, not only in the streets of London, but in those of nearly every city in Great Britain. It is the general opinion, however, of all those who ought to know, and have made a careful study of the situation, that this petrol omnibus will not prove, and is not intended to prove, a serious competitor to the electric tramways. There is no more economical method of operating a tramway to-day, in the ordinary thickly settled municipal area of any city, than by electricity. Wherever there still remain, however, horse omnibuses, as in London, where there are still something like twenty thousand, the petrol omnibus will form a most formidable competitor, and without doubt will oust the horse omnibus from existence within the next few years, or just as fast as the petrol busses can be made and paid for. As the whole subject, however, has been so carefully ventilated in the press lately, it might be as well to state that there is also little doubt that the motor omnibus will come to be used as auxiliaries by the electric tramway companies, or by the municipalities operating the tramways themselves, in many cities where there are outlying districts where it would not pay to lay steel rails or put up the necessary overhead construction. In these cities, the motor omnibus will be employed to collect people from these sparsely settled districts, and so act as feeders to the tramways. In proof of this, there already appears a motion in the agenda in a number of the municipalities making applications for the use of such omnibuses. The same use will also be given to motor omnibuses by the large railways, and it would appear that the railway companies especially are really hailing with delight the approach of a substantial and economically operated petrol 'bus, which will enable them, in their judgment, to regain some of their lost local traffic. The advent of the motor 'bus is also having a certain effect on the cabmen of London, and the Cabman's Union are already investigating the subject of the best way of introducing motor cabs, so as to compete on more level terms with motor omnibus. Summarizing, therefore, it might be well to state simply and emphatically that much of the present talk of the supersession of electric trams is simply "scare" talk and likely to be the prelude to the flotation of a large motor omnibus industry; that while there is a large field for the growth of the motor omnibus industry, the idea of their ever displacing electric tramways is almost too ridiculous for serious argument.

The subject of allowing the London County Council to operate tramways on the Victoria Embankment, and also to permit these tramways to cross Blackfriars Bridge so that the Northern and Southern lines may be connected, is again a burning question. It was thought a little time ago that the Corporation of London would be on the side of granting the privilege of the tramways on the Embankment, but it would now appear that they have voted strongly against it. The feeling is becoming so strong now that some of the morning papers have inaugurated petitions which have been signed by many thousands of London's working classes, who have to walk across the bridges morning and evening before they can get to the cars which take them near their homes.

Major Von Donop, one of the inspectors of the Board of Trade, paid a visit to Edinburgh recently and went over some of the principal cable lines with the view of reporting on the expediency of permitting an acceleration of the present rates of speed. At the present time motor cars, carriages, and cabs travel on the average at greater speeds than the cables, and as electric cars are allowed to run in other towns at considerably higher speeds, it is urged that a further concession ought to be made in the case of cable lines.

Mr. Frederick Coutts, general manager of the Ayr Corporation Tramways, has been appointed manager of the Paisley Tramways at a commencing salary of £400 per annum. Mr. Coutts came to Ayr from Dundee when the tramways were inaugurated in 1901, and his management of the system has been characterized by conspicuous success.

The Lambton collieries in the county of Durham, managed by Sir James Joicey, Bart., M. P., are about to be equipped with electric power supply. This power is to be supplied by the Sunderland District Electric Tramways, Ltd., and will be used for hauling, pumping, coal cutting, lighting and winding purposes, as well as for the engine works at Philadelphia. These collieries employ over 10,000 men, and have an output of over three million tons per annum.

Mr. T. B. Holliday, the engineer and manager of the Brighton Corporation Tramways, has resigned that position and has accepted that of engineer and manager to the Hastings & District Tramways Company. For a number of years he held a responsible position in the service of the Imperial Tramways Company, and supervised the laying of its tracks in London, Bristol, Stockton-on-Tees, Middlesborough, and other towns; and he was previously for eleven years with the Melbourne Cable Tramways Company. He was appointed engineer and manager of the Brighton Tramways in August, 1900, and the work of constructing the first route was commenced on January 25, 1901.

Speaking at the half-yearly meeting of the London, Chatham & Dover Railway Company, the chairman (Sir Edward Leigh Pemberton, K. C. B.), in an allusion to the experiments of the London & Brighton Company, said that if these proved successful—as there was reason to hope they would—the London and Chatham shareholders would certainly see steam ousted from their metropolitan sections.

The Metropolitan Tramways, Ltd., hope in a short time now to open another section of their tramways in the north of London. The line in question extends from Highgate, northwards in the county of Middlesex, and will enter Hertfordshire, near Barnet, and continue to the town of Hertford. When the whole system is completed, this company will have a vast network of tramways lying in the various suburbs to the north of London.

The Corporation of Manchester has now pretty well developed its tramways system for the collection, conveyance and delivery of parcels over the whole of its routes. The central receiving office will be established in the city near the Infirmary, where excellent facilities have been procured for handling a large volume of traffic. The receiving office will take parcels weighing up to 56 lbs. in weight, and will not only receive these parcels over the counter, but will use collecting vans in the city proper. It is intended to establish twenty-six depots at various points of the tramway system, where messengers will be stationed, who will immediately deliver the parcels to the addresses in the vicinity, the outlying districts being served by means of vans. In addition there will be also appointed a number of smaller agents along the lines of route, who will receive the parcels on behalf of the Corporation and deliver them to the Corporation cars.

We have dealt rather largely above with the subject of tramways versus motor omnibuses, and have touched rather lightly on the subject of the great railways of the United Kingdom endeavoring to use them. There has, however, been held recently in London a conference of the Municipal Tramways Association at which many representatives of the various local authorities and municipalities and tramway companies operating tramways were present. It appears that, at least, three of the most important railway companies, namely, the Midland Railway Company, the North Eastern Railway Company and the Great Western Railway Company, are intending to apply to Parliament during the present session for powers to use motor omnibuses in connection with their railways, for the avowed purpose of distributing their passengers from the various stations in cities to any parts of the town. This, of course, has aroused the tramway people to energetic opposition, as they naturally consider that the conveyance of passengers in cities belongs to them, and not to the railway companies, and resolutions to oppose these bills were accordingly passed.

Mr. C. R. Bellamy, general manager of the Liverpool Corporation Tramways, has again been going very thoroughly into the question of halfpenny fares, and has recommended very strongly that they be not instituted in Liverpool. Mr. Bellamy estimates that were halfpenny fares to be introduced in that city, it would be a result in reduction of something like £95,000 per annum in the receipts, and therefore, in his opinion, the introduction of halfpenny stages would seriously jeopardise the commercial stability of their undertaking. A. C. S.

NEW WORK IN WHEELING

The Wheeling Traction Company, of Wheeling, W. Va., will build about 3 miles of new track and purchase about ten double-truck cars during the coming year. The Steubenville & Wheeling Traction Company, a constituent, plans to build 8 miles on the Ohio side of the River from Martin's Ferry north, which will be about one-half of the unfinished line from Wheeling to Steubenville, Ohio. The new line to be built this year will, of course, necessitate the purchase of rolling stock. The Wheeling & Western Railway, which is being extended into Ohio, from Bridgeport, just opposite Wheeling, will probably build 4 miles between Barton and St. Clairville, and will require additional cars. Outside of a small storage battery to be installed for the Wheeling & Western, no additional power station apparatus will be needed, as the company has recently completed two direct-current stations with sufficient capacity to care for all extensions at present contemplated.

PARIS LETTER

(From Our Regular Correspondent.)

The Gardner-Serpollet Company has been turning out some steam omnibuses recently for transport of passengers in localities where a tramway system would as yet not be able to reach a paying basis. Some little time ago this firm supplied several steam omnibuses for the postal service of Guadeloupe, one of the French Colonies. An omnibus destined for regular service between Nice-La Turbie-Menton, a very hilly district, has just completed trials in and around Paris. It made some successful attempts to climb the formidable grades of Montmartre. The omnibus will hold 16 passengers, and is furnished with a motor of 20 hp. It weighs, empty, some 5874 lbs., and loaded 8536 lbs. The trials are held to have been very successful.

