Street Railway Journal

VOL. XVIII. NEW YORK AND CHICAGO, DECEMBER 7, 1901 No. 23.

THE SYSTEM OF THE MILFORD, HOLLISTON & FRAMINGHAM STREET RAILWAY COMPANY

Probably the most remarkable street railway development which is going on at the present time in New England, if not in the country, is that of the roads around Milford, Mass. About a year and a half ago the Milford, Holliston & Framingham Street Railway Company changed ownership, and E. W. Goss was elected general manager of the system. During the time Mr. Goss has held this position he has very materially improved the road, and the system will shortly present one of the most thoroughly up-to-date representations of interurban electric railway engineering to be found in the East.

When the new management assumed control the road consisted of a single-track line from Hopedale to South Framingham, a distance of 14½ miles, and a branch from Milford to Medway, a distance of about 7 miles. These lines cover the territory lying northeast of Milford. Hopedale, a distance of about 2 miles, but of considerable importance from a traffic standpoint, is a large manufacturing town, it being here that the works of the Draper Company are located. During the past year extensions have been made from Hopedale to Uxbridge on the southwest, North Grafton on the northwest and Hopkinton on the north. These, when completed, will more than double the mileage of the company's system as operated a year ago. The branch from Hopedale to Uxbridge is to be operated by a separate company known as the Milford & Uxbridge Street Railway Company, but is controlled by the same financial management, and has practically the same officers. At present the branch to North Grafton, which is to be an electrification of an old steam road, is operated by steam, and the branch to Uxbridge, which is all new construction, is nearing completion. The entire system, however, is expected to be opened and running by electricity within a month or so.

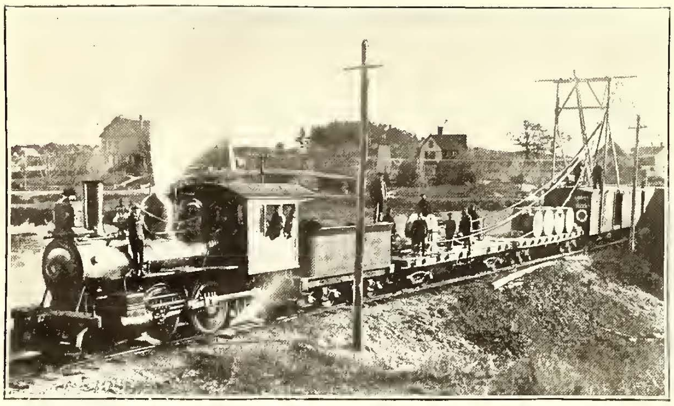
U. S. PATENT OFFICE DEC 9 1901

VIEWS IN LAKE MENDON PARK

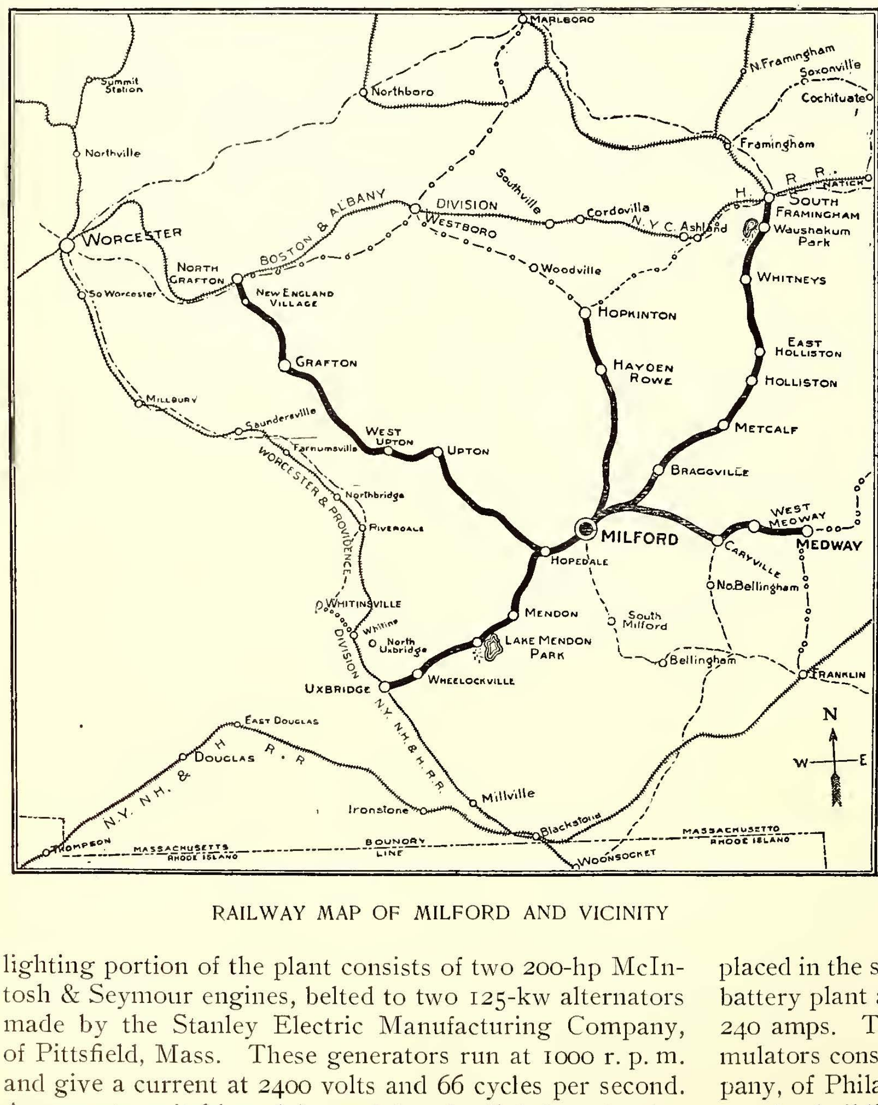
POWER STATION

The power station for the entire system is located in Milford. It not only supplies current for the railway, but also for the lighting circuits of the town. The lighting business, however, is controlled by a separate company, the Milford Electric Light Company, which has charge of the distribution and sale of the current in both Milford and Hopedale, the lighting company taking control at the switchboard in the power station. The power station is being greatly enlarged to supply accommodation for the new generating machinery necessary to operate the lines after the extensions have been completed, but this work is hardly sufficiently advanced to obtain satisfactory photographs of the plant.

The present equipment consists of four Dillon return tubular boilers made by D. M. Dillon, of South Boston, Mass., and one Stewart boiler of similar type. All the boilers are of 150-hp capacity. Space has been provided for four more boilers of the same type and capacity, but no more boiler power will be required at present. The lighting portion of the plant consists of two 200-hp McIntosh & Seymour engines, belted to two 125-kw alternators made by the Stanley Electric Manufacturing Company, of Pittsfield, Mass. These generators run at 1000 r. p. m. and give a current at 2400 volts and 66 cycles per second. A separate switchboard is used for the lighting circuits, and is placed at some distance from the railway board, so that any danger of the two departments being affected by each other is obviated. About 150 kw is supplied by the station for lighting, the street lighting of the town being done by both arc and incandescent lamps. The arc lamps, of which there are between fifty and sixty in number, are operated on a constant-current circuit, a constant-current 26½-kw General Electric transformer being installed in the power station. The lamps are 75 volts each.



STRINGING FOUR CABLES AT ONCE



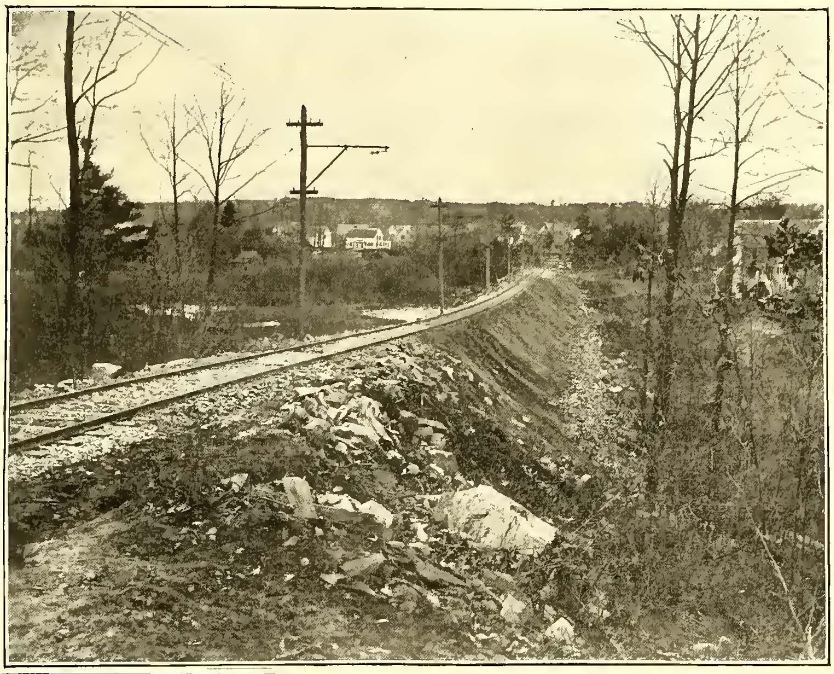
RAILWAY MAP OF MILFORD AND VICINITY

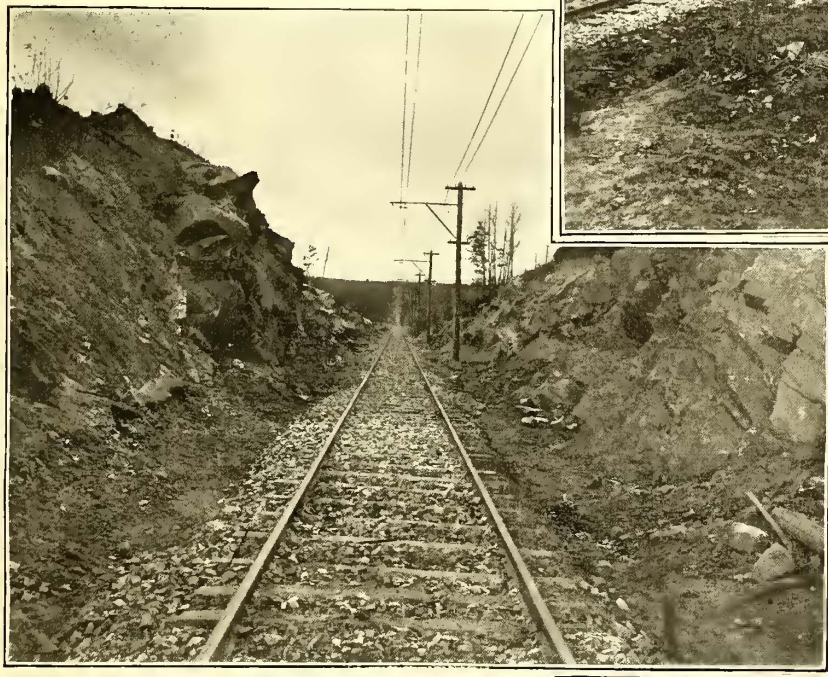
At present power for the railway work is furnished by two General Electric six-pole 600-volt railway generators. These generators are of 225-kw and 325-kw capacity, respectively, and both run at a speed of 100 r. p. m. They are direct coupled to simple engines made by the Slater Engine Company, Warren, Mass., the smaller having an 18-in. x 42-in. cylinder, and the larger a 22-in. x 48-in. cylinder. The engines are operated condensing, Warren condensers being used. In the extension which is being built will be erected a 600-kw Westinghouse railway generator, direct connected to a Filer & Stowell cross-compound engine. The size of the engine will be 22-ins. and 42-in. x 42-in. stroke, and it will run at 100 r. p. m. Warren vertical type condensers will be used with this engine.

The power station receives water from a cistern on the edge of a pond near by for both condensing and boiler-feeding purposes. The water as taken from the cistern contains more or less mud, and a special provision had to be made before it reached the boilers for the removal of this sediment. The Wainwright "even-flow" water-tube heaters were selected as being the most serviceable under the conditions, and a special type was designed having extra large, clean-cut openings in the heads or covers at each end. The frequent cleaning of the heater, which is necessary under the circumstances, is made extremely easy by this means, and the corrugated tubes which are contained in the heaters have been shown to be kept clean by the comparative high velocity which is obtainable, the mud found in the water chambers at each end of the heater being all that was present. There are two Wainwright heaters so far installed—one of 500 hp and the other of 1200-hp capacity—but another of 800-hp capacity will be installed with the new engine. One is used as a primary heater, using steam from the engine, while the other makes use of steam from the auxiliaries and steam pumps.

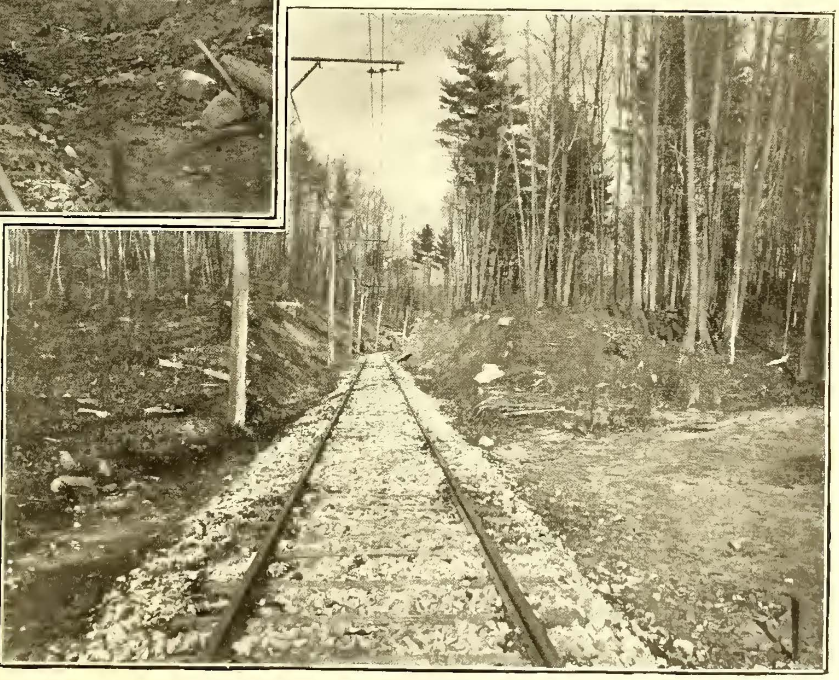
SUB-STATION

There will be three sub-stations when the enlarged system is opened. Two of these will be installed on the new branches soon to be operated. One is to be a storage-battery sub-station situated at Lake Mendon Park, and the other a rotary converter station at Grafton. The latter will contain a 150-kw Westinghouse rotary converter, which will be a counterpart of one to be installed at the power station in Milford. The rotary will be placed in the steam railroad station at Grafton. The storage-battery plant at Lake Mendon Park will have a capacity of 240 amps. The cells used in this plant are chloride accumulators constructed by the Electric Storage Battery Company, of Philadelphia, and they will be placed in a separate wooden building erected for the purpose. Another storage-battery sub-station is in use at East Holliston, of the same capacity. There are 216 cells of the same make as the others installed here, each cell containing thirteen plates. The cells, however, are large enough to receive nineteen plates each, which gives an opportunity for a considerable increase in the capacity of the battery. The North Grafton branch is to be operated by a high-tension transmission line between the Milford power station and the Grafton sub-station. This transmission line consists of No. 4 B. & S. aluminum wire strung on the regular trolley poles. The transmission is made by a three-phase 10,000-volt circuit. Besides the high-tension aluminum feeders, there is a 360,000-circ. mil aluminum feeder for direct-current distribution. This aluminum feeder is equivalent to a No. 0000 copper feeder, and with the aid of the Grafton sub-station will be amply sufficient to supply the trolley wire of this branch with the required current. The construction of this line was made under rather





peculiar circumstances. The road, as stated, is an old steam road, and in order to prevent interruption of steam traffic while building the overhead construction, the poles were erected before the bracket arms were attached. This left a pole iine on which the wires could be rapidly strung. The accompanying illustration shows a train of four cars and an engine which was used to string four wires at one time. In this way 24 miles of wire were put in position on a Sunday without interfering at all with the regular steam traffic. After the four wires, which consisted of the conductors of the three-phase circuit and the large aluminum feeder, had been put on the poles the brackets were attached. A novel form of platform was designed, which would furnish the workmen a strong support while placing the bracket in position, and yet was entirely out of the way of passing trains. These platforms consisted of a plank about 6 ft. long and 1 ft. wide, provided with wrought-iron braces or frames, and cut at one end to fit around the pole. When lifted to position at the top of the pole by means of ropes, a firm support was offered to the workmen. Guy ropes from the end of the platforms were attached to the track to increase the rigidity of the platforms. Upon a train passing it was only necessary to remove these guy ropes and leave the track entirely free. The accompanying cut shows three of the platforms in service.



NEW CONSTRUCTION BETWEEN HOPEDALE AND MENDON

TRACK CONSTRUCTION

The track from Milford to Framingham, which is about 12½ miles in length, has been practically rebuilt since the new management took control of the road. The construction on this line was not up to the requirements of the high-speed service which is being operated, and considerable work was necessary at the curves and switches to bring it up to standard practice. The track on this line, as well as on the 2 miles which run to Hopedale, is 50-lb. T-rail. Through the center of the town of Milford there is one-half mile of double track constructed of 9-in., 90-lb. girder-rail, paved with granite blocks. This is largely new construction, the old turnouts which were formerly in use having been of insufficient capacity to provide for the traffic at this point. The new construction between Hopedale and Uxbridge is being made of 60-lb. A. S. C. E. section rail, and for about 1½ miles where it runs on the company's own right of way it is rock ballasted and built acording to the most improved steam railroad practice. A rock-crushing plant is located on this line, an illustration of which is given.

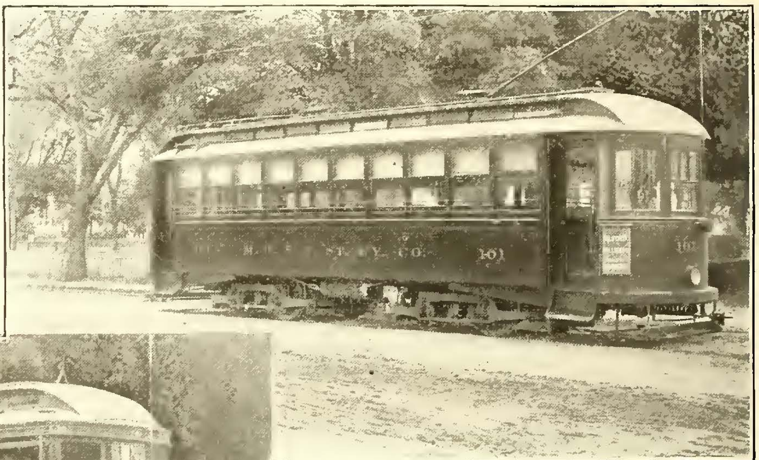
The old steam railroad construction is to be used on the Grafton branch, and consists of 50-lb. T-rail, which has been bonded with Chase-Shawmut bonds. In Upton 3 miles of new track are being laid for reaching the various parts of the town. The track work here is of 60-lb. T-rail. The Medway branch is laid with 56-lb. T-rail.

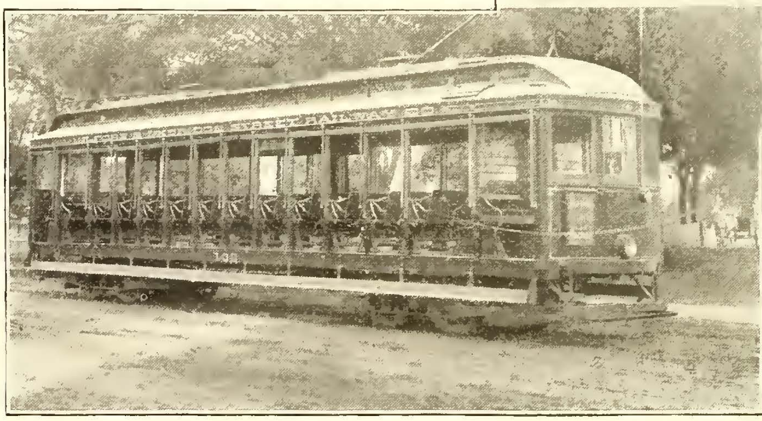
All of the branches are of single track with turnouts at from 3 miles to 4 miles apart. The overhead construction of the Milford & Uxbridge line is to be double trolley wire, and the old ones are expected to be changed over to the double wire in the near future. This does away with all trouble due to overhead switches at turnouts, and the extra trolley wire acts as an additional feeder, necessitating the use of no more copper.

ROLLING STOCK

Since the company necessarily expects to do a large pleasure business in connection with its park, a considerable number of open cars has been ordered. Among the most recent to be received are five fifteen-bench, double-truck cars made by J. M. Jones' Sons, of West Troy, N. Y. These cars are fitted with Bemis trucks and are vestibuled, the vestibules being provided with curtains at the side and solid fronts with window sash. They have the dome or monitor type of roof running the full length of car and extending over the platform, as in steam railroad practice, and are strengthened with steel sill-plates for the full length of the car. These cars are owned by the Milford & Uxbridge Company. There are besides fifteen open ten-bench cars, made by the Massachusetts Car Company, equipped with single trucks, made by the Peckham Manufacturing Company, which have been in service on the road for some time. These cars are to accommodate the general summer traffic. Five new cars have been ordered from the Osgood-Bradley Car Works, of Worcester, Mass. These cars are to be 40 ft. 4 ins. over all, and seat forty-four passengers. They are equipped with cross seats made by the Heywood Brothers & Wakefield Company, of Wakefield, Mass., and have double Bemis trucks. Besides these new cars, the road has in operation single-truck cars with both side and cross seats. These cars are of the standard type, with interior finish of mahogany, and have the seats upholstered in carpet. In all there are ten side-seat cars fitted with Peckham four-wheel trucks, and two cross-seat cars fitted with Bemis four-wheel trucks. Most of these cars were furnished by the American Car & Foundry Company from its Jackson & Sharp plant, which has also supplied three double-truck closed cars. The latter are 38 ft. over all, and are of the straight-sided type with cross seats, the illustrated car interior shown being made from a photograph of one. These cars are 8 ft. 4 ins. wide, and will comfortably carry, without overloading, fifty passengers. All of the closed cars are vestibuled with solid doors, the majority of them being fitted with the Agard sliding door.

INTERIOR OF STANDARD CLOSED CAR



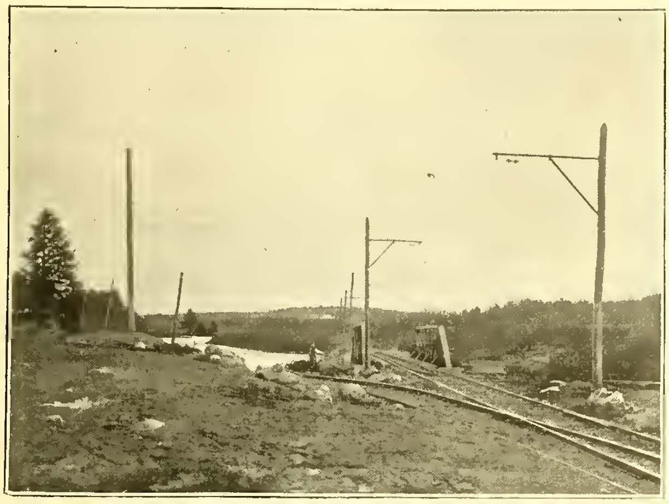


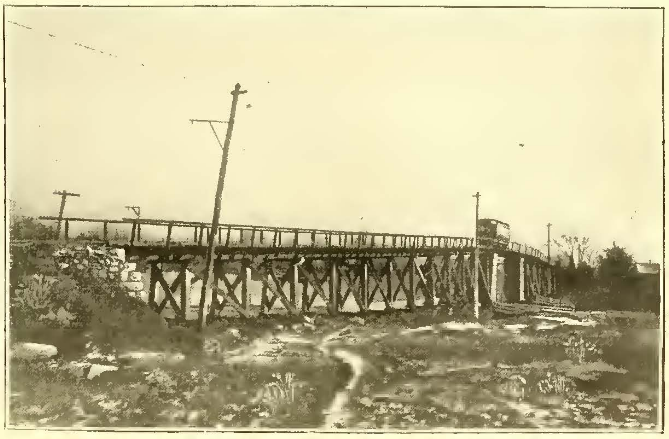
CLOSED AND OPEN CARS

ONE OF THE SNOW PLOWS

The company already owns five snowplows and has contracted for two more. The five that it now has consist of three four-wheel, small-nose plows, made by Pollard & Grothe, one from the Taunton Locomotive Manufacturing Company, and a large double-truck Ruggles double-rotary plow made by the Peckham Manufacturing Company. This latter plow, which is illustrated herewith, was in service last winter, and gave excellent satisfaction, the construction being such that the rotary fans clean the snow very close to the track.

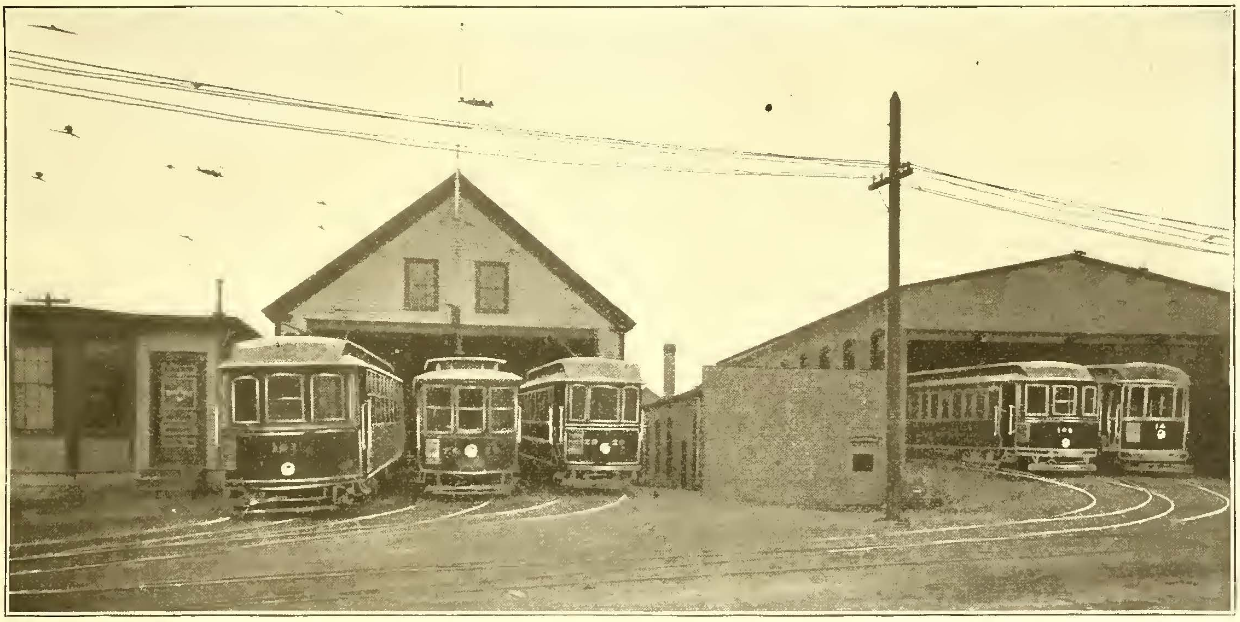
All the large cars of the company are equipped with the





TWO OF THE BRIDGES

Standard Traction Brake Company's air brakes with axle-driven compressors. Where compressed air is available whistles are used. The registers are of the single type, and were made by the New Haven Car Register Company. The Wilson trolley catcher made by the Frank Ridlon



OFFICE OF THE COMPANY AND CAR HOUSES IN MILFORD

Company and those made by the New Haven Car Register Company are both used.

PARKS

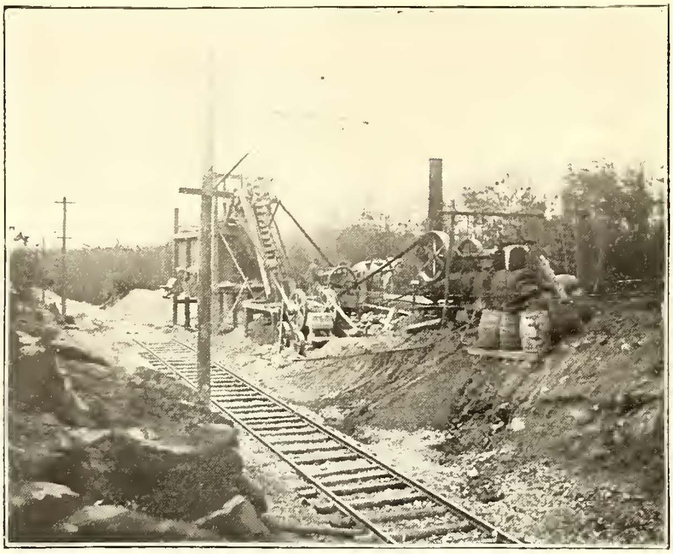
On the line of the Milford & Uxbridge Road the company has purchased a tract of woodland of about 15 acres, which it will fit up and use for a park known as Lake Mendon Park. A boathouse has been erected, and other buildings, such as pavilions and theater, will be built during the coming winter. It is proposed to have boats and launches on the lake, which contains about a hundred acres. The water in this lake is very clear, being fed by springs, with very little watershed, and is one of the most attractive places in this vicinity. Among the accompanying illustrations a view is shown of a waiting station that has just been completed at the entrance. A spur of track enters the park, so that a number of cars may be held here without interfering with the main-line traffic.