The special commission appointed to inquire into the conditions relating to the passage under the Seine of No. 4 line of the Paris Metropolitan has just awarded the contract to M. Chagnaud. The double-tube scheme has been put aside, and also because of the disturbance to traffic the caisson system of construction. The tunnel will be quite shallow, and will be constructed in a manner similar to the remainder of the Metropolitan, that is, mainly of masonry arch with iron tube lining. The contract amounts to Frs. 10,629,000, and will be executed in 18 months. Several prizes of small sums have been awarded to unsuccessful bidders.

The Tramway Sud, one of the few remaining horse tramways of Paris of any extent, is undergoing transformation to electric service. The system is quite considerable and extends for a considerable distance south of the city. Within the principal streets the conduit type of construction has been adopted, with trolley line on the outskirts. The French Thomson-Houston Company is undertaking the work.

The progress within the past three or four years in French tramway construction has not been very rapid. The period of great activity in this direction ended with 1901, and only a few hundred kilometers have been built since this time. The situation is somewhat better as regards interurban tramways or light railways, which have increased by 2000 km since 1902. The average net profits in the French provinces for this class of undertaking is 4 per cent, whilst in Paris the net earnings do not amount to more than 3 per cent. The following is a summary of the French tramway situation to the end of 1904:

Length in service, about 2150 km.
Capital invested, about f.665,000,000.
Gross receipts, about f.107,000,000.
Net profits, about f.24,000,000.

The average fare per passenger is about 10 centimes in the provinces, and slightly higher for Paris. These figures give a capital expenditure of about Frs 321,000 per km, with Frs 50,000 receipts per km. The low fares charged are held responsible for the poor financial condition of many of the tramways, and the low receipts per kilometer, compared with Germany or England.

The city of Paris has had no reason to regret its bargain with the Metropolitan Railway, with respect to its capital expenditure on the tunnels of this system. The city by means of a loan raises the necessary capital for the construction of tunnels, and the operating company pays a certain percentage of its gross receipts as payment for interest on the loan. This percentage of gross receipts has in the past amounted to about 10 per cent of the capital expenditure of the city, and the operating company has had left only 6 per cent on its expenditure. It is true that in view of the capital expenditure of the Metropolitan Company for material and equipments not yet in use, a part of the money is unproductive at present, but the percentage remaining is after all not a very favorable figure compared with the good bargain made by the municipality.

A lawsuit against the city of Paris has recently been brought before the Council of State by the Paris General Omnibus Company for damages (dommages-interets) occasioned by the disturbance in its regular traffic and lines of route over which its trams and buses run, and under which the Metropolitan Railway lines have been or are under construction. The works have been in some cases carried out on the cut and cover plan, and in others by overhead viaduct. This has, of course, caused cessation of traffic on the tramway routes, and a deflection of the usual omnibus routes. The council of the Seine, to which the suit was first presented, has recognized the claim of the Omnibus Company to damages as regards the obstruction of the tramway routes, and has named experts to consider the amount of indemnity which should be awarded to the Omnibus Company. It rejected, however, the claim for indemnity as regards losses of traffic, receipts, damages to material, loss of horses, and even accidents to persons occurring on the routes where omnibuses passed along, as distinct from the tramway routes. The Omnibus Company appealed to the Council of the State, and the general verdict has now been given which is favorable to the claims of the Omnibus Company, although the exact amount of such indemnity has not yet been stated. The matter will probably be referred to experts.

DETROIT TROLLEY SONG CONTEST DECIDED

The award has been made of the special prize of $200 offered by the Detroit United Railways Company for the best "trolley song." Strangely enough, a Detroit man, Paul Hoffrichter, is the winner. The title of his composition is "Come Along." The contest was opened Sept. 29 last, and was closed Jan. 7. Only last week did the judges complete their work of going over the manuscripts and announce the decision. As previously stated in the STREET RAILWAY JOURNAL, the song is dedicated to the Detroit United Railways Company, which retains the right to use it for advertising purposes. The copyright and royalties, however, are the composer's. As soon as the copyright is secured, the song and verses will be given to the public. Competing for the prize were contestants from nearly all the large cities. The key to the names of the writers, which was not looked into until after the decision had been reached, showed that a number of writers of successful light operas and musical comedies were among the competitors.

A SYSTEM PROJECTED FOR YORK

Another step in the project of building an electric railway in York, Pa., was taken recently, when Howard W. Stanford, of Philadelphia, and Edward S. Preston, of Moylan, arrived in the city to secure data and take measurements from which to estimate the cost of the 30 miles of electric railway to be laid in the city and county, according to plans already made under the instruction of Philadelphia and New York capitalists. John B. MacAfee is at the head of the construction, and William Hall is engineer and the president of the company.

About the beginning of the year, charters were granted at Harrisburg to the York Electric & Western Company, whose line will run east and west on Philadelphia and King Streets; to the York Intramural Railway Company, the line running north and south on Duke and Beaver Streets, and to the York & Hanover Western Company, this line running from the western end of the city to Hanover. On Jan. 18 a charter was granted to the King Street & Carlisle Avenue Street Railway Company for a loop to connect the King and Philadelphia Street lines by running around through Eberton. Its course will be from West King Street to Dewey Street, north to Market Street, west to Highland Street, north to Stanton Street, west to Adams Street, north to the Carlisle road and southwestwardly to the terminus at the main entrance to the fair grounds.

Certain extensions of these lines have since been filed. The principal one starts at the main entrance at the fair ground on Carlisle Avenue, and runs the entire length of Madison Avenue to Farquhar Park. At the northern corner of the park it goes into Newberry Street, thence to Jefferson Avenue, to Beaver Street, to the northern terminus of the Intramural line, which is at North Street.

The Intramural line will start at the Northern Central Railway depot, at Duke Street, run south on Duke Street to Springetsbury Avenue, then to Beaver Street, to Jackson, to Cleveland Avenue, to Lafayette Street, to Water, to Princess, to Beaver and thence to North Street.

The extension from the fair grounds over Madison Avenue and over Farquhar Park is considered to be the only feasible route of tapping that resort, as at the northern portion the grade is not so steep as at any other portion.

In the east end, the Philadelphia Street and the King Street lines will be connected by a line across Hartman Street.

The line to Hanover will follow the Gettysburg turnpike generally until it reaches the Five-Mile house. It will then follow the York and Hanover road into York Street, Hanover, and then on to Franklin Square. The Spring Grove spur will leave the main line just beyond Nashville, run through the town of Spring Grove and then rejoin it at another point. Several routes are under consideration for this line.

Millet, Roe & Hagen, of New York, are offering $500,000 New Jersey & Hudson River Railway & Ferry Company first mortgage 4 per cent gold bonds. A detailed circular, together with a map, showing the company's lines and connections, is issued by the firm.

THE STREET RAILWAYS OF CONNECTICUT FOR THE YEAR

There is much that is of interest in the annual report of the Railroad Commissioners of Connecticut, although it deals with conditions in that State as they were on June 30, 1904. First of all, the report treats of the situation in general, reviewing the progress during the previous year. Mention is made of extensions to existing systems, and of plans in contemplation for new work to be done. These considerations, however, are almost purely local, and of little interest, except that they tend to increase the aggregate mileage within the State. Special mention is made of the Consolidated Railway Company, organized in the interest of the New York, New Haven & Hartford Railroad Company, to operate its electric railway properties. At the date of the commissioner's report this company was in control of only the local New Haven system, the Meriden Street Railway, the Worcester & Connecticut Eastern Street Railway, the Danielson & Norwich Street Railway, and the People's Tramway Company. Its aggregate of mileage, as reported at that time was 190.6 miles, as compared with 366 miles, as given in the STREET RAILWAY JOURNAL of Dec. 24, 1904.

Perhaps of greatest interest are the data covering mileage, capitalization, etc. According to the report, the mileage is arranged as follows: Length of road (first main track), 560.247 miles; length of second main track, 109.087 miles; total length of main tracks, 669.334 miles. Length of sidings and turnouts, 31.521 miles; total, computed as single track, 700.855 miles. The three companies controlling the greatest mileage of main tracks are the Consolidated Railway Company, representing 181.805 miles, the Connecticut Railway & Lighting Company, 168.269 miles, and the Hartford Street Railway Company, 76.868 miles; leaving 242.392 miles operated by the other companies, although some of these companies are owned by the three first named, but are reported under a separate management.

The total capital stock of the companies, outstanding, is $30,659,748.00, representing 631.825 miles of street railway owned; also, in some instances, gas and electric properties. If this stock was all considered as applicable to street railways, and was divided by the 631.825 miles owned, upon which it was issued, it would show the average stock per mile to be $48,525.69.

The total bonded debt of the street railway companies is $22,207,342.27, and, like the stock, covers not only street railway, but also gas and electric light properties. If divided by the number of miles of all street railways owned, viz., 641.653, it would show an issue of $34,609.58 per mile. As a matter of fact, however, these bonds cover only 610.620 miles of the roads owned, showing an average bonded indebtedness of $36,380.43 per mile on the roads so covered.

The floating indebtedness of the companies is $2,540,189.30, and the total stock, bonds, and floating indebtedness $55,407,279.57.

The cost of construction and equipment reported is $55,575,086.57, which also includes the cost of the street railways and gas and electric light properties. If this amount was divided by the entire number of miles owned, viz., 641.653, it would give $86,612.37 per mile, including the cost of gas and electric light properties.

The gross earnings for the past year have been $4,924,151.46, being $420,580.17 more than for the preceding year. The gross earnings of the Consolidated Railway for the year were $1,533,- The number of miles operated were 685.128. The gross earnings per car hour were $3.23. The largest gross earnings per mile operated were $10,819.24, on the New London Street Railway; the second largest, $9,704.49, on the Hartford Street Railway; and the third largest, $8,432.98, on the Consolidated Railway. The gross earnings of the Consolidated Railway for the year were $1,533,158.60, the Connecticut Railway & Lighting $1,248,670.54, and the Hartford Street Railway $897,122.59.

The operating expenses for the year were $3,287,113.55, being $122,514.48 more than for the previous year, and are $4,797.81 per mile operated and $0.1445 per mile run. The expenses were 66.75 per cent of the gross earnings.

The net earnings for the year were $1,637,037.91, as compared with $1,338,972.22 for the preceding year, and were $2,389.39 per mile operated and $0.0719 per mile run.

Eight companies have paid $120,050.00 in dividends upon capital stock amounting to $1,900,000.00, while no dividends are reported as paid on $28,759,748.00 of capital stock. This is $249,766.24 less than the amount paid last year, arising principally from the fact that none are reported as paid by the Fair Haven & Westville and Winchester Avenue Railroad Companies, which last year amounted to $245,486.24.

The sum of $876,658.99 in interest has been paid on a total bonded and floating indebtedness amounting to $24,747,531.57.

The amount of taxes paid to the State by the various companies is $260,046.07.

Number of miles run, 22,750,560. The gross earnings per mile run have been $0.2164, operating expenses $0.1445, and net earnings $0.0719. The number of miles run, as reported, was 1,720,671 more than last year; the gross and net earnings per mile run slightly more and the operating expenses slightly less.

The number of fare passengers carried were 93,111,402, compared with 96,857,782 last year, a decrease of 3,746,380, contrasted with 64,315,374 carried by the steam railroads, which number was also a decrease of 603,098 in the number carried the previous year. The number of fare passengers per mile of main track operated was 135,903, compared with 146,213 last year, and the number of fare passengers per mile run 4.09.

The number of employees was 3297, averaging about 4.8 per mile of road operated.

The number of persons injured in the operation of the street railways during the past year was 383, compared with 370 for the previous year, of which number 23 were killed, four more than last year. The number of passengers injured was 212, of whom 4 were killed; the number of employees injured 20, of whom 2 were killed; and the number of other persons injured 151, of whom 17 were killed.

REPORT OF CHICAGO UNION TRACTION COMPANY

The earnings of the Chicago Union Traction Company, for three months ending Dec. 31, 1904, and the corresponding period of the previous year, as shown by the statement filed by the receivers, are as follows:

Quarter ending Dec. 31, 1904:

Earnings—	West Chicago	North Chicago	Both	Consol. Traction
*Passenger	$474,051	$253,457	$727,508	$110,169
Miscellaneous	2,801	3,152	5,953	522
Gross	$476,852	$256,609	$733,461	$110,692
Operating expenses	323,424	177,148	500,572	115,070
Net	$153,429	$79,461	$232,890	†$4,378
Other income	4,243	1,949	6,192	6,664
Total income	$157,672	$81,410	$239,082	$2,286
Charges	118,523	64,564	183,087	59,424
Balance	$39,140	$16,846	$55,995	†57,138

Quarter ending Dec. 31, 1903:

Earnings—	West Chicago	North Chicago	Both	Consol. Traction
*Passenger	$432,899	$240,837	$673,736	$97,911
Miscellaneous	2,982	3,555	6,537	688
Gross	$435,882	$244,392	$680,274	$98,599
Operating expenses	332,872	181,601	514,473	89,234
Net	$103,010	$62,791	$165,801	$9,366
Other income	3,237	2,534	5,771	6,656
Total income	$106,247	$65,325	$171,572	$16,022
Charges	123,727	67,893	191,620	64,699
Balance	†$17,480	†$2,568	†$20,048	†$48,677

* Includes mail and chartered cars. † Deficit.

PERJURER CONVICTED IN CHICAGO

The long-drawn-out trial at Chicago of Inga Hanson, for perjury, has terminated in her conviction. Miss Hanson claimed to have been injured, in March, 1898, while alighting from a car of the Chicago City Railway. Several months later she began suit for $50,000 damages for personal injuries. Her claim was that, as a result of the accident she had been made deaf, dumb and blind, and that paralysis had also resulted from the fall. The jury at the first trial stood 11 to 1 in her favor. The second trial was begun Nov. 3, 1903. At each session Miss Hanson was carried into the court room on a cot. This trial came to a sudden termination when private detectives, after spying on her in her room in the Sherman House, testified that when she believed herself to be alone her eyesight, speech and hearing returned. After her second trial Miss Hanson disappeared. She was afterward arrested in New York, free from all afflictions. She said she had been cured by prayer. When returned to Chicago to stand trial for perjury, her paralysis, she claimed, returned. The perjury trial began Dec. 28, and after continuing for six weeks ended in a verdict of guilty.

It was asserted in court that the Chicago City Railway Company expended nearly $50,000 to convict the woman.

COMPANY TO HOLD NEW YORK CENTRAL'S TROLLEY LINES

The opinion seems to prevail in Central New York that the Mohawk Valley Company, now seeking incorporation with a capital stock of $100,000 is to be the holding company for the New York Central, of its electric railway properties. The incorporators and directors, according to the certificate on file at Albany, are William A. Greer, of New York; Milton S. Barger, of Newport, R. I.; Frederick H. Meeder, of New York; Charles H. Chambers, of White Plains; William Hutchinson, of New York; William S. Langford, of Yonkers, and Landreth H. King, of Dobbs Ferry. Only three are subscribers for stock, Messrs. King, Hutchinson and Greer. The properties coming under the Mohawk Company's control in the event of its being the holding company for the Central, are the Syracuse Rapid Transit Railway Company and the Utica & Mohawk Valley Railway Company, the Schenectady Railway Company, which is jointly controlled by the Central and the Delaware & Hudson; the Oneida Railway Company, the Rome Street Railway Company and the sections of the West Shore Railroad which will be equipped with electricity; also whatever new roads to the west and branch roads which will be acquired to complete the cross-State system.