On the line of the Milford, Holliston & Framingham road, about $1\frac{1}{2}$ miles from its terminus at South Framingham is another pleasure ground known as Waushakum Park. This one the street railway company has nothing to do with as far as its operation is concerned, but it affords for the people at that end of the line an opportunity for amusement. The two parks are some 16 miles apart, and it is not considered that one will draw attendance from the other, on account of the distance. At neither is the sale of alcoholic beverages permitted, and the entertainments will be of the most refined character. No admission will be charged at the park controlled by the company, either to trolley riders or those who arrive in carriages.

OPERATION

The entire system is connected by a telephone circuit, which is placed about midway between the ground and the feeder circuit, both to obviate interference with the telephone currents by the trolley circuit and to allow for connection directly with the telephone wires, if it be advisable later to install a portable telephone system. At every turnout a permanent telephone is installed.

The Milford & Uxbridge line is built to a very large extent on the company's own right of way. This was necessitated at some points by the steep grades which occurred on the public roads, and which were somewhat reduced by choosing another route. The running time is thus not only greatly decreased, but the beauties of the road itself considerably enhanced. The large amount of excavating and filling that has been necessary and the construction of several handsome bridges has made this line very expensive to build, but the country which it will open up and the attractiveness, which is a result of the extra expenditure, will probably amply repay the engineers.



STONE CRUSHING PLANT, MILFORD AND UXBRIDGE LINE

The officers of the Milford, Holliston & Framingham Street Railway Company are: John T. Manson, president; Sidney Harwood, vice-president; E. W. Goss, treasurer and general manager, and M. E. Nash, superintendent. The officers of the Milford & Uxbridge Street Railway Company are practically the same, with the exception of the vice-president, whose position on the latter road is filled by Arthur R. Taft.

FIG. 2.—DROP HAMMER IN OPERATION

The Track Construction Department of the Union Traction Company, Philadelphia

There is probably no street railway company in the country which has a larger or more complete department devoted to track work construction and maintenance, or one which has developed a larger number of new types of track appliances, than the Union Traction Company, of Philadelphia. The track department is a branch of the engineering department of the company, and is in control of H. B. Nichols, engineer of maintenance of way, who is responsible in turn to W. S. Twining, chief engineer of the company. The yards of the company are located at Fifty-First Street and Haverford Avenue, where the company has facilities for making and assembling special work, all of which is designed in the railway drafting room, and a large part of which is of original design, to meet the conditions encountered in Philadelphia. In addition, the company has a most complete set of track apparatus and tools, which are described below.

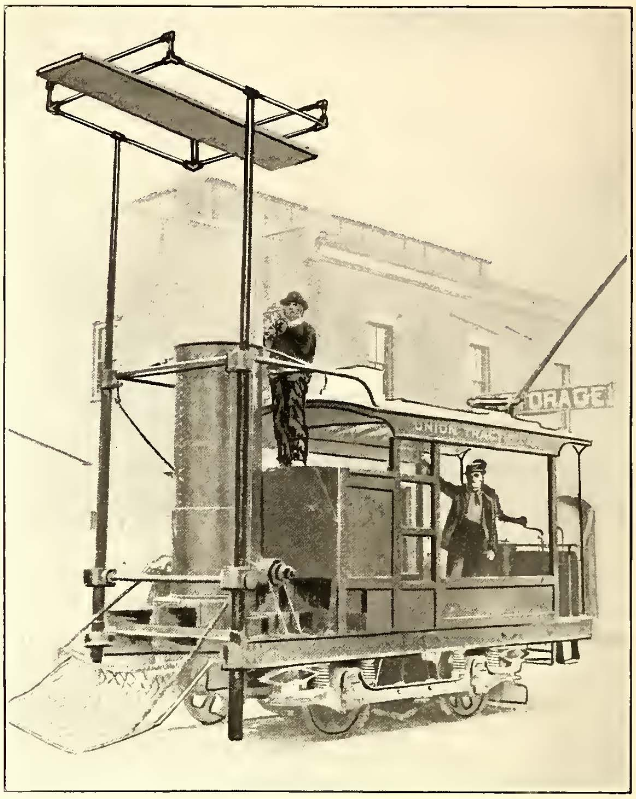


FIG. 1.—ELECTRICALLY DRIVEN CAST WELDING CUPOLA

CAST-WELDED JOINTS

During the past two or three years the Union Traction Company has cast-welded more than 5000 joints of old track, and about 2000 joints of new track. The joints so cast have stood very well under service; in fact, the method has been used to prolong materially the life of old track which was so worn that the ordinary angle-plates could not be installed upon it. The height of the rails so welded varies from $4\frac{1}{2}$ ins. to 9 ins., but better results were found with the 9-in. rail than with a shallower rail. Most of these joints have been cast by William Wharton, Jr., & Company. The company has, however, a special repair cupola, shown in Fig. 1, mounted on an old car truck and operated by motors. The cupola was originally used on a wagon, but was transferred to the electric truck about three years ago for ease in transportation. The only obstacle in the way of using a cupola operated over the tracks of the company was the danger from the hot blast from the top of the cupola injuring the trolley wire, which necessarily had to be right over it. This was avoided by suspending a sheet of asbestos, 20 ins. wide and 10 ft. long, above the cupola. This asbestos shield is carried on a frame, and its height is made adjustable, so that it can be lowered to allow the car to pass under a low bridge. The frame is counterbalanced, so that it can be raised and lowered easily.

FIG. 3.—DROP HAMMER

The cupola has a diameter inside of 22 ins., and from 6000 to 7000 lbs. of iron can be melted in it before blowing off. The air is supplied by a Sturtevant blower run by a 5-hp motor. The cupola is hinged on the platform by a universal joint to keep it level, and the top of it is held steady by springs to the frame. No injury has been found to result to a cast-welded joint by running the car over it a few minutes after it has been cast. The cupola holds about 1600 lbs. to 1800 lbs. of iron. The motor and blower are carried in the middle of the platform, and receptacles on each side provide for the coal, tools, iron, etc., carried on the car.

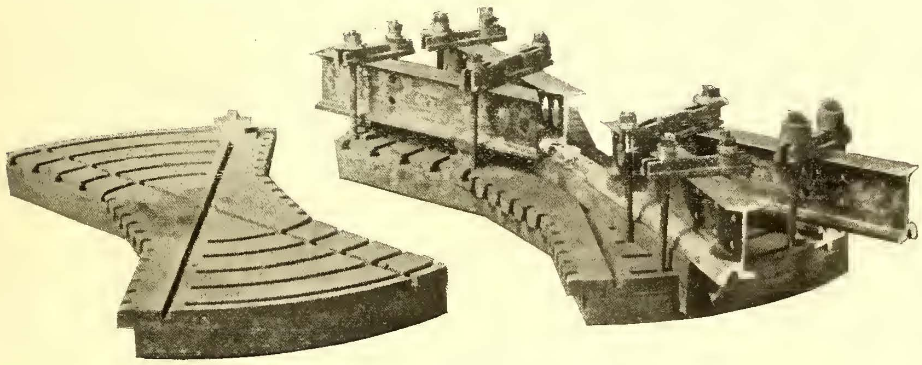


FIG. 4.—CROSSING CLAMP

It should be stated, however, that the company is not now cast-welding rail-joints, but is carrying on a series of extensive experiments with a "zinc joint," which was described in this paper for April, 1901.

PORTABLE DROP HAMMER

Another special appliance designed in the shops of the company and illustrated in Figs. 2 and 3 is the portable drop hammer designed for breaking cast-welded joints and pigs for the cupola. This is not electrically propelled, but is drawn by another car from point to point as its services are required. The winch is operated directly, however, by a G. E.-800 railway motor.

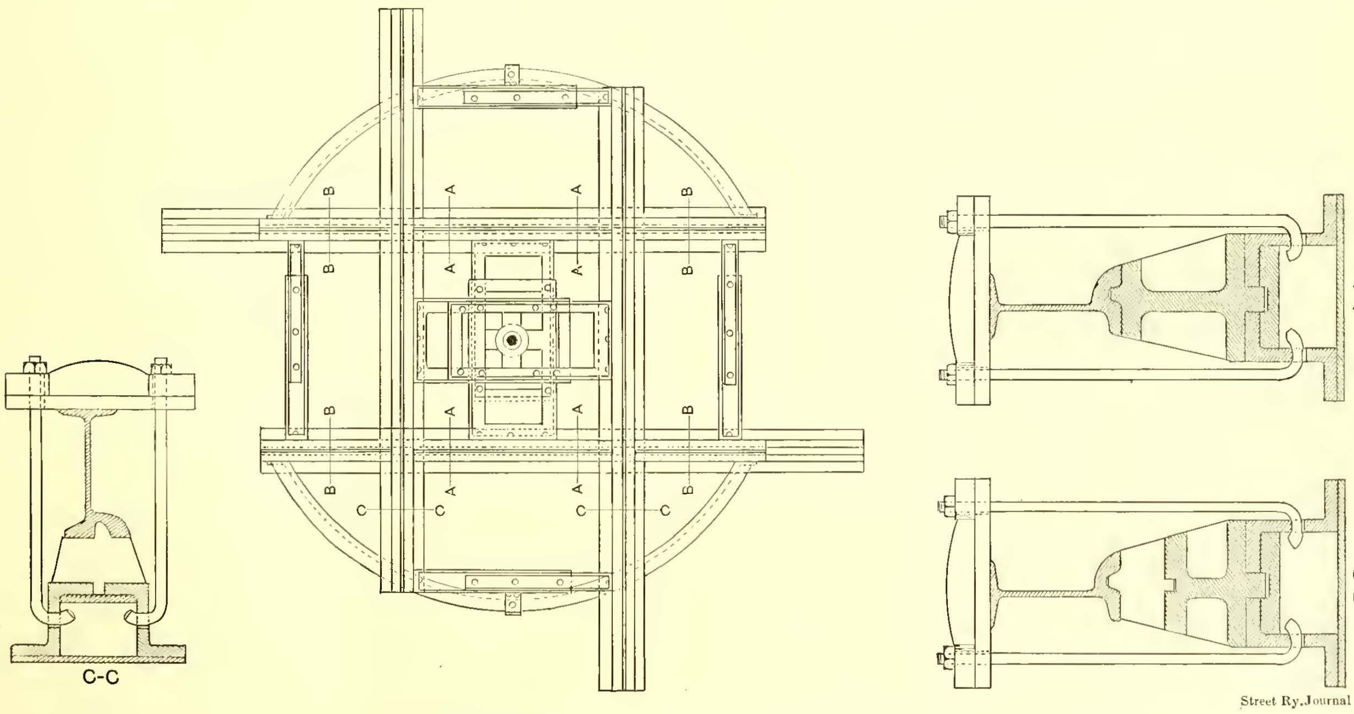


FIG. 5.—PLAN AND SECTIONS OF CROSSING CLAMP

The drop hammer weighs 1500 lbs. and has a fall of 16 ft. It is found that this drop hammer will break 9-in. joints without trouble, the hammer being dropped on the middle of the joint. Difficulty is experienced, however, in breaking joints in $4\frac{1}{2}$-in rail, as the joint and rails will bend under the hammer, crushing into the ties. Cast-welded track of this height is usually taken out by cutting the rail out every second joint.