ADDITIONAL SUBWAY PLANS IN NEW YORK

The committee on plans and contracts of the New York Rapid Transit Commission recommended at the meeting of the commission on Tuesday, Feb. 28, the building of more than a dozen new subway and elevated lines, with a number of alternate routes. The Bronx, Westchester, Williamsburg, East New York and Staten Island are to be tapped by the lines, all of which have been so planned that they may be operated either independently or in conjunction with present lines. To build the systems as proposed would cost, approximately, $250,000,000. It is expected that the recommendations will be placed before the full board about March 9.

WASHINGTON RAILWAY & ELECTRIC EARNINGS

The annual report of the Washington Railway & Electric Company to its stockholders for the year ended Dec. 31, 1904, says that the "properties have continued to show a gratifying increase in earning capacity." It shows a progressive increase in gross earnings since 1900 as follows: 1901, 7.90 per cent; 1902, 7.54 per cent; 1903, 5.87 per cent; 1904, 7.40 per cent. In 1900 there was, after fixed charges, a deficit of $158,509.55, but since then there has been each year a handsome surplus, as follows: 1901, $118,535.19; 1902, $201,128.76; 1903, $221,878.97; 1904, $356,522.75.

The report says:

"Your particular attention is directed to the balance sheet dated Dec. 31, 1904, appearing on page 10, from which it will be seen that the financial condition of your company is excellent. After payment on Dec. 1, 1904, of a dividend of 2½ per cent on $8,500,000 preferred stock amounting to $212,500, there remained on Dec. 31, 1904, a profit and loss surplus of $720,902.59. You will note that this is not simply a book surplus, but an actual surplus in cash or its equivalent."

An instructive exhibit of the report is the comparative income account for the years 1900 to 1904, inclusive, as follows:

	1900	1901	1902	1903	1904
Gross earnings	$2,004,142	$2,162,559	$2,325,775	$2,462,294	$2,644,360
Oper. expenses	1,313,383	1,187,449	1,251,814	1,328,051	1,355,822
Net earnings	$690,759	$975,110	$1,073,961	$1,134,243	$1,288,537
Miscel. income	16,510	16,016	19,644	32,905	49,024
Gross income	$707,269	$991,126	$1,093,605	$1,167,149	$1,337,562
Fixed charges—					
Taxes	$97,333	$104,145	$124,030	$146,032	$148,377
Interest	*768,445	*768,445	768,445	799,237	832,662
Total	$865,779	$872,591	$892,476	$945,270	$981,039
Surplus	......	$118,535	$201,128	$221,878	$358,522
Deficit	$158,509	......	......	......	......
Per cent of oper. exp. to gross earnings	65.52	54.90	53.84	53.95	51.29

* Note: For comparison, shown in 1900 and 1901 the same as in 1902.

ELIMINATING GRADE CROSSINGS IN CLEVELAND

The city of Cleveland has laid out an active campaign for the elimination of grade crossings the coming summer. Work will be started on eleven crossings which will cost about $1,000,000. Some work in this direction has already been done, and an extensive undergrade crossing has just been completed under the tracks of the Lake Shore & Michigan Southern Railway at Detroit Street, eliminating a crossing which has been particularly dangerous for the Cleveland Electric Railway. Work is already under way for an overhead crossing over the Nickel Plate Railway on the same street. Of the eleven crossings which will be built this year, five of them will eliminate crossings for the street railway company. The plans laid out have all been agreed to by the steam roads, which will pay half the expense, the city bearing the other half. This arrangement is in accordance with a law passed by the Ohio Legislature last year. Consistent with his policy in the demand for lower fares, Mayor Johnson has not demanded that the street railway company pay any portion of the cost of eliminating such crossings, further than that the company shall remove its tracks and arrange to keep the line open during construction. In the case of the Detroit Street crossing, recently completed, the company was obliged to build a temporary line on private right of way. Its outlay in connection with the work was about $12,000.

McGANN BRAKES FOR TORONTO

The Toronto Railway Company, of Toronto, Ont., has decided to equip its system with McGann air brakes. The Street Railway Journal hopes to be able soon to publish details as to the number of equipments and the charging stations.

NEW YORK, WESTCHESTER & BOSTON ORGANIZATION

At a meeting of the board of directors of the New York, Westchester & Boston Railway Company, on Thursday, Feb. 23, Andrew Freedman, a director of the Interborough Rapid Transit Company, controlling the elevated and the subway lines in New York, was elected to the Westchester board. John B. Jackson, president of the Fidelity Title & Trust Company, of Pittsburg, has also been elected to the board of directors. The full board, as now constituted, is as follows: William Lanman Bull, president; Evans R. Dick, of Dick & Robinson and Dick Brothers & Company; Samuel Hunt, vice-president; Charles B. Lewis, of New York; John B. Jackson, president Fidelity Title & Trust Company, of Pittsburg; John H. McAllister, president Franklin National Bank, of Philadelphia; William Barclay Parsons, engineer; Robert C. Pruyn, president National Commercial Bank, Albany; Robert E. Robinson, of Dick & Robinson; Frederick E. Whitridge, of New York; Andrew Freedman, director Interborough Rapid Transit Company; William H. Buckley of New York; H. Carroll Winchester, secretary, New York.

For purposes of building the road, the engineering corps has been practically completed as follows: William A. Pratt, formerly chief engineer of the Staten Island Rapid Transit Railroad, will be the chief engineer. The consulting engineers will be William Barclay Parsons, formerly engineer of the Rapid Transit Commission, and John Bogart, formerly State Engineer. George Tatnall has been engaged as the principal assistant engineer. He will have charge of all general engineering matters, under the supervision of the chief engineer. He has had wide experience in building railroads in the United States and Central America, having been for the past twenty-three years with the Pennsylvania Railroad in its design and construction departments. James Leland Crider has been chosen division engineer of that portion of the line in the borough of the Bronx and the "annex" district. He will have immediate charge of the field corps on location and construction. To accept this position, he resigns the general direction of elevating the tracks and eliminating grade crossings of the Baltimore & Ohio Railroad in Pittsburg. E. V. Maitland, who has had charge of the work of elevating the Pennsylvania Railroad tracks through the cities of Chester and Wilmington, will be resident engineer in the borough of the Bronx. E. B. Naylor, who has been engineer in the construction of the subway tunnel for the Rapid Transit Subway under the Harlem River, is to be resident engineer in charge of the branch of the road from the city limits to White Plains. On March 1 a corps of engineers will be put to work in laying out details of the line between the city limits and Portchester. The names of the engineer of structures and the electrical engineer, as well as additional resident engineers, will be announced shortly, so the company informs the Street Railway Journal.

TROLLEY RUINS BROOKLYN-NEW YORK FERRY TRAFFIC

According to the Brooklyn Union Ferry Company, the losses in patronage it has sustained within the past few years through the trend of traffic to new channels make it absolutely impossible for the company to continue to operate under the basis of its present grant from the city. So marked have been the losses that the company has actually notified the city that unless some definite arrangement is reached whereby it shall pay to the city a small percentage of its earnings, instead of the 7¾ per cent of gross receipts, arranged for under the lease of 1901, the company will withdraw service from the five lines it now operates between New York and Brooklyn. To substantiate its contention that a rearrangement of its agreement with the city must be had if it continues to operate, the company has published figures of its Fulton Ferry line which show the falling off in traffic to have resulted in a reduction of the number of passengers carried from 10,000,000 in 1898 to 3,800,000 in 1904. This remarkable decrease is attributable in the main to the operation of trolley cars directly into New York over the Brooklyn Bridge. It was in 1898 that this service was begun. Previous to that time the terminus of most of the lines now operated over the bridge was at Fulton Ferry, the traffic of which is cited by the company in substantiation of its plea for less onerous operating conditions. Before the Brooklyn Bridge service was begun, Fulton Ferry was closed to vehicles during the rush hours so that the passenger traffic might be cared for. Even at this the service on the ferry was indifferent, and the turning of traffic to the bridge soon greatly affected Fulton Ferry, as it did also the other lines operated by the company. A similar condition of affairs confronts the ferry company operating the lines from the foot of Broadway, Brooklyn, to New York, which serve the territory in the vicinity of the terminal of the new Williamsburg Bridge. Surface lines formerly terminating at the foot of Broadway are now diverted to the bridge to meet the demands of traffic, and the ferries are carrying only hundreds of passengers when before they carried thousands. Further losses of traffic over the ferries operating from Broadway will most likely follow when the elevated lines are run over the new bridge.

THE AUTOMOBILE IN WASHINGTON

George H. Harris, vice-president of the Washington Railway & Electric Company, of Washington, D. C., which proposes to operate an automobile service in connection with its street car lines in the district, as previously noted in the Street Railway Journal, says that but one route has been decided upon for the new service. This is for a crosstown line from the vicinity of the connection of New York Avenue and P Street Northeast, along P Street to Dupont Circle, returning by the same route, and the operation also of a line from Eleventh and G. Streets southeast up Eleventh Street and Maryland Avenue to the vicinity of Fifteenth and H Streets northeast, returning by the same route. Other routes will, of course, be opened as traffic demands. For the operation of the new service, it has been decided to use an electric vehicle with a seating capacity of twenty-four persons.

CHICAGO PROPOSITION FOR RAPID TRANSIT

The local transportation committee of the City Council has finished the City Railway franchise extension ordinance, and it will be voted on by the Council Monday evening, March 6. It provides for the surrender, of the ninety-nine-year claims by the company, municipal ownership after thirteen years, universal transfers, underground trolley north of Eighteenth Street, and the payment of 5 per cent of gross receipts to the city for thirteen years, and 10 per cent thereafter.

UNION OF TROLLEY AND STEAM IN MARYLAND

The Cumberland & Pennsylvania Railroad has made a proposition to the Cumberland Electric Railway Company, of which ex-Senator George L. Wellington is president, to connect with this line the Cumberland & Pennsylvania and to turn its Eckhart branch line into an electric road. This branch, now used exclusively for transporting coal, is of easy grade, and runs between Cumberland and Eckhart. The road would be extended from Eckhart to Frostburg over land controlled by the Cumberland & Pennsylvania. This plan, it seems, is part of the campaign against the Cumberland & Westernport Electric Railway, which runs into Cumberland over the Cumberland Electric Railway Company's tracks, the two lines having a traffic agreement.

BOSTON & PROVIDENCE RAILWAY PLANS CRYSTALLIZE

The plans for a high-speed electric railway between Boston, Mass., and Providence, R. I., which have been making for some months, have crystallized in the organization of a new company to be known as the Boston, Pawtucket & Providence Street Railway Company. The new organization is backed by the Boston & Suburban Railway, the Shaw and the Kidder-Peabody interests in the Boston Elevated Railway Company, and the Massachusetts Gas Companies. The striking feature of the scheme from an operating standpoint is the plan to connect with the Boston elevated's new elevated terminal at Forest Hills, cars running thence by private right of way to the Rhode Island State line, and through Pawtucket to Providence. It is estimated that from twenty minutes to half an hour will be saved over the slower plan of entering Boston by the tracks of surface lines. On the Boston & Worcester Electric Railway about one-fifth of the running time between the termini is occupied in traversing the distance from Park Square, Boston, to Chestnut Hill.

The details of the route are not as yet definitely settled, except that the line will probably cross to the west of the present Boston-Providence steam line after leaving Forest Hill and then proceed through Dedham, Sharon, Foxboro and the Attleboros to the State line. The preliminary plans for this projected line were published in the June 11, 1904, issue of the Street Railway Journal, although it will be noted that the plans for entering Boston have been materially changed. It is hoped to make the run in about an hour and forty-five minutes. The rate of fare between the two cities will, it is thought, be forty-five cents.

LOS ANGELES COMPANIES NOT OBLIGED TO GIVE TRANSFERS

The Supreme Court of California has decided that the Pacific Electric Railway Company and the Los Angeles Railway Company are not obliged to issue or accept interchangeable transfers. This decision comes as a reversal of the judgment of Judge Conrey, of the Superior Court of Los Angeles County, in the case of the people, represented by D. S. Reynolds, to compel the street railways to comply with rights which were supposed to exist under the franchises by virtue of which the companies operate. This case was one of a number arising about a year ago in the attempt of the citizens of East Ninth Street, Los Angeles, to secure transfers from the Pacific Electric Company, which operates along that thorougfare, to intersecting lines of the Los Angeles Railway Company. The Reynolds case was the only one in which the writ of mandate was invoked.

When the city of Los Angeles granted a franchise to one Kays, in 1897, to operate a street railway line on East Ninth Street, the following clause (section 6) was inserted: "Provided, further, that said grantee and his assigns will issue to and receive from the present line of street railway located on Mateo Street and Santa Fe Avenue, and all other lines of street railways in said city operated by said grantee or his assigns, transfers good for continuous single trips thereon in said city."

The Los Angeles Railway Company first operated under this franchise on East Ninth Street. Later the franchise was transferred to the Pacific Electric Railway Company. Transfer privileges with the Los Angeles Railway Company were then cut off.

Interpreting the above clause the Supreme Court says: "The Pacific Electric Railway Company has never issued transfers to passengers entitling them to ride upon the cars of the Los Angeles Railway Company, nor has the Los Angeles Railway Company ever issued transfers to passengers entitling them to ride upon the cars of the Pacific Electric Railway Company on East Ninth Street. The plain and obvious meaning of section six is that the person or corporation owning and enjoying the franchise to operate cars upon East Ninth Street shall be bound to the performance of certain obligations by reason of that ownership and enjoyment. We have failed to bring to light one case where it is held that the liabilities and burdens remain when the full enjoyment of the franchise and privileges have been legally passed to another.

"While the Los Angeles Railway Company was the assignee of Kays, it admittedly fulfilled all obligations. When it transferred the franchise by valid legal sale, as the court finds, to the Pacific Electric Railway Company, the Los Angeles Railway Company ceased to be the assignee of the franchise, and the Pacific Electric Railway Company then became the assignee.

"It is found that the two corporations defendant are independent, and no right existed to compel an interchange of transfers between them. The judgment appealed from is therefore reversed."

The East Ninth Street people contemplate taking an appeal to the United States Supreme Court.

LARGE BRAKE ORDER FOR BROOKLYN

In the Street Railway Journal of Feb. 25, an item was published relative to the 200 surface cars ordered by the Brooklyn Rapid Transit Company of the J. G. Brill Company and the Jewett Car Company. Word has just come to hand that every one of these cars will be equipped with the "Peacock" mechanical brakes made by the National Brake Company, Inc., of Buffalo, N. Y., covering a total of 400 brakes. This order is particularly noteworthy, because the cars on which these brakes are to be used are 41 feet long, weigh upward of 30 tons, and seat forty-eight passengers. The cars will be designed along the lines of the Brooklyn Rapid Transit Company's elevated type, modified to meet surface railway conditions, which, of course, involve frequent stops.

Not only have a large number of traction companies shown their confidence in the value of this brake for use on heavy cars, but car builders like the J. G. Brill Company and the Cincinnati Car Company have ordered numerous equipments for cars they are furnishing to different traction companies.