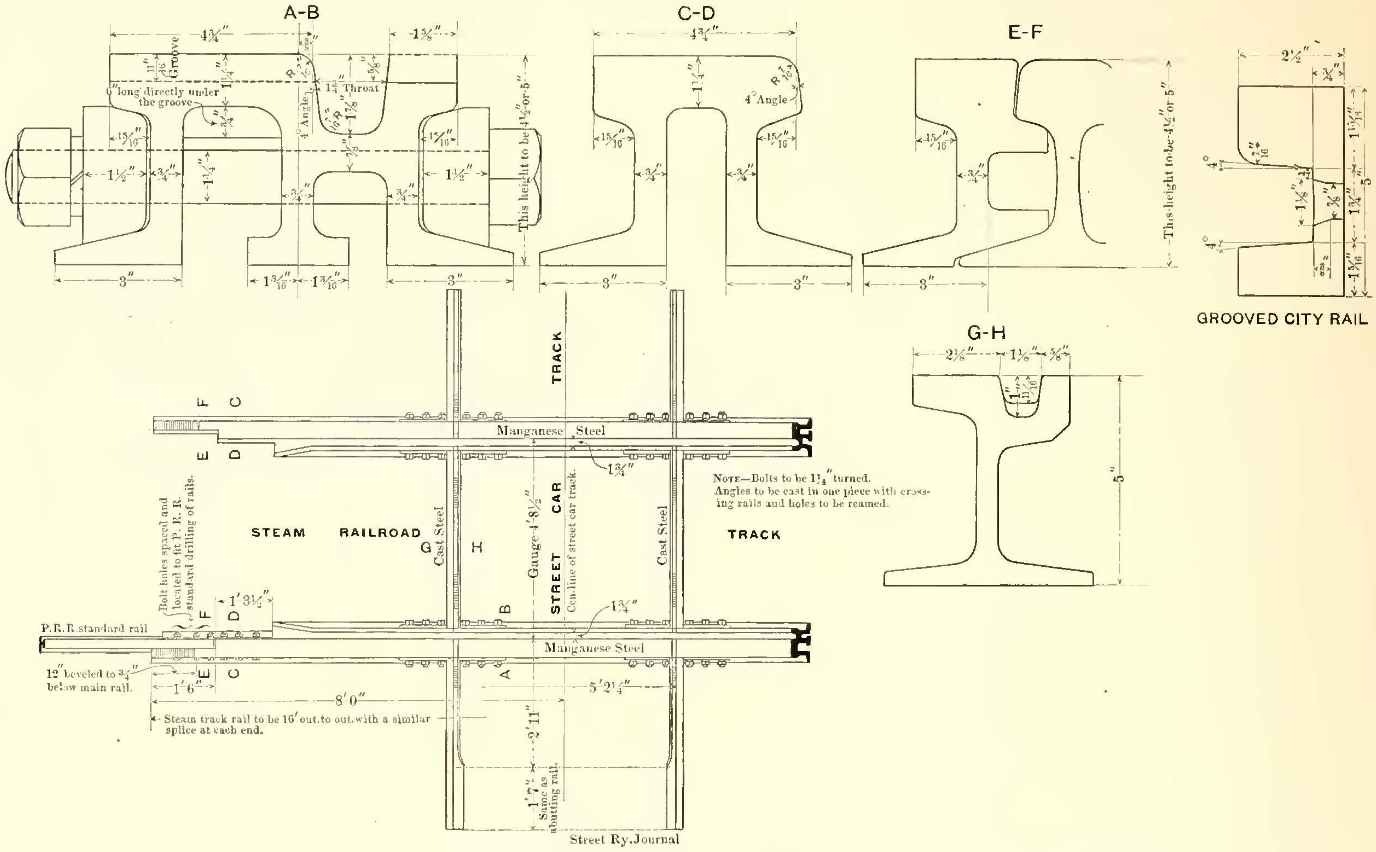


FIG. 6.—PLAN AND SECTIONS OF OLD FORM OF STANDARD STEAM RAILROAD CROSSING

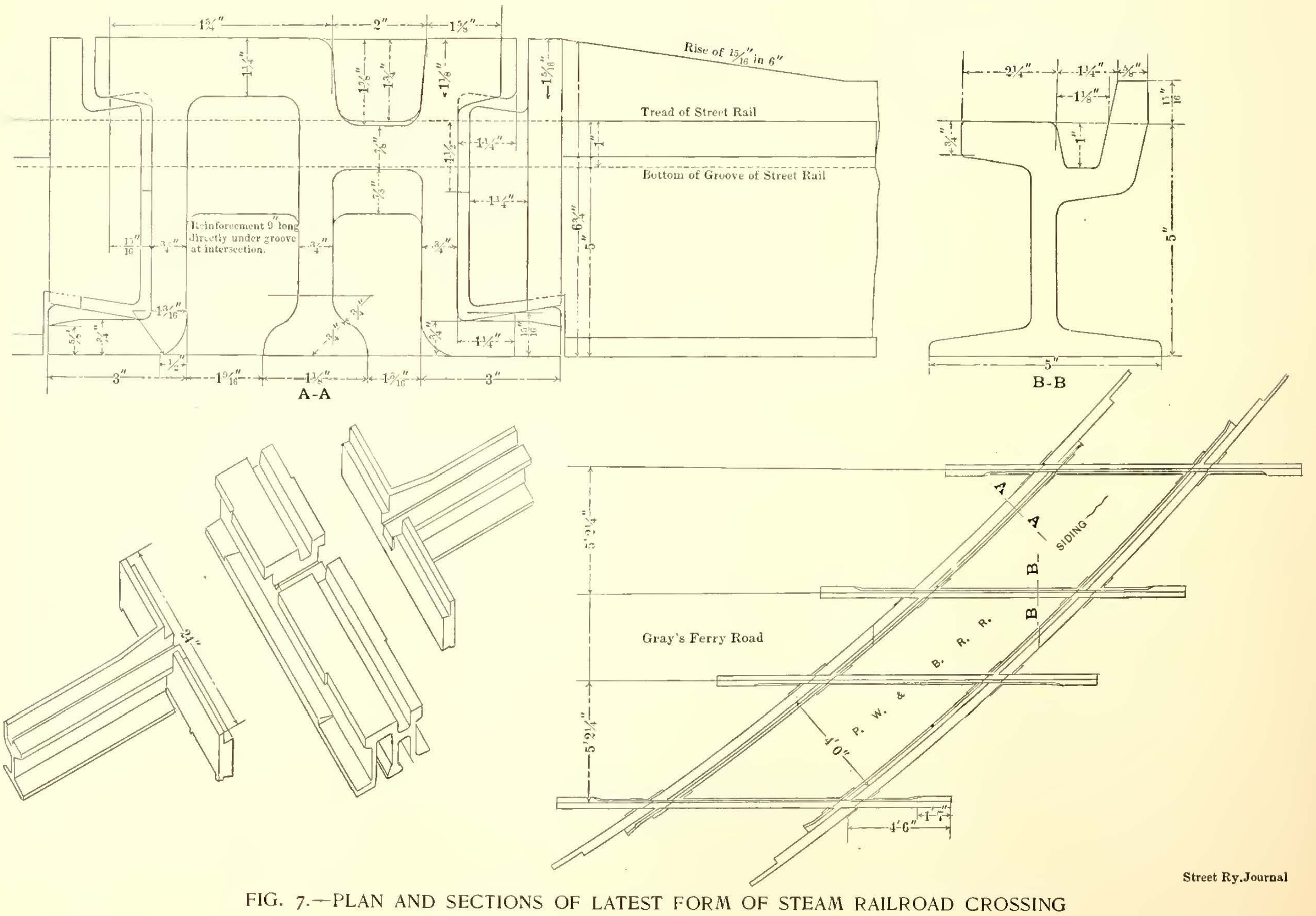


FIG. 7.—PLAN AND SECTIONS OF LATEST FORM OF STEAM RAILROAD CROSSING

60-FT. RAIL TRUCK

For transporting 60-ft. rails from one point to another a novel collapsible truck is employed. This is designed to be drawn by horses, and is arranged similar to a fire truck, with a steering wheel connected to the rear axle. The frame connecting the two ends of the truck consists of a 6-in. pipe into which a 4½-in. pipe is slid. In this way the wagon, which can be shortened to a length of 36 ft. for storage, can be extended 54 ft. or more in length when in use. When of the required length the pipes are held rigidly in place by pins passing through both pipes. The davits at each end are for raising and lowering rails from the track.

TRACK GAGE

One of the products of the track shops is a track gage made of steel tubing and malleable iron ends. It weighs about 18 lbs., and, being entirely of metal, is not subject to as much damage as a wooden track gage would be.

SPECIAL WORK

The Haverford Avenue shops of the company turn out a large amount of special work for its own system. Chrome steel centers are largely used for the special work built. For the manufacture of all of this class of crossings the device illustrated in Figs. 4 and 5, and called a crossing clamp, is used. As shown in the plan, Fig. 5, the clamp is set for making a right-angle crossing, but the ends can be swung to one side or the other to make a crossing of any angle desired. After the rails required for making the crossing are cut to the proper length and shape desired, they are clamped in the proper position on this device, which is set in foundry sand, and the joints are then cast. The steel centers are, of course, set in after the joints of the crossing have been cast, and are held in place by zinc by a method patented by the engineers of the company. The diameter of the circle on which the arms of the clamping device swings is 8 ft.

STANDARD STEAM RAILROAD CROSSING

Fig. 6 shows an old form and Fig. 7 the latest form of standard steam railroad crossing built by the company, and

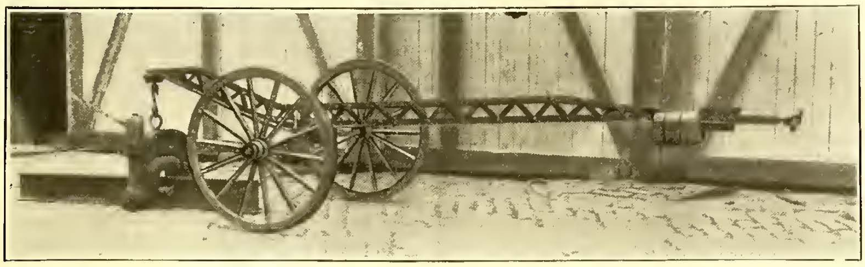


FIG. 8.—PORTABLE RAIL PUNCH

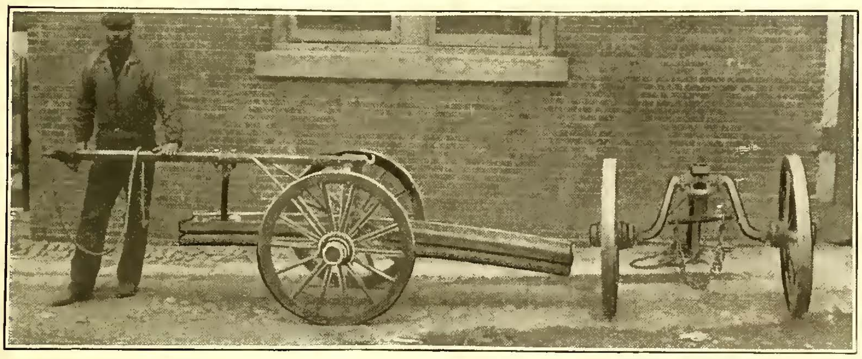


FIG 9.—HAND TRUCK FOR CARRYING PIECES OF SPECIAL WORK

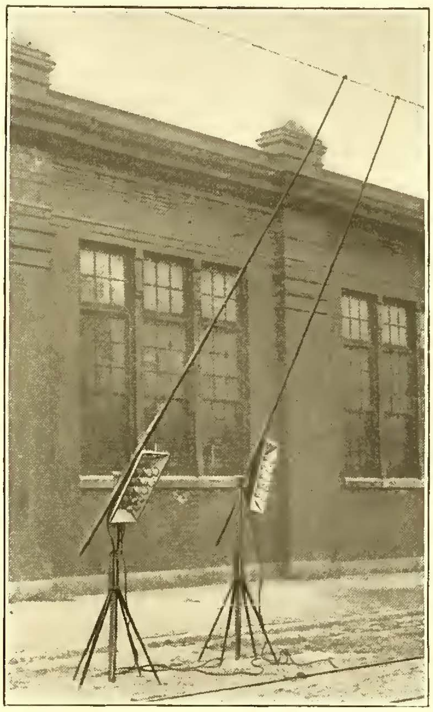


FIG. 10.—NIGHT LIGHT STAND

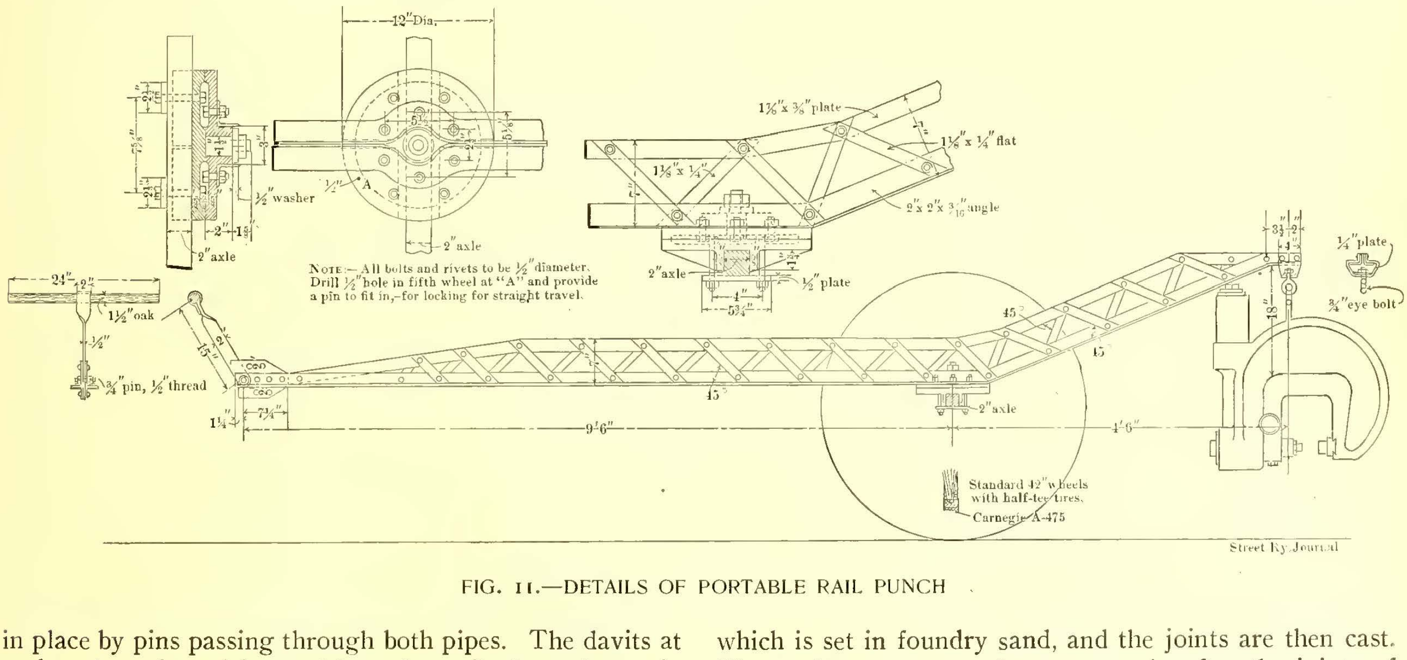


FIG. 11.—DETAILS OF PORTABLE RAIL PUNCH

adopted by the Pennsylvania Railroad, Baltimore & Ohio and other steam railroads crossing the tracks of the Union Traction Company. The two are alike, except that in Fig. 6 the street railway rails are bolted on to the steam railroad rails, while in Fig. 7 they are all cast together. Fig. 6 shows a standard right-angle crossing, while Fig. 7 shows an oblique crossing, but either can, of course, be made to any angle. The method employed in Fig. 7, of course, avoids the necessity of all fitting of the steel and manganese steel. Generally the two tracks are on a level, and the manganese steel rail for the steam railroads is cast with a groove to take the flange of the street railway wheel. Each of these crossings provides manganese steel service rails in one piece for the steam railroad service, while the street car rails are of cast steel. In this connection it should be stated that most, if not all, of the special work and devices made and employed in the shops of the Union Traction Company are manufactured under patents granted to engineers of the company.