AUSTRALIAN TRAMWAY SYSTEMS

In no part of the world, in proportion to the number of population, writes John Plummer, of Sydney, are street tramways more extensively used as a means of passenger transit than in the leading Australian State capitals. In Sydney the tramways were originally worked by steam power, the cars being double-decked, like the railway carriages on several of the Paris suburban lines, but subsequently the cable system was introduced, and later on electricity became utilized as the motive power, and with such success that it is only a question of time when the locomotive and cable will be found dispensed with. The various tramlines, which, like the railways, are the property of the State, form a complete network of communication between nearly every part of Sydney and its suburbs, thus assisting in counteracting the tendency to overcrowding which forms one of the evils associated with large centers of population. The total length of tramlines open on June 30, 1903, was 124½ miles, representing an expenditure of £3,371,587 for construction and equipment, the number of passengers carried during 1903 being 130,405,402. The Melbourne system, embracing a length of 48 miles, 43½ miles of which are worked by cable and 4½ miles by horse power, was constructed by a municipal trust at a cost of £1,705,794, and is leased to a company. The number of passengers carried during the year was 47,564,942. There are also several suburban lines worked by limited liability companies as follows: Horse, 8½ miles; electricity, 4 miles, and cable, 2¼ miles. In Brisbane the tramlines were originally worked by horse power, but in 1897 it became replaced by electricity, the tramways being the property of an English company and covering a total length of 28 miles. As the traffic increases, extensions are effected. At the close of 1902 there were in the State 65 miles of tramways, including those in Brisbane, the number of passengers carried during 1903 being 18,125,302.

In Adelaide there are several tramway lines worked by horse power, but an attempt is being made to secure the introduction of the electric system. The lines are owned by private companies. In Western Australia Perth has a well-organized system of electric tramways, which, like that in the Kalgoorlie Municipalities, is the property of a private company. Fremantle and Boulder City also will shortly be in possession of electric tramway systems, constructed by private enterprise under municipal supervision. The only State-owned tramway is that running between the port of Roebourne and the town of Cossack, a distance of 8½ miles, in the northwestern portion of the State. In Tasmania the Hobart tramways are worked by electricity, and extend a distance of about 9 miles. They are owned by a private company, and were opened in 1901, in which year they carried 1,432,176 passengers. There is also a steam tramway in the northwest portion of the State, connecting Zeehan with Williamsford, a distance of 11 miles, its summit being 1500 ft. above sea level. Compared with other Australian tramway systems, that of Sydney is considerably the most efficient, there being a continuous succession of trams from early morning until midnight, an all-night service being established on several lines.

All the Australian electric systems are on the overhead wire principle, which is not found to interfere with the work of fire brigades to anything like the extent originally anticipated. The cost of the New South Wales tramways was defrayed out of loan revenue, and they constitute one of the most valuable assets of the State.

BOSTON & WORCESTER TO ISSUE STOCK TO RETIRE DEBT

At a special meeting of the stockholders of the Boston & Worcester Electric Companies, held Feb. 16, it was voted to authorize the issue of 1000 shares new preferred and 1500 shares new common stock to retire the floating debt.

It is understood that this new stock has already been sold at a good price. The larger part of the floating debt of the company represented 5 per cent notes, which were issued to purchase the stock of the Boston & Worcester Street Railway Company.

The earnings of the Boston & Worcester Street Railway Company for the quarter ended Dec. 31, 1904, compare with same quarter in 1903, as follows:

	1904	1903
Gross	$90,387	$77,704
Expenses	58,474	52,528
Net	$31,912	$25,176
Charges	23,851	24,234
Balance	$8,061	$942

CAN'T TAX RAILWAY FOR PUBLIC IMPROVEMENTS

The Supreme Court of California has decided that the city of Los Angeles cannot place an assessment upon the railway rights of way passing through it for the purpose of raising money to pay for improvements made upon streets intersected by those rights of way.

The opinion is in the form of a decision affirming the judgment of the lower court in the case of the Southern California Railway Company vs. City Treasurer, W. H. Workman and E. R. Fox, to whom a bond was sold by the city. The decision is of interest to all street railway companies in California holding railway franchises, as many companies in all parts of the State do hold such grants.

The city of Los Angeles decided upon street improvements on Pasadena Avenue. The work was done and an attempt was made to assess the railroad company on the ground that its property adjoined the improved land. The company refused to pay the tax, and the city issued a bond upon a portion of its holdings which was sold to E. R. Fox. An attempt was made to sell the property in order to realize the amount of the assessment. The company sought an injunction to prevent such action. This was granted temporarily and in the proceedings which followed was made permanent. Mr. Workman and Mr. Fox appealed to the Supreme Court. In its decision that body states that the city cannot make an assessment, because the railway company's franchise expressly states to what extent it shall be responsible for street improvements, to wit:

"That it will see that its right of way is kept in accordance with the remainder of the street between the rails and for a fixed space on either side, its share of the expense being born in this provision, the cost of the remaining improvements developing upon the property owners on either side of the street."

ST. LOUIS PRIZES FOR DESIGNERS OF GENERAL ELECTRIC APPARATUS

The International Committee of the Louisiana Purchase Exposition has recognized the engineering ability of the designers of the apparatus exhibited by the General Electric Company, in awarding grand prizes, as follows:—

To Elihu Thomson, Swampscott, Mass., for various applications of electricity; also to Charles P. Steinmetz, Schenectady, N. Y., for electric lighting; and to Frank J. Sprague, New York City, for the application of electricity to transportation.

The committee has also awarded gold medals to C. G. Curtis, of New York City, "the originator of the Curtis multi-stage steam turbine;" to W. L. R. Emmett, of Schenectady, "designer of the vertical type of Curtis steam turbine and generator;" and to W. B. Potter, Schenectady, N. Y., for applications of electricity to transportation.

Silver medals have been awarded to W. S. Moody, Schenectady, N. Y., for transformers; to M. M. Hewlett, Schenectady, N. Y., for distribution of energy, switchboards, etc.; to H. F. T. Erben, Schenectady, N. Y., for apparatus for generating electricity; to H. G. Reist, Schenectady, N. Y., for apparatus for generating electricity; to L. T. Robinson, Schenectady, N. Y., for scientific apparatus, measuring apparatus and laboratory and standard instruments; and to F. P. Cox, Lynn, Mass., for measuring instruments, indicating, recording and integrating.

CHANGE OF OWNERSHIP IN BUFFALO

A syndicate, headed by Henry J. Pierce, of Buffalo, has secured control of the International Railway Company, operating in and about Buffalo, through the purchase of a majority of the capital stock. As a result of this purchase, Henry J. Pierce has just been elected president of the company to succeed W. Caryl Ely, resigned. Mr. Pierce, the new president, is a capitalist and financier whose name is prominently identified with the business and commercial interests of Buffalo and the western part of New York State. He is president of the Wood Products Company, whose activities include the manufacture and sale of most of the wood alcohol produced in this country. He is a member of the Board of Trade, and president of the Chamber of Commerce in the city of Buffalo, and has always taken a lively and active interest in the welfare of his home city. In addition to local enterprises in which he is interested, he is president of the Netherlands Tramways Company, which has recently completed an up-to-date interurban electric railway from Amsterdam to Haarlem, Holland. He has been a director of the International Railway Company since its organization.

NEW PUBLICATIONS

Letters From an Old Railway Official to His Son, a Division Superintendent. By Charles De Lano Hine. Chicago: The Railway Age; 179 pages. Price, $1.50.

This volume is written in a most entertaining way, and consists of twenty-four letters which the reader is invited to believe were written by an old railway official to his son, who has just been promoted to the position of division superintendent. They treat of a variety of subjects, including discipline, operation and ethics, and while devoted to steam railroad topics there are many points which are equally applicable in electric railway practice. The advice offered is extremely practical, and is given in such a pleasant form as to make the volume very readable.

The Railway and Engineering Review. Railroad Transportation Number. Chicago, Ill.

"Railroad Transportation at the Universal Exposition," is the theme of the World's Fair number of The Railway and Engineering Review. It may seem rather late in the day to publish a description of the Fair exhibits, but the subject has been treated so comprehensively in this number that earlier publication would have been impossible. The striking feature of this issue is the logical order in which the steam railroad exhibits are described. Beginning with the cars and apparatus for the earthwork and ballasting, track construction and track tools are considered, then bridges, tunnel construction, buildings, water service, signals, railroad terminals—in fact, every department of a steam railroad's activity. In addition, considerable attention is given to the historical exhibits, the testing plants, traffic exhibits, etc., so that the whole may be said to form an excellent epitome of steam railroad practice from its early beginnings to the present time.