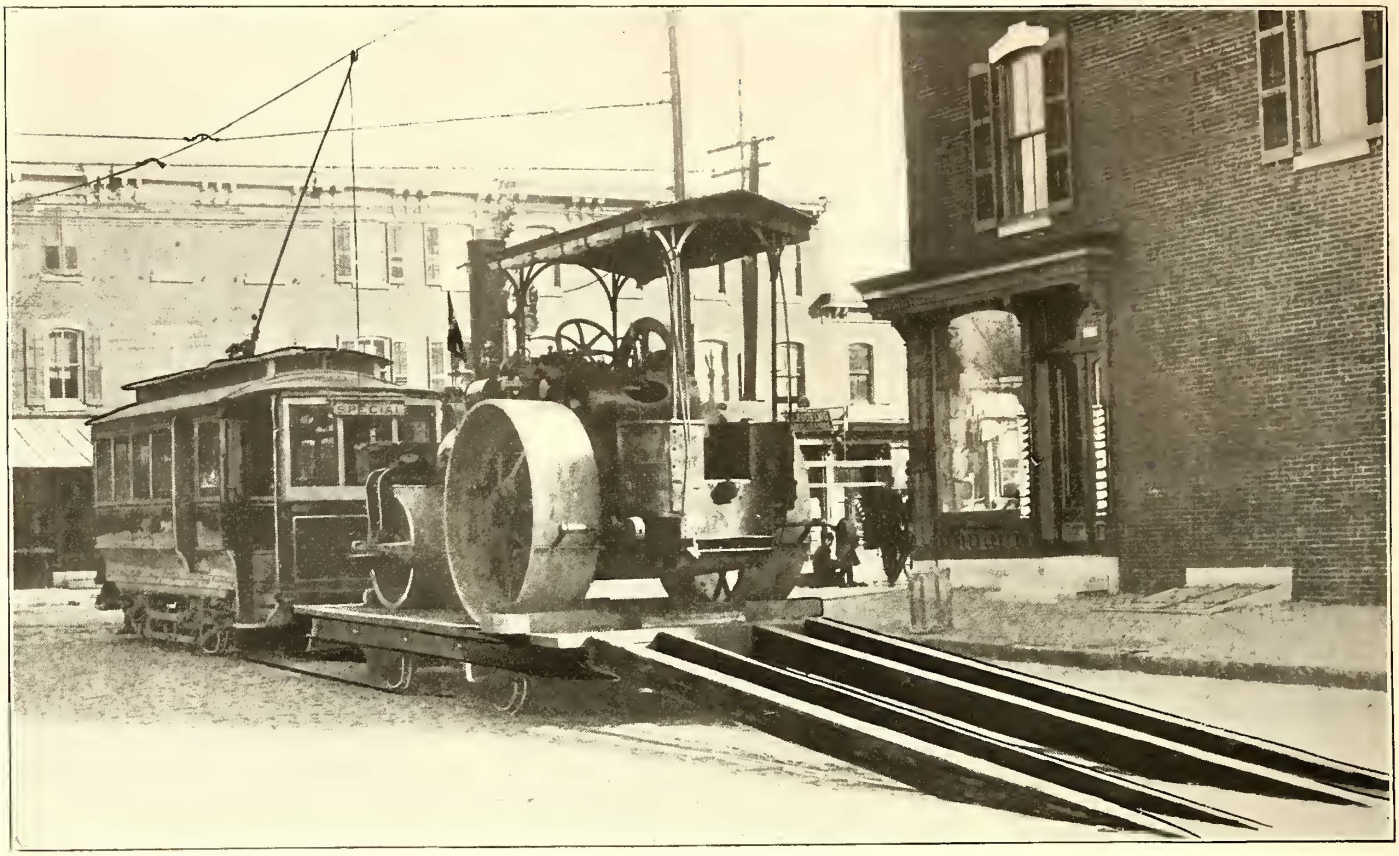


FIG. 13.—ROAD ROLLER AND TRUCK

FIG. 12.—ELECTRICALLY DRIVEN PORTABLE EMERY WHEEL

PORTABLE RAIL PUNCH

Figs. 8 and 11 show a portable rail punch for punching holes in joint-plates, etc. This is carried on the arm of a hand-wheel car, which is counterbalanced at the end to assist in raising the punch. The punch is used principally on the streets.

RAIL TRUCK

Fig. 9 illustrates a hand truck used for carrying short pieces of rail or parts of special work from one point of the grounds to another. As shown, the rail is slipped in a chain loop hung from the yoke of the truck, and is balanced by a brace set a short distance out on the handle of the truck. The chain has several large links, so that the loop can be made longer or shorter, according to the size of the piece of special work to be transported.

NIGHT LIGHT STANDS

The next engraving, Fig. 10, shows the very convenient piece of apparatus used to illuminate the work at night on the streets. As will be seen, it consists of a portable stand carrying a bank of ten lamps, with fishing-pole connection to the trolley wire. The ground terminal is connected to the rails. When a car passes, the poles are simply raised from the trolley wire, without disturbing the position of the stand.

RAIL GRINDER

Fig. 12 shows the portable rail grinder used for smoothing down cast-welded joints when they were employed. As

FIG 14.—GREASE CHARIOT

shown, it consists of a barrow on which is carried an electric motor of 2 hp, connected by a Stow flexible shaft with an emery wheel, which is held down on the rail by the worker.

ROAD ROLLER TRUCK

As the terms of the company's franchise provide for considerable macadam paving, the company owns a 15-ton road roller, and to assist in transporting it from one part

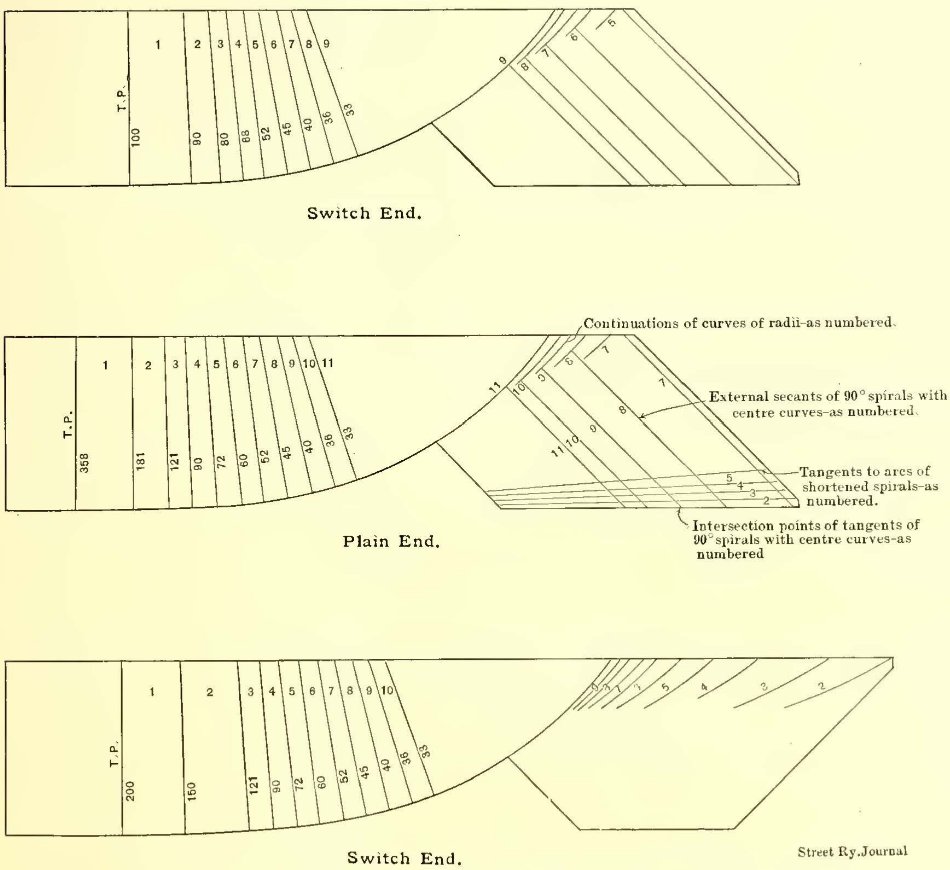


FIG. 16.—TEMPLETS USED IN LAYING OUT SPIRAL TRANSITION CURVES

of the city to another the ingenious truck illustrated in Fig. 13 has been devised. This truck is provided with an inclined plane, as shown, by which the road roller is run upon the truck, and it is then blocked in place. The truck is then hauled by means of a motor car.

GREASE CHARIOTS

This is the euphonious title applied to the vehicles adopted by the Union Traction Company to do away with the individual curve greaser. It was not found feasible to send the men out on foot with grease pails, as they could

FIG. 15.—GREASE CHARIOT

not carry very much with them and would take too long in going from one curve to another. It was also considered undesirable to send them around on the cars, as this plan involved a danger of soiling the clothes of the passengers. Each curve greaser has, therefore, been supplied with a little cart, illustrated in Figs. 14 and 15, and of which there are about fifteen employed on the system. These wagons are large enough to hold two pails of grease, sand, salt, a switch iron and a broom, and the men go rapidly from one curve to another. All curves on the system are greased at least once a day, and some curves three or four times a day. The chariot is large enough to carry all the material required during the day by each man.

SPIRAL CURVES

The company is using in all of its curve construction spiral transition curves of different types, depending on the radius of the curve. The standard initial radii are 100, 200 or 500 ft., and tables and diagrams prepared by the engineering department for laying out and installing these curves were published in the Street Railway Journal for February, 1899. It has been found convenient, however, in the drafting room to employ three standard templets in laying out the standard spirals. These templets are made of celluloid, and are reproduced in Fig. 16, which is just one-half the size of the templets used. The method of using these templets is as follows:

When the location of the straight tracks and all surveyed data where a curve is necessary are plotted, the templet is applied with its tangent side along the track line. It is then moved to and from the point of intersection of the track lines to determine the radius of the standard curve to be used, in order to clear curb intersections, manholes or other obstructions that may be on the ground. When the desired radius is determined upon, the center of the curve is located by the "Ordinates of Centers" given in the tables of the company, which were published in this paper for February, 1899, and which are used in connection with these templets. From the located center lay off the abscissas, which are also given in the tables under "Abscissas of Centers," thus getting the P. T. of the spiral. Then by applying the templet with the P. T.'s coinciding, the spiral part is drawn up to the point of C. C. of the determined curve; at the same time two points are marked on the paper at each side of the templet for the different radii of the spiral. The templet is then removed and the curve completed by drawing center curves by means of compasses, and the different radii of the spiral are drawn in by connecting the respective points already marked. The corresponding outside curve can be drawn in with the same templets by moving the P. T. of the templet ahead of the P. T. already determined until the gage at the C. C. is correct.

The spiral or cubic parabola curves, which are ideal for railway work, have been adopted by many progressive engineers as standard, but one of the reasons, if not the only reason, why they have not been universally adopted is the trouble, time and annoyance in preparing accurate drawings and making the necessary calculations, and for those not used to higher mathematics such curves are difficult to determine. With the help of such templets and standard tables, spirals can be laid out accurately and calculated with as much ease and rapidity as plain curves. The method employed at Philadelphia may go a long way to make spiral curves universal, at the same time may save a great deal of gray matter.

PRIVATE TELEPHONE SYSTEM

All of the offices, car houses and stations of the company are connected by a private telephone system, and telephones have also been located along the streets for the use of despatchers, inspectors, and for general railway purposes. The company has its own central exchange, which is located at the main car house of the company, at Eighth and Dauphin Streets, and the switchboard has 150 drops, representing that number of instruments in different parts of the city.

POWER STATION

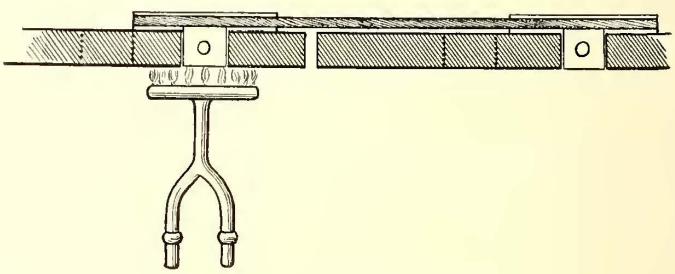
Owing to the large number of double-truck cars which have been placed in service recently, and most of which take the place of only one single-truck car each, the demands for current on the power stations of the company have been steadily increasing during the past year. The double-truck car has now been adopted as a standard on practically all the lines, and will replace the shorter cars as the latter wear out. A statement was published in the April issue of the STREET RAILWAY JOURNAL on the kilowatt output during 1900 of the seven different power stations of the company, and showed an aggregate output per month varying between 6,320,667 for September to 7,667,599 for December, 1901. This has increased during the past year, so that the output during October, 1901, was over 8,000,000 kw-hours. This increase has required an increase in power-station capacity, which has been partly secured by the addition of a 1500-kw Westinghouse generator, direct connected to Wetherill engines, in the Thirteenth and Mt. Vernon Street station, and which will be further supplemented by an 800-kw Bullock generator in the station at Thirty-Second and Dauphin Streets.

At the time of the consolidation of the various companies now comprising the system of the Union Traction Company there were ten power stations, of which two, shortly after the consolidation, were dismantled, and one was leased to the local electric light company. Of the remaining seven stations three were originally run non-condensing and three used mechanical draft. Natural draft and a cooling tower have been installed in the Thirty-Third and Market Street station, and a change to natural draft has been made in the Thirteenth and Mt. Vernon Street station. This leaves only one station, that at 920 North Delaware Avenue, with mechanical draft, and three are still run non-condensing.

A New Type of Rail Bond

The tramway system of Geneva, Switzerland, which, it will be remembered, is under the management of Stephen D. Field, the well-known American engineer and electric railway pioneer, has been using a type of soldered and protected rail-bond which has proved very satisfactory. Through the courtesy of Mr. Field, a view of the method of attaching this rail-bond is presented herewith.

The bond consists of a stranded U-shaped conductor, of fine copper wire, with plug terminals, and is designed to go under the angle-plate. The method of attaching the bond is as follows: The rail is bored, and the inside of the hole is thoroughly tinned. The bond-plug terminals are then inserted in the hole and an oxyhydrogen flame with a circular burner, something like an Argand gas burner, is then applied on the opposite side of the rail. The plug in the end of the bond contains a hole which is filled with solder. This melts out at the proper time through the agency of the heat, and completely fills the rail hole. The cost of the bond, complete and attached, is about 25 cents. Before the angle-plate is attached, the effectiveness of the soldering can be determined by pushing on the end of the terminal, and the integrity of the bond is thus assured. Although this method has been in use for considerable time, no defective bonds have been discovered.



RAIL BOND USED IN GENEVA

For the Demerbe rail, of which there is a considerable amount in Geneva, Mr. Field has devised a slightly different type of bond which has no plugs, but the terminals of the stranded cables are bound together by a flattened tube of perforated copper. This rail has a section something like an inverted U. The ballast is packed in under the head, in this way supporting the rail. The bond is clamped to the rail-web, and soldered on to it by the use of a gasoline torch.

The Milan-Monza Interurban Tramway

BY GUIDO SEMENZA

The first interurban electric railway of considerable importance put in operation in Italy was that connecting Monza and Milan, between which there is a large traffic, owing to the industrial character of both cities. This road

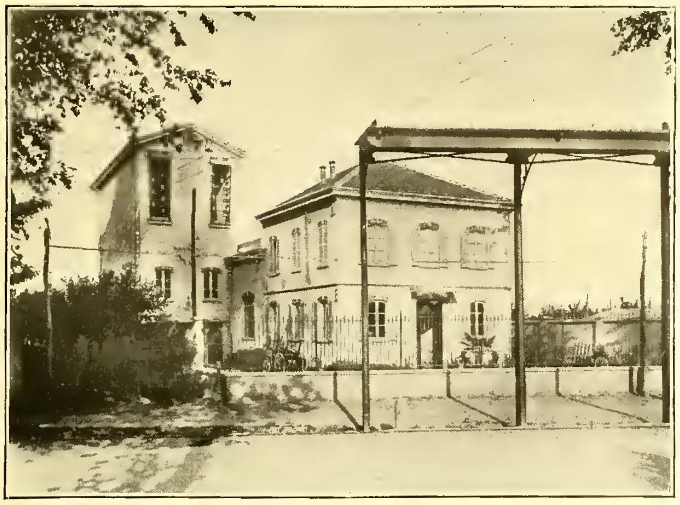


FIG. 1.—CONVERTER STATION AND MAIN DISTRIBUTING POINT FOR POWER ON LINE

was formerly operated by horses, and had to compete for traffic with a steam trunk railroad and two steam tram-

FIG. 2.—METHOD OF BRAZING RAIL BONDS

ways, and so continued until the last day of the last century. The road belongs to the Milan Edison Company, which also owns and operates the principal electrical distribution systems in the two cities mentioned, including lighting, power distribution and electric traction.

The line from Milan to Monza has a length of 10½ miles, including 2 miles of city track belonging to the local tramway system of Milan. The cars start from the very heart of the latter city close to the famous Milan Cathedral. From this point to Loreto at the city limits the track is double, and consists of a 93-lb. grooved rail of special profile called the "Milano type," shown in Fig. 3. Leaving this point the line runs for 5 miles on a beautiful avenue with high trees on both sides, and for the rest of the distance on an ordinary country road. After entering the city of Monza it terminates at the gates of a splendid park, where was the favorite residence of the late King Hum-

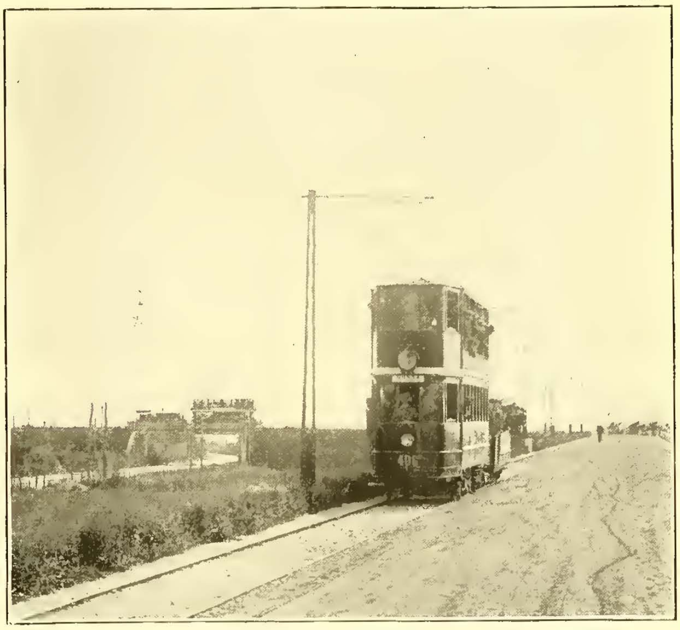


FIG. 4.—VIEW ON LINE BETWEEN MILAN AND MONZA

bert, and near which he was cruelly murdered. This park is one of the principal summer resorts of the public, both of Monza and Milan. The track for all of this part of the line is single, and consists of 53-lb. Vignole (T) rail. In general, the profile is flat, except at the point shown in Fig. 4, where the road crosses a bridge with 2 per cent grades at each side. The shortest radius curves are in Monza, the minimum radius being 54 ft.

The rail-bonding throughout is the same as that employed all over the Milan system, that is, two copper wires brazed to the foot of the rail. This method, which has been used since 1897, has given very satisfactory results. In fact, cases of electrolytic corrosion in pipes are quite unknown in Milan, and the bonds are always found in perfect condition. The brazing is done by making a coil at the end of the bond and using a hand blower. The process is well

FIG. 3.—A BRAZED RAIL BOND AS USED IN MILAN

illustrated in Fig. 2, and is of a section of the line between Milan and Monza, while a joint completed is shown in Fig. 3. The writer takes this opportunity of suggesting that this method of brazing the bond terminals has many advantages over that of employing solder for making the joint, as practiced by the Salt Lake Rapid Transit Company, and described in the STREET RAILWAY JOURNAL for March, 1901. At all events, he is glad to attest the fact

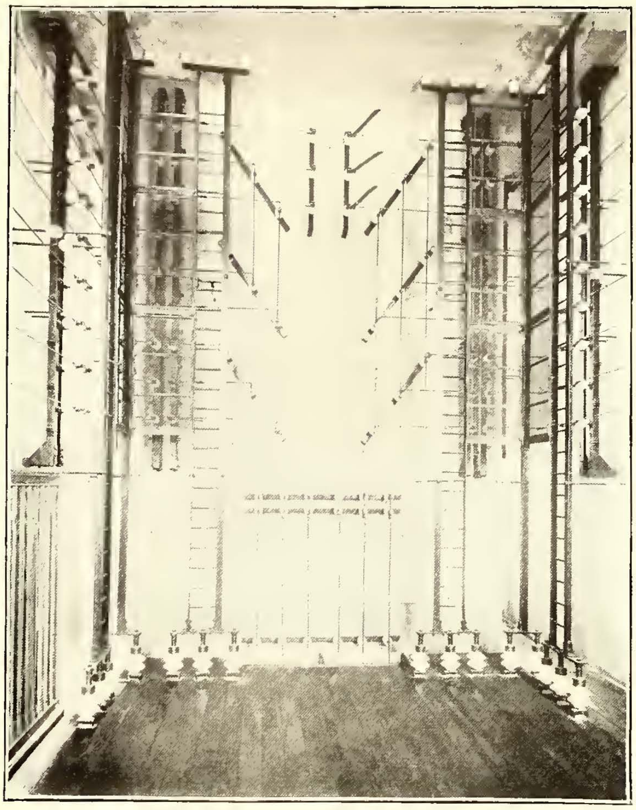


FIG. 5.—INTERIOR OF TOWER OF CONVERTER STATION

that an experience of nearly four years in Milan is quite favorable for the system of brazing.

The overhead system is used. Two No. 00 trolley wires are employed, supported for the greater part of the distance by iron bracket poles. These poles are composed with two U-shaped beams connected by a very light lattice work; the bracket is substantially made of an iron tube with some simple ornament. The overhead line insulators come from the General Electric Company, and do not need any

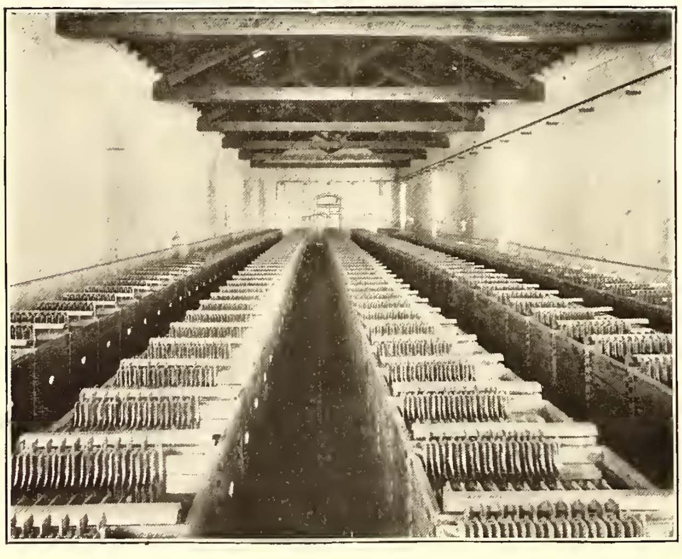


FIG. 7—STORAGE BATTERY ROOM

description. Besides the two trolley wires, a No. 00 feeder extends toward Monza for a distance of 2½ miles.

The generating station is located at the center of distribution, 2½ miles from Loreto. At this point the Paderno-Milan electric transmission line crosses the railway. This

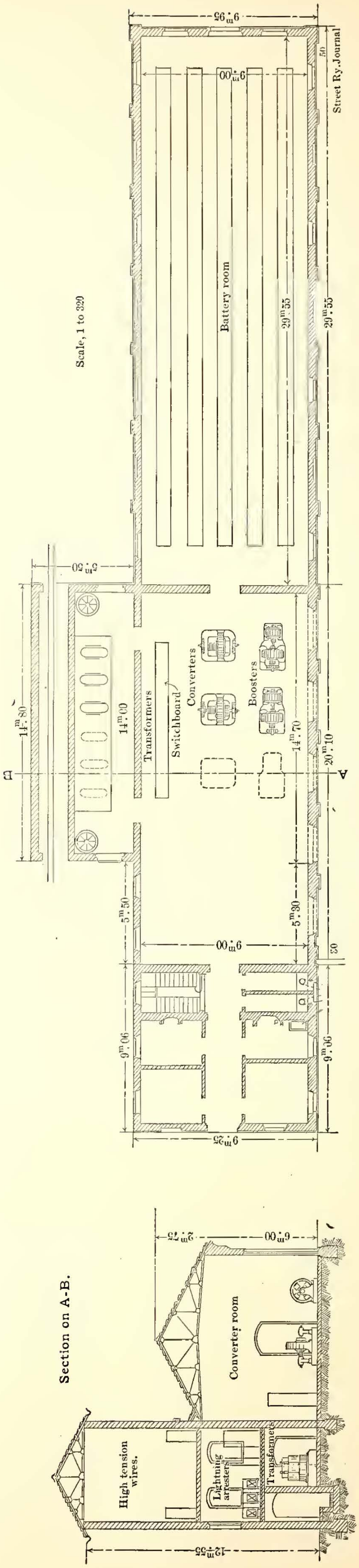


FIG. 6—SECTION AND PLAN OF CONVERTER STATION

line transmits to Milan the power of the rapids of the River Adda and is the principal source of energy for the plant of the Milan Edison Company. Near the crossing a sub-station was erected where the power derived from the line is transformed to direct current for railway use. The transmission line is composed of eighteen bare copper wires, No. 00, the current used being three-phase at 42 cycles, 15,000 volts.

FIG. 8—INTERIOR OF MAIN ROTARY STATION

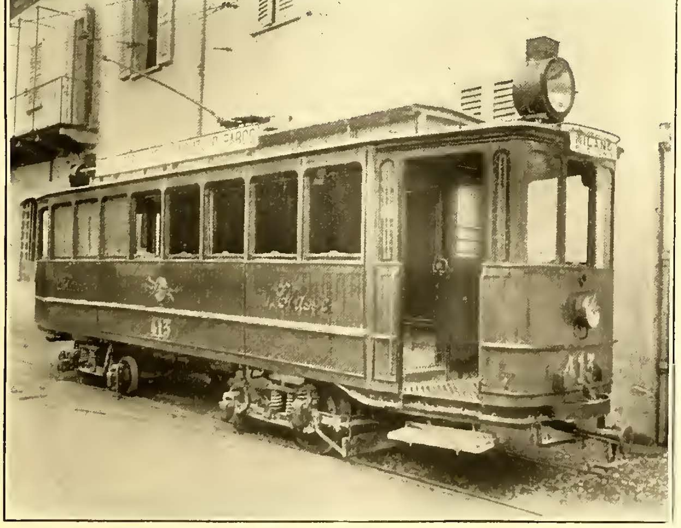


FIG. 9—CAR FOR WINTER SERVICE

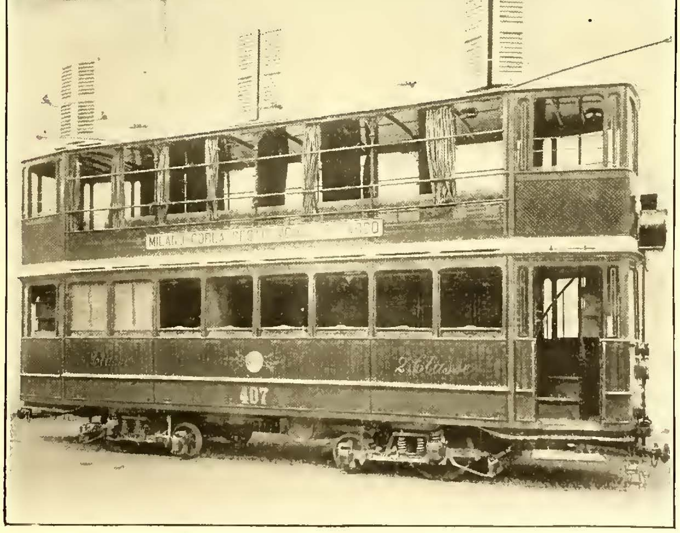


FIG. 10—SAME CAR WITH UPPER DECK FOR SUMMER

The sub-station is provided with a tower, through which these eighteen wires pass. The interior of the higher floor of this tower is represented in Fig. 5. On each of the side walls wires of the line are visible, while on the wall facing the reader is wiring necessary to tap current from any of the wires of the line. This same room is used also as a section point of the transmission line, and this explains the number of section switches that can be seen on the walls. From this room six wires descend into a room below where the transformers are placed. They are three in number and reduce the tension from 15,000 volts to 330 volts. The transformers are manufactured by Ganz & Company, of Buda-Pest, and are air cooled.

Next to this room is the machine room, in which two 200-kw rotary converters and two specially designed boosters driven by asinchronous motors are installed. The rotary converters were built by the General Electric Company, in Schenectady, N. Y., and the only special feature about them is that they work at a frequency of 42 cycles. This periodicity has not proved to be quite so satisfactory

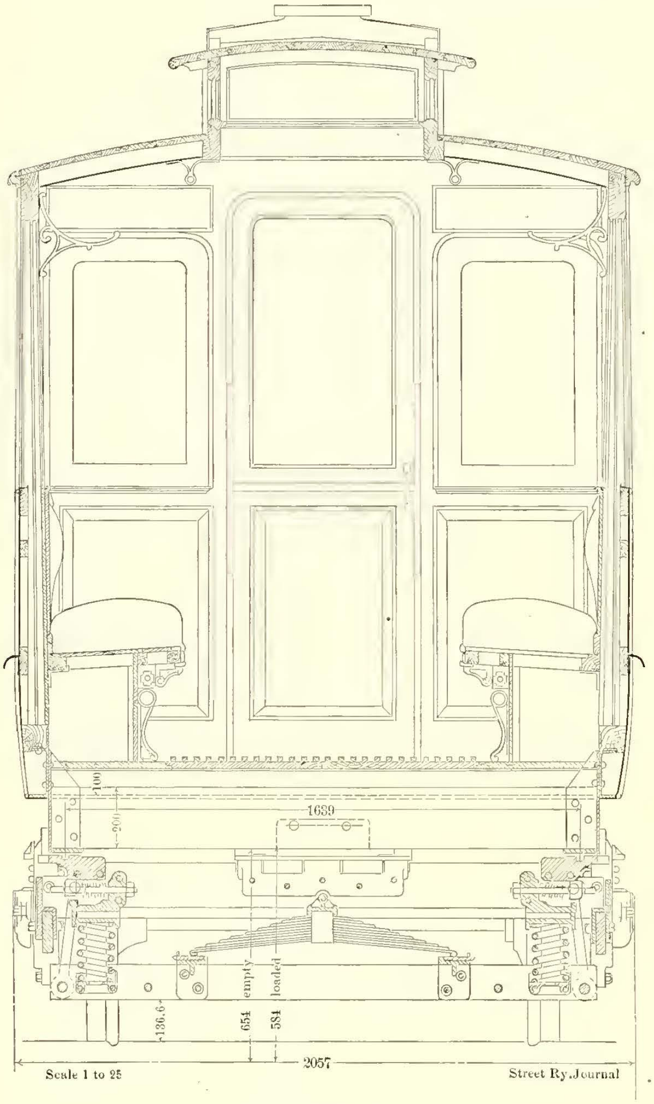


FIG. 11.—CROSS SECTION OF CAR

so far as the railway is concerned as that of 25 cycles. A storage battery works in parallel with the rotaries. To obtain good regulation a reactive coil was connected in series with the alternating side of the rotary. The combined effect of this reactive coil with the series winding of the rotary's field raises and lowers the continuous current voltage in correspondence with any decrease and increase of the load.