PERSONAL MENTION

MR. L. B. WARNER, vice-president of the Jamestown Street Railway Company, of Jamestown, N. Y., is dead, aged 77 years.

MR. CHARLES D. MATLACK, for many years secretary and treasurer of the Second & Third Streets Railway, of Philadelphia, now part of the Philadelphia Rapid Transit Company system, died suddenly of heart disease a few days ago at his home in that city.

MR. FRANK H. HARRIS, formerly connected with the light and power department of the Birmingham Railway & Light Company, of Birmingham, Ala., has accepted the position of superintendent of the Anderson Traction Company, of Anderson, S. C., which includes in its operations the street railway, electric light and power interests of that city.

MR. EDGAR ANDERSON and MR. P. H. M'CARTHY have formed a partnership to engage in engineering work in Dublin, Ireland. Mr. Anderson is a recent graduate of Trinity College, where he studied electrical engineering. He is a son of Mr. William Anderson, J. P., whose name has been so long associated with the Dublin United Tramways.

MR. J. E. ANGER, general superintendent of the Electric Railway & Tramway Carriage Works, of Preston, England, is spending a short vacation in this country after a residence of some six years abroad. Before going to Preston, Mr. Anger was prominently identified with a number of the principal car building companies in this country, including the Jackson & Sharp and the Jones and Gilbert companies. In all this work he has been associated with Mr. E. A. Stanley, who is now general manager of the Preston works. Mr. Anger expects to return to Preston during the next month.

MR. FRANK H. GALE, who for several years has conducted miscellaneous publicity matters for the General Electric Company, has succeeded the late Mr. E. H. Mullin in charge of the company's advertising. Mr. Gale managed the company's exhibits at conventions, and at the Pan-American, Charleston and St. Louis expositions. His headquarters have been at Schenectady, but he will now spend part of each week in New York.

MR. CAMPBELL SCOTT, who was for many years prominent in the management of the C. & C. Electric Company, and whose resignation therefrom was announced recently in these columns, has now assumed the position of manager of the main works of the Otis Elevator Company, at Yonkers, N. Y. Mr. Scott has had considerable experience as a works director, and has many special qualifications for the responsible duties which he now takes up.

MR. JAMES A. BLAKE has just been appointed amusement manager of the Consolidated Railway Company, which is the holding company of the electric railway properties owned by the New York, New Haven & Hartford Railroad Company. Mr. Blake will have charge of Savin Rock Park, New Haven; Rye Beach, New York; Hanover Park, Meriden; Crystal Park, Middletown; Fairview Park, Southbridge, Mass.; Pinehurst Park, near Worcester, Mass.; Wildwood Park, Putnam, Conn.; Berkshire Park, Pittsfield, Mass., and several other enterprises.

MR. EUGENE F. PHILLIPS, the founder of the American Electrical Works, succumbed to pneumonia and heart failure on Feb. 22, at his home in Providence, after an illness of some three weeks. Mr. Phillips was born in Providence Nov. 10, 1843. While still a pupil in the high school he enlisted in the civil war, finishing his education when he returned from the front. He was engaged at first in banking, but afterwards turned his attention to the manufacture of insulated telegraph wire, a small shed constituting his workshop. From this modest beginning he built up one of the largest industries of the kind in the country, being at the time of his death, general manager of the American Electrical Works and president of the Washburn Wire Company, both of which have large plants at Phillipsdale, East Providence. Mr. Phillips is survived by a widow and the two sons, Frank N. and E. Roland, who will now carry on the great industry committed to their care.

MR. HENRY M. SPERRY has resigned as signal engineer and agent for the Union Switch & Signal Company, to become consulting signal engineer for the Hudson Companies, recently formed to complete the construction of the four tunnels under the Hudson River between Jersey City and New York. The scope of Mr. Sperry's work with the Hudson Companies will be very broad, involving considerations of traffic and track arrangements, and of questions which are affected by the use of the most refined methods of automatic and block signaling. Mr. Sperry's experience in this important field has been very extensive, begining in 1881, upon the Pennsylvania Railroad. Until 1884 he was connected with the engineering corps of the New York Division of that railroad, after which he was promoted to the position of supervisor of signals upon the same division, in charge of construction and maintenance; during this time the line from Philadelphia to New York was changed from a two to a four-track system, which required the construction of a large number of interlocking plants, all of which came under his supervision. From 1891 to 1894 he held the position of general agent of the Johnson Railway Signal Company, having general charge of the installation of block signals upon the New York Central & Hudson River Railroad. From 1894 to 1899 Mr. Sperry was signal engineer and agent of the National Switch & Signal Company, in charge of the Western District, in which capacity he designed and constructed a large interlocking plant of 137 levers at State Line, Ind., and subsequently the signaling system of the elevated railroads of Chicago, the most important of which was that for the Union Elevated Loop in that city. Since 1899 he has held the position of signal engineer and agent of the Union Switch & Signal Company, for which he has had charge of many important installations. Perhaps his most important work while with the company was that of planning the block signal system for the subway system of the Interborough Rapid Transit Company, in New York City. For this system he prepared the preliminary plans, which were adopted. While the greater part of Mr. Sperry's time will hereafter be given to the preparation of traffic plans for the uptown and the downtown tunnels under the Hudson River, of the Hudson Companies, a portion of his time will be available for consulting purposes in the field of railway signaling. Mr. Sperry is a member of the American Society of Civil Engineers, the Western Society of Engineers, and the Railway Signal Association.

TABLE OF OPERATING STATISTICS

Notice.—These statistics will be carefully revised from month to month, upon information received from the companies direct, or from official sources. The table should be used in connection with our Financial Supplement "American Street Railway Investments," which contains the annual operating reports to the ends of the various financial years. Similar statistics in regard to roads not reporting are solicited by the editors. * Including taxes. † Deficit. ‡ After allowing for other income received.