The boosters have a double function: (1) to boost up the voltage of the rotaries in order to charge the battery, and (2) to act as boosters for the line feeder. They are, therefore, provided with a shunt and a series field; the first one to be used when charging the battery; the second for feeder service.

A plan of the station is given in Fig. 6, and a view of the rotary-converter room is given in Fig. 8.

The battery was supplied by the Cruto Company, of Turin. Its capacity at a one-hour-discharge rate is 800 amp.-hours. Space has been left, however, to increase the capacity up to 1200 amp.-hours. The number of elements is 280. The positive plate is of the Mayert type, the negative one of the Pescetto type. A view of the battery is given in Fig. 7.

The standard motor car is vestibuled and mounted on double trucks. Fig. 9 shows the car with a single deck, as it will be used in winter, while in the summer season a second deck is mounted on the roof, as shown in Fig. 10. The interior of the car is divided into two compartments for first and second-class, and there are nine seats in the former and seventeen in the latter. The upper deck contains thirty-two seats of the second-class. In all, the car can carry sixty-eight passengers, and, when crowded, up to seventy-five.

In the construction of the car body there are several points that differ from the general American practice, specially as regards the amount of iron used. The lower frame is composed of U-beams, as will be seen from Fig. 11. The most important parts of the structure are strengthened by iron. The interior of the cars is very elegantly trimmed with woodwork, and the seats are of red and green velvet. The bodies were built in the works of the Milan Edison Company. The trucks come from the Brill company, and are of the standard maximum traction type. The electrical equipment consists of two G. E.-57 motors and type BA-23 standard controllers. Both motor and trail cars are provided with electric and hand brakes, and electric car heaters. The whole length of the car is 31 ft., and the weight of the empty car, with electrical equipment, is 14 tons. The trailers are of the same type as the motor cars, and have a single deck in the winter and a double deck in the summer. They differ from the motor car only in having one entrance in the center, instead of two vestibule entrances at the extreme ends.

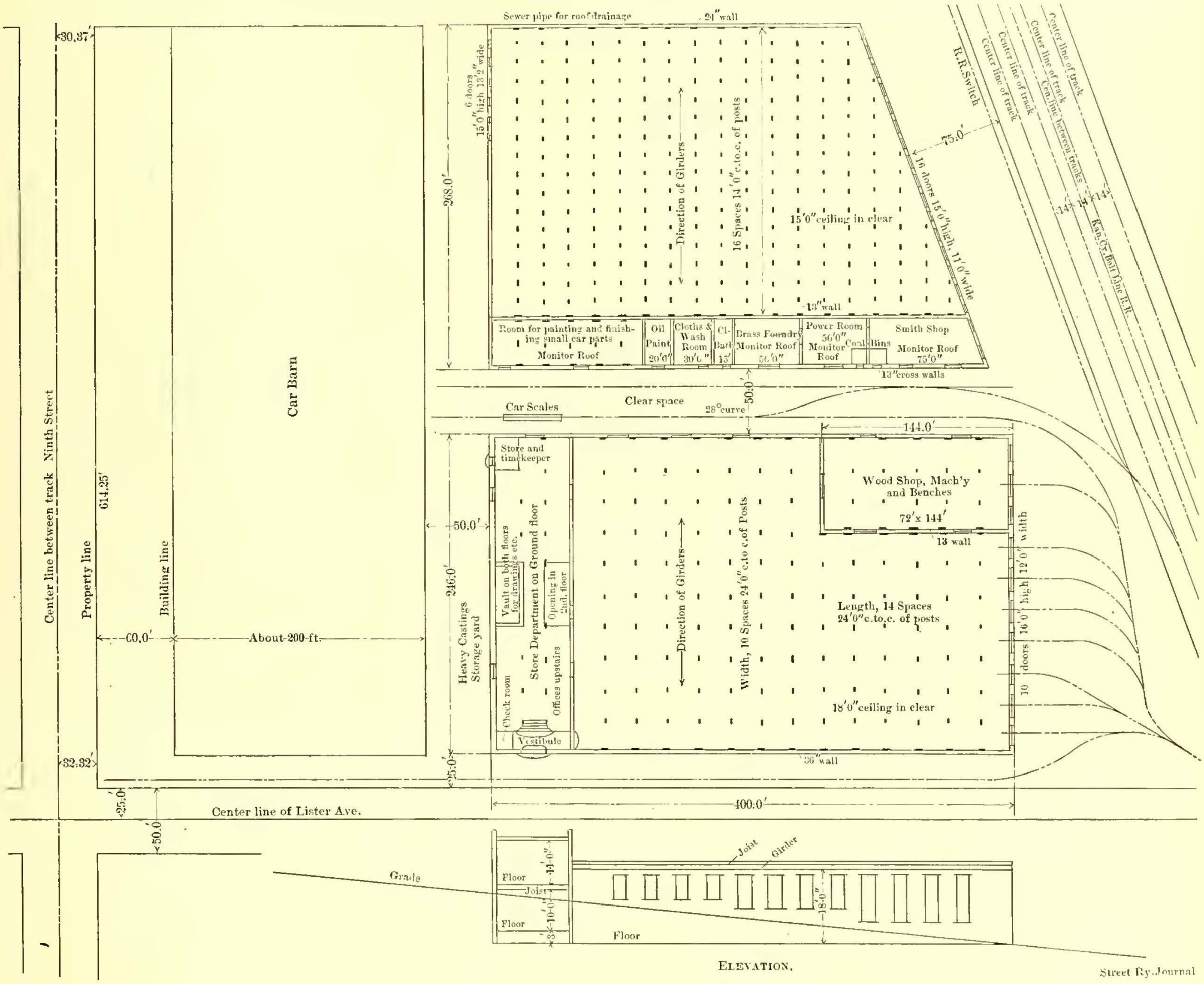
Extensive Repair Shops at Kansas City

Within about a year the Metropolitan Street Railway Company in Kansas City will have one of the most convenient and efficient shops in the United States. The plans have been made and the buildings are in process of construction. The original plans were sketched by James W. G. Becker, master mechanic of the company, and approved by W. H. Holmes and C. F. Holmes, president and general manager, respectively. The total cost will be about $190,000. The company will be equipped to build one hundred cars at a time if it should decide to build its own cars. Besides, it will be thoroughly equipped for all sorts of repairing.

The Metropolitan shops are being built on a tract of land containing 13½ acres, and will be very conveniently located. On one side of the tract is the Independence electric line, over which cars may be taken to and away from the shops. On the south side of the ground are the tracks of the Chicago, Milwaukee & St. Paul, the Atchison, Topeka & Santa Fe and the Kansas City belt railroads, which will conveniently carry all material and freight to the shops. There will be numerous switches from the railroads and from the electric lines entering the shops, increasing the convenience of hauling freight and moving cars.

The shops will be included in two large buildings—the paint shop and the construction shop. Besides these, there will be a car house.

The paint shop is already nearing completion. It is a one-story brick building, 340 ft. long x 268 ft. wide, and the railroad tracks run along the south side of it. At one end of the building is a subdividing wall, a fire wall, cutting off a strip 38 ft. wide, and extending the entire length of the building. This strip is divided into several smaller rooms, which are to be used for various purposes. The first of these is the blacksmith shop, 75 ft. x 38 ft. In this there will be a steam hammer and four blacksmith fires and several furnaces. The next room, another subdivision of the long strip along the side of the paint shop, is the brass foundry. This is 50 ft. x 38 ft. in dimensions. It will have a sand floor, and will be complete in every particular. New apparatus will be bought for it—benches, flasks, furnace crucibles of different sizes and the other appliances that will be needed.



PLAN OF NEW REPAIR SHOPS OF THE METROPOLITAN STREET RAILWAY COMPANY AT KANSAS CITY

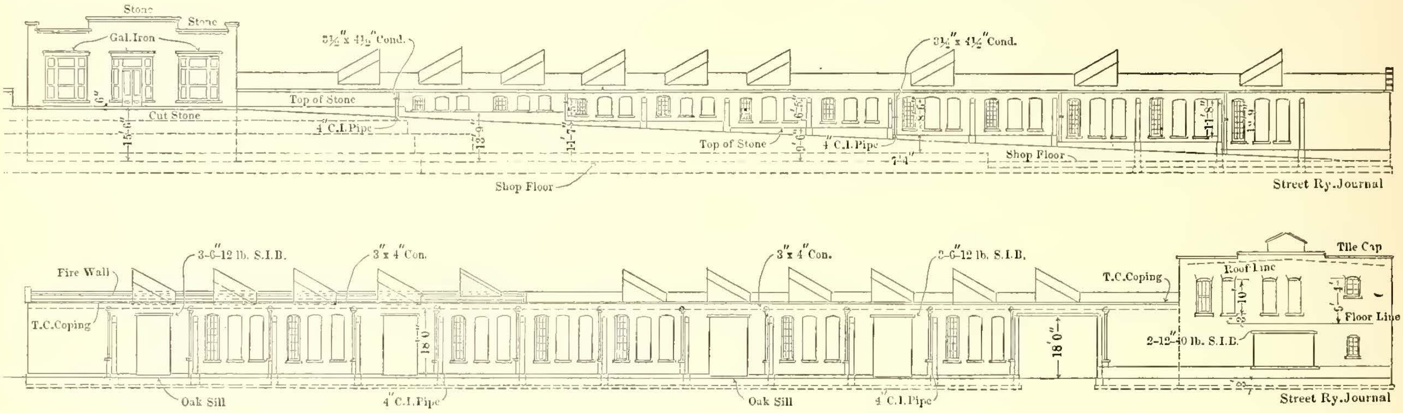
Next to the brass foundry will be the toilet rooms and bath rooms. This room will be 15 ft. x 38 ft. The men employed in the cramped shops of the Metropolitan Company now are obliged to go to their homes dirty after a day's work because there is not room in the building to provide the necessary toilet facilities. In the new shops there will be tub and shower baths and every necessary and convenient thing for the bath rooms, for next to the toilet and bath room is the large wash and clothes room. In this there will be one hundred fireproof lockers, and washbowls, so that from twelve to fifteen men can wash at once. As soon as the men reach the shops in the morning they will go to the clothes room, change their clothes for the overalls of the shops, and lock their other clothing in their lockers. At night, after washing off the grime of a day's work, they will change their clothes again and go to their homes clean and refreshed.

An oil and paint room, 20 ft. x 38 ft., adjoins the wash and clothes room. The walls of this room will be carried up higher than the walls surrounding it, like a low chimney, for in this room will be stored the supply of oils and paints, and there would be danger of fire. The last of this row of rooms is the largest, being 140 ft. x 38 ft., and it will be used for painting the trimmings and smaller parts of the cars, such as sashes, linings and other parts.

The main part of the building will be used, of course, for painting the cars, and they will stand in the building until dry. Sixteen tracks will enter the building and connect with the Independence electric line, over which cars will be taken to and from the shops.

This paint shop will be one-story high, with skylights over the main part of it, saw-tooth section roof, the windows facing south. The ceiling will be painted white for better light. Over the side rooms, the blacksmith shop, brass foundry, etc., there will be monitor roofs. The building will be of mill construction, wooden columns, girders and joists. This building will be completed first.

Next to it will be the big construction shop, 246 ft. x 400 ft. In the southeast corner of this large room, occupying a space of 144 ft. x 72 ft., will be the wood-shop machinery, including the apparatus for mill and bench work. A strip 60 ft. wide at the north end of the building will be separated by a wall, and will be two stories high, while the main part of the construction shop will be one-story high. The two-story section will be used for a storeroom and for the offices of the master mechanic and the chief electrician and their assistants. The offices will occupy the top floor. There will be a vault for records and for drawings, etc. In the end of the storeroom will be a fireproof vault divided into two parts. In one part will be kept the electrical instruments and testing apparatus, and in the other part the oils, varnish and paint of the store stock.



END ELEVATIONS OF MACHINE SHOP

The main part of the construction shop will be used for the repairing and construction of cars. There will be an electric department and machine shop, the former extending the entire length of the building on the west side, and the latter extending along the east side, while the construction will be carried on in the center of the shop. The tool room will be in the machine shop. In the construction shop there will be four traveling cranes of 20 tons each, three lengthwise of the building and one across, so that a load can be carried from any part of the shop to any other part on a traveling crane. There will also be a crane in the storeroom running out on to a platform, so that the heavy material in the store stock can be handled easily and with despatch. There will be doors opening into the storeroom from the shop for further convenience. Windows will open from the office down into the shop, so that the master mechanic can see all parts of the shop without leaving his desk.

The construction shops will have steel Lorimer columns, girders and steel beams. The roof will be of mill construction. There will be numerous switches into the shop from the electric line which runs alongside, and switch facilities from the railroad tracks, so that new material can be taken at once on freight cars to the shops.

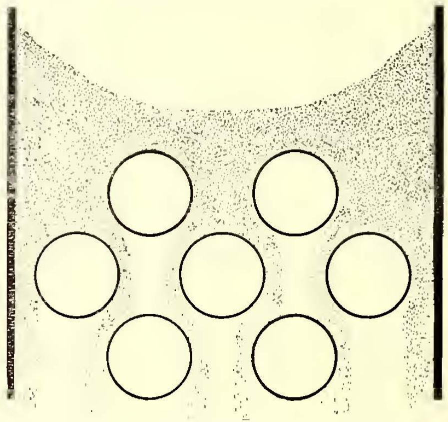
Plans have also been made for a large car house on this tract of 13½ acres. This car house will be 600 ft. long and 200 ft. wide, and have a capacity for storing about 300 42-ft. cars. This will be built when the shops are completed. There is also planned a dry kiln of late design near the main buildings, for the purpose of drying the lumber used in the repair and construction of cars. Besides this, there will be ground remaining to store heavy and bulky material, like rough lumber, ties, rails, etc.

The whole grounds will be surrounded by a high, solid board fence surmounted by barbed wire, with sliding gates for the admission of cars.