Company	Period	Total Gross Earnings	Operating Expenses	Net Earnings	Deductions From Income	Net Income, Amount Available for Dividends
AKRON, O.	1 m. Jan. '05	65,465	37,092	28,373	22,917	5,456
Northern Ohio Tr. &	1 " " '04	59,607	37,098	22,509	22,467	43
Light Co	12 " Dec. '04	895,731	486,980	408,751	273,664	135,087
	12 " " '03	882,276	482,575	399,701	268,132	131,569
BELOIT, WIS.						
Rockford, Beloit &	1 m., Jan. '05	8,196	------	------	------	------
Janesville R. R. Co.	1 " " '04	7,463	------	------	------	------
	1 m., Jan. '05	18,238	------	------	------	------
BINGHAMTON, N. Y.	1 " " '04	16,764	10,812	5,952	------	------
Binghamton Ry. Co.	7 " " '05	155,866	------	------	------	------
	7 " " '04	144,951	75,003	69,949	------	------
	1 m., Jan. '05	296,970	201,389	95,581	136,703	†41,122
BUFFALO, N. Y.	1 " " '04	320 069	203,834	116 235	137,104	†20 869
International Tr. Co.	7 " " '05	2,549,699	1,350,673	1,199 025	970,044	228,982
	7 " " '04	2,494,834	1,368,611	1,126,223	933,548	192,674
	1 m., Jan. '05	21 826	14,654	10,173	------	------
CHICAGO, ILL.	1 " " '04	18,987	10,812	8,175	------	------
Chicago & Milwaukee	12 " Dec. '04	464 655	179,038	285,618	------	------
Elec. R. R. Co	12 " " '03	292 247	98,627	193,620	------	------
Metropolitan West Side	1 m., Jan. '05	179,820	------	------	------	------
Elev. Ry. Co	6 " " '04	174,240	------	------	------	------
Northwestern Elev. R.	1 m., Jan. '05	114,278	------	------	------	------
R. Co	1 " " '04	108,816	------	------	------	------
South Side Elev. R. R.	1 m., Jan. '05	131,221	------	------	------	------
Co	1 " " '04	135,781	------	------	------	------
CLEVELAND, O.	1 m., Jan. '05	13,346	9,737	3 609	------	------
Cleveland Painesville	1 " " '04	11,740	9,024	2,716	------	------
& Eastern, R. R. Co.	12 " Dec. '04	225,751	136,021	89,730	80,250	9,480
	12 " " '03	214,631	127,149	87,482	78,007	9,475
	1 m., Jan. '05	34,760	22,777	11,983	------	------
Cleveland & Southwest-	1 " " '04	27,852	22,557	5,294	------	------
ern Traction Co	12 " Dec. '04	445,362	293,615	181,746	------	------
	12 " " '03	445,168	264 232	180,936	------	------
	1 m., Jan. '05	356,195	* 229 205	126,990	93,437	33,553
DETROIT, MICH.	1 " " '04	311,440	* 226,103	85,337	87,567	†2,230
Detroit United Ry	12 " Dec. '04	4,581,582	*2763092	1,821,490	1,075,786	745,704
	12 " " '03	4,425,836	*2613976	1,811,860	1,000,000	811,860
	1 m., Jan. '05	47,593	27,908	19,685	16,729	2,956
DULUTH, MINN.	1 " " '04	45,543	28,795	16,748	16,374	374
Duluth St. Ry. Co	12 " Dec. '04	619,172	326,049	293,123	202,602	90,521
	12 " " '03	622,044	345,327	276,717	186,590	90,127
	1 m., Jan. '05	44,109	26,225	17,885	10,224	7,661
FORT WORTH, TEX.	1 " " '04	37,630	25,469	12,162	9,333	2,828
Northern Texas Trac-	12 " Dec. '04	564,711	316,529	248,181	121,043	127,138
tion Co	12 " " '03	465,394	261,357	204,037	111,371	92,667
HAMILTON, OHIO.	1 m., Dec. '04	37,300	------	------	------	------
Cincinnati, Dayton &	1 " 03	36,939	------	------	------	------
Toledo Trac. Co	12 " " '04	496,319	------	------	------	------
	12 " " '03	514,787	------	------	------	------
HANCOCK, MICH.	1 m., Dec. '04	17,079	13,493	3,587	3,333	254
Honghton County St.	1 " " '03	13,756	12,008	1,748	2,697	† 949
Ry. Co	12 " " '04	199 513	135,414	64,098	40,444	23,654
	12 " " '03	189,404	122,840	66,564	34,933	31,631
	1 m., Dec. '04	38 106	23,481	14,625	8,269	6,356
HOUSTON, TEX.	1 " " '03	29 707	24,956	4,752	8,109	†3,358
Houston Elec. Co	5 " " '04	178,032	113,770	64,262	41,464	22,798
	5 " " '03	176,179	121,447	54,732	38,143	16,589
INDIANAPOLIS, IND.						
Indianapolis & East-	1 m., Jan. '05	15,126	10,240	4,886	4,166	720
ern Ry. Co	1 " " '04	13,523	8,453	5,070	4,166	904
MILWAUKEE, WIS.	1 m., Jan. '05	256,458	130,228	126,230	74,351	51,880
Milwaukee El. Ry. &	1 " " '04	259,413	139,552	119 862	74,719	45,143
Lt. Co	12 " Dec. '04	3 285,378	1,592,414	1,692,964	916,460	776,505
	12 " " '03	3,096,324	1,526,910	1,569,414	871,685	697,730
	1 m., Jan. '05	38,523	19,781	18 742	18,943	† 201
Milwaukee Lt., Ht. &	1 " " '04	30 082	17,819	12,263	14,220	†1,958
Tr. Co	12 " Dec. '04	492,228	216,964	275,264	203,731	71,533
	12 " " '03	452,931	213,020	239,911	168,990	70,921
	1 m., Jan. '05	203,235	151,676	51,560	19,035	32,524
MONTREAL, QUE.	1 " " '04	183,708	131,487	52,221	16,482	35,739
Moatreal St. Ry. Co	4 " " '05	841,350	553,982	287,367	75,328	212,039
	4 " " '04	769,136	486,837	282,299	68,848	213,451
	3 m., Dec. '04	348,810	294 963	53,847	71,431	†17,455
	3 " " '03	358,474	276 938	81,536	67,392	‡14,385
NEW YORK CITY.	6 " " '04	860 648	597,761	262,887	144,080	‡119,085
Coney Island & Brook-	6 " " '03	875,044	570,643	304,401	135,020	‡169 809
lyn R. R. Co	12 " " '04	1,633,570	1,095,402	538 168	281,765	‡256,281
	12 " " '03	1,618,820	1,053,263	565,557	269,564	‡297,225
	1 m., Jan. '05	107,588	------	------	------	------
PHILADELPHIA, PA.	1 " " '04	98,945	------	------	------	------
American Rys. Co	7 " " '05	884,267	------	------	------	------
	7 " " '04	851,540	------	------	------	------
	1 m., Jan. '05	134,951	77,591	57,360	26,986	30,374
ROCHESTER, N. Y.	1 " " '04	113,454	70,865	42,589	26,125	16,464
Rochester Ry. Co	12 " Dec. '04	1,496,593	824,489	672,104	------	------
	12 " " '03	1,280,373	656,071	624,303	------	------
SAN FRANCISCO, CAL.						
United Railroads of	1 m., Jan. '05	543 371	------	------	------	------
San Francisco	1 " " '04	526,910	------	------	------	------
	1 m., Dec. '04	48,454	32,855	15 599	10,552	5,047
SAVANNAH, GA.	1 " " '03	45,143	23 980	21,163	10,454	10,709
Savannah Electric Co.	12 " " '04	544,144	316,784	227,360	126,121	101,239
	12 " " '03	519,774	307,699	212,075	119,327	92,749
	1 m., Dec. '04	208,727	150,500	58,227	25,320	32,908
SEATTLE, WASH.	1 " " '03	193 592	127,127	66,465	16,347	50,118
Seattle Electric Co	12 " " '04	2,321,235	1,609,639	711,596	295,472	416,123
	12 " " '03	2,096,726	1,497,905	598,821	280,375	318,447
	1 m., Dec. '04	79,282	45,524	33,758	20,258	13,499
SYRACUSE, N. Y.	1 " " '03	73,650	43,067	30,583	20,246	10,337
Syracuse R. T. Co	6 " " '04	440,611	248,457	192,154	121,725	70,429
	6 " " '03	424,645	239,156	185,488	121,706	63,782
	1 m., Dec. '04	52,070	32,510	19,561	9,221	10,339
TERRE HAUTE, IND.	1 " " '03	45,524	34,405	11,119	9,480	1,639
Terre Haute Tr. & Lt.	12 " " '04	569,429	369,005	200,424	113,873	86,550
Co	12 " " '03	474,250	312,084	162,167	87,385	74,782
	1 m., Jan. '05	150,944	*76,090	74,854	42,701	32,153
TOLEDO, O.	1 " " '04	137,517	*73,806	63 711	41,312	22,399
Toledo Rys. & Lt. Co.	12 " Dec. '04	1,752,833	*923,208	829,625	499,874	329,751
	12 " " '03	1,663,794	*856,526	807,268	488,200	319,068
UTICA, N. Y.	3 m., Dec. '04	186,758	129,269	57,489	44,244	‡14,191
Utica & Mohawk Val-	3 " " '03	170,349	113,350	56,999	40,589	‡17,416
ley Ry. Co	6 " " '04	412,495	265,227	147,268	88,879	‡60,303
	6 " " '03	386,586	238,203	148,383	81,638	‡68,749