To fit up its shops, the Metropolitan Company will require a considerable quantity of new machinery. There will be an individual motor for the machine shop and wood shop, an air compressor and pipe plant complete. Compressed air will be used for hoisting, for cleaning cars, for drilling and chipping in the machine shop and for many other things.

Sacramento Notes

The Sacramento Electric, Gas & Railway Company has a system so located geographically that it is possible to have the conductors turn in their collections every trip. All the lines in town terminate at the Southern Pacific Depot, at which point is also the Southern Pacific Company's main repair shop. As a great deal of the travel comes from the workmen employed in the shops, the terminus for all of the cars at this point is desirable. The men are paid every night by the receiver at the common terminus and sign a receipt for their wages. Twenty-one cars are run on ordinary schedule, which number is increased to thirty-six on holidays. The population of Sacramento is about 29,000, and it is well spread out. The company furnishes family tickets, which are good for two rides a day for the use of each employee's family. This is done because by enabling the employee's wife or some other member of his family to go to market in the central part of the city every day it is possible for the employees to buy to much better advantage than if dependent upon the small stores located in the outskirts, and the company feels that it should help its employees to this extent. The company sells twenty-two tickets for $1, and the tickets used are of aluminum, about the size of a nickel. Half-fare tickets for children under twelve are of aluminum of hexagonal form. The cars are equipped with what is known on the Pacific Coast as the Clark automatic fender, which was devised in Oakland. The amount of money paid out for damages and accident claims is less than 1 per cent of the gross earnings. The shops are well equipped with apparatus for handling wheels and armatures. The pits have sectioned track for removing wheels, and jacks for letting down armatures and wheels.



SECTION OF ELECTRIC SAND DRYER

As the company gets its power from a waterfall, it is enabled to use an electric heater for drying sand. The principle of this heater will be made clear by a glance at the accompanying sketch. The sketch represents a cross section through a part of the heater. The tubes shown are electrically heated by having wire wound on them, and as the sand becomes dry it drops down in the space between the tubes. Until it becomes dry it cannot drop through. The railway is but one department of the company, which operates also an electric light and power service. F. A. Ross is superintendent of the railway department.

The Performance of Electric Railway Motors

BY GEORGE T. HANCHETT

After the preliminary survey has been made, the schedule speed fixed, the weight of the cars evaluated, and the draw-bar pull on the various parts of the line computed, comes the selection of a railway motor to do the work. It is a grave error to compute the necessary horse-power and buy a motor rated to correspond, for railway motor ratings are made on an artificial basis for the purpose of relative comparison, and are a very insufficient guide to an intelligent selection. Reference must be had to a reliable system of performance curves over the limits of load, and these curves are so useful and important that, even at the risk of being elementary, the writer proposes to devote a few paragraphs to the analysis of their general character before dwelling on their application.

All the functions of a railway motor performance vary with the current load, and it is, therefore, customary to plot them all on the same sheet, with amperes as the abscissa, reserving the ordinate for the characteristic function to be displayed. These curves, in the order of their importance, are as follows:

1.—The curve of horizontal effort or draw-bar pull.
2.—The speed curve.
3.—The temperature or time curves.
4.—The horse-power input curve.
5.—The efficiency curve.
6.—The horse-power output curve.

The horizontal effort is first, for the first requirement is that the motor pull the load. How fast it pulls it, makes the speed curve of next interest. Reference to the heat data must next be had to be sure that the motor will do the work without destroying itself, and having thus obtained assurance that the motor will safely and satisfactorily perform the work, the necessary energy to be expended is interesting, and the efficiency with which the motor employs it is to be considered, leaving the horse-power output last of all, a quantity irrevocably fixed by the load and speed, and, therefore, not to be changed by motor selection.

Taking these curves up in order, we have first that of horizontal effort, which is directly proportional to the torque of the motor, and can be converted thereto by simple multiplication by a constant dependent on the gear reduction and the wheel diameter. Therefore, the draw-bar pull is directly proportional to the product of the current, and the strength of the field, and its equation is $H = f\,k\,c$, where H is the horizontal effort, f the field strength, c the armature current, and k a constant dependent on the design of the motor and its connection to the car. If f was constant, the draw-bar pull curve would be a straight line inclined to the axes, but as f increases with the current, the curve is a more complex function, and exhibits a departure from a straight line, bowing downward from the axis of H. As the current increases, so also does f, but not proportionally, and at saturation f becomes approximately constant. Therefore, beyond the saturation current the H curve becomes a straight line, and its widest departure therefrom is to be found near the origin where the increase of f with the increasing current is greatest. Fig. 1 displays a typical curve of horizontal effort, in which the features referred to can be clearly seen. The curve does not intersect the origin, because near that point the speed becomes so high that all the torque developed is needed to overcome the motor friction.

The curve of speed roughly approximates a hyperbola asymtotic to the speed axis. Therefore, a railway motor, or, indeed, any series motor, rapidly gains in speed as the load falls off. If the motor had no losses the speed at zero load would, according to the equation, be infinite and practically might reach a very dangerous figure. As a railway motor is never relieved of its mechanical load in service, only such parts of the speed curve as correspond to working load are of interest.

Considering the typical curve also shown in Fig. 1, we find that as the current increases the speed diminishes.

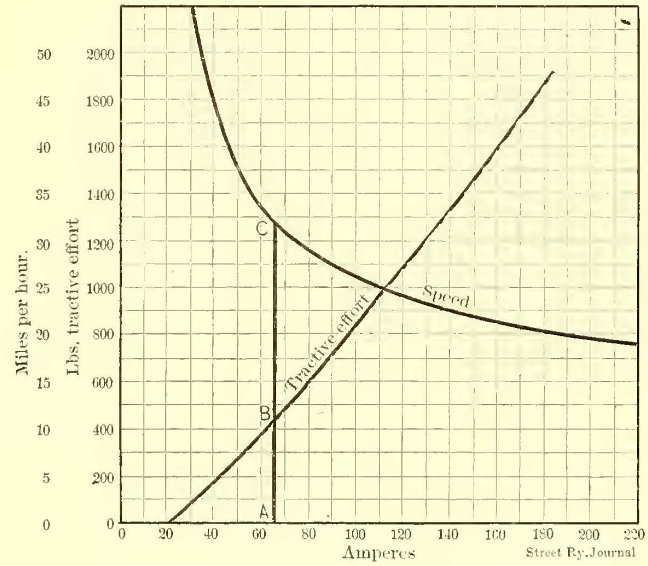


FIG 1.—CURVES OF SPEED AND TRACTIVE EFFORT

This is due to two causes; first, the increasing field strength to which the speed is inversely proportional, and, second, because of the increased armature drop, which entails a reduction of back e. m. f., and, therefore, of speed, in order to permit the necessary current to flow. The armature drop factor is small, compared with the field factor, and hence the speed curve of a series motor is a rough kind of saturation curve plotted in a peculiar way, the "knee" of the curve occurring at that point where it turns to approximate parallelism with the current axis. From this it follows that the sooner this occurs, as the current increases, the greater the reluctance of the magnetic circuit, and other things being equal, the lighter the motor. It is sometimes convenient to plot speed curves at different voltages which produces a family of approximate hyperbolae, the lower voltage curve including those of higher voltage.

Temperature, or time curves, of railway motors are unfortunately not as satisfactory a performance guide, as they cannot be taken under conditions which duplicate the variable character of those of practice. They commonly appear, as shown in Fig. 2, as curves, concave to both axes and asymtotic to both. The horizontal axis is, as usual, represented in amperes, and the vertical axis in minutes, the points of the curve representing the time which must elapse before the motor reaches a given temperature, say 75 degs. centigrade above the atmosphere for any given value of current. It is customary to assume a starting temperature, say 25 degs. centigrade, but it is obviously erroneous to assume that any constant value can be given to this quantity. Car tests are little better than stand tests, because of the difficulty of obtaining a representative average of the varying values of the functions to be measured.

A family of heat or time curves, as they are sometimes called, is obtained by plotting them with reference to different final temperatures.

The efficiency curve does not start at the origin, but on the current axis, at the same point as does the curve of draw-bar pull, where the horse-power output shows an excess over the losses of the motor. It rapidly rises with

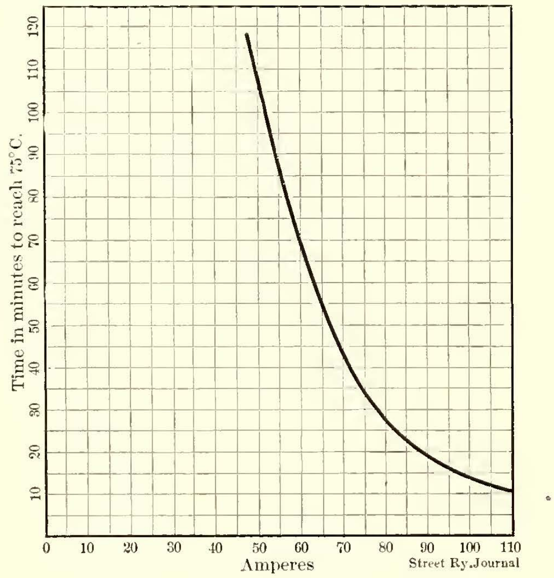


FIG. 2.—TYPICAL TIME CURVE

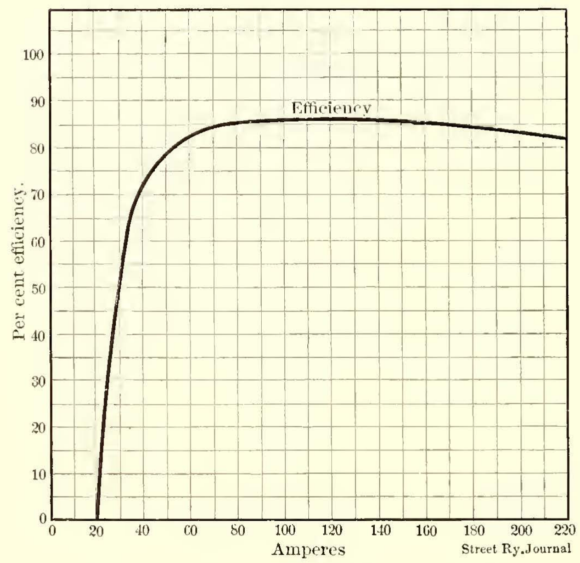


FIG. 3.—TYPICAL EFFICIENCY CURVE

the current, and quickly reaches a maximum value, after which it begins to droop.

This curve is computed from the ratio of the ordinates of the horse-power output to the horse-power input curves. The location of maximum efficiency with reference to the load is important, for, other things being satisfactory, it is obvious that it is best to select a motor whose efficiency shall be highest at the particular load at which it is to operate most of the time. The efficiency of a railway motor rarely exceeds 85 per cent, for the reason that it is necessary to work the materials at their maximum possible output. A typical efficiency curve is shown in Fig. 3.

The horse-power input can always be calculated from the current if the voltage be known, and is represented by a straight line intersecting the origin and inclined to both axes, because with constant voltage the horse-power is directly proportional to the current.

The curve of brake horse-power is best considered by plotting it on the same sheet with the curve, or straight line, of horse-power input.

It exhibits a concavity upward toward the horse-power axis. The horse-power input being always greater than

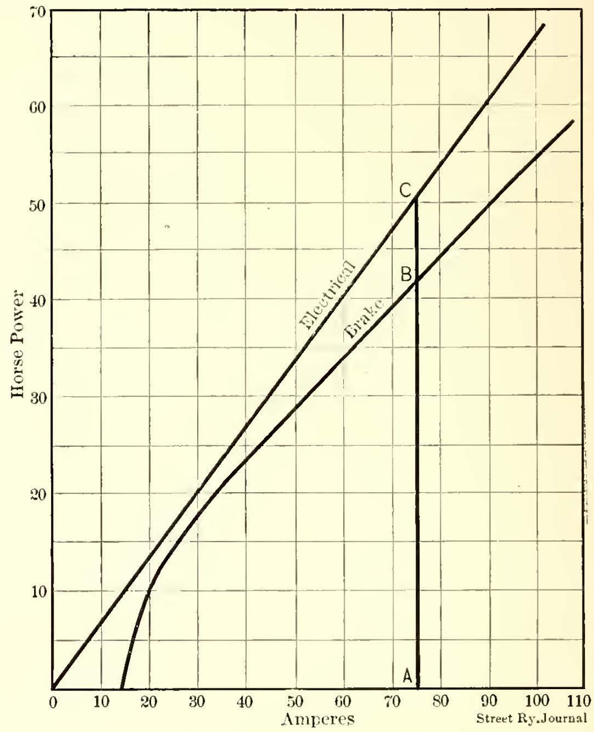


FIG. 4.—HORSE-POWER INPUT AND OUTPUT

the corresponding brake horse-power, it is plain that the line representing it must lie entirely above the latter curve. The horse-power distance between these two lines at any given ordinate represents the losses of the motor expressed in horse-power. Such a line is represented by *B C*. See Fig. 4. It will be noted that the losses diminish with the load until a certain point is reached, when they begin to increase. It requires a little analysis of the losses to account for this increase of loss at light load. The copper loss, which is one of the principal losses of the motor, increases as the square of the current. The hysteresis loss is proportional to the speed, and to the 1.6 power of the field strength, and the loss due to eddy currents is proportional to the square of the speed. The friction losses increase with the speed in a rather indeterminate function. It will, therefore, be seen that at the light loads, where speed begins to rise at very high figures, the losses which increase with the speed will begin to assert themselves, and in spite of the fact that the $C^2 R$ loss is diminished, the grand total loss increases.

It will be remembered that the efficiency curve does not start at the origin, but at a current value, such that the horse-power output shows itself to be a measurable amount. It is plain that this must be so, for not until this is the fact can the numerator of the ratio of the input and output have other than a zero value. The rapid rise in efficiency curve corresponds to the rapid diminution of loss and increase of output as the motor comes down to working speed. Beyond this point the efficiency curve is roughly a horizontal line, and the horse-power input and output curves are approximately two straight lines, diverging uniformly. Corresponding with the droop of the efficiency curve the horse-power output curve begins to droop also, the loss increasing more rapidly than does the load, and if both curves were continued to the limit they would turn downward, striking the ampere axis at that current value which would obtain if the motor were stalled and full voltage applied. These extremes are beyond the working limits of the motor, and are of theoretical interest only.

Although these various curves are exceedingly useful in selecting a motor, and, in fact, constitute the only data by which the selection can be intelligently made, it is unfortunate that some curves are not truly representative of the performance of the motors to which they are attributed. Fortunately, however, it is possible to test a system of curves, and check them one upon each other, and in this way it can quickly be determined whether the results are those of test, and how to interpret them. These methods of checking the curves are interesting; first, intrinsically, and, second, because they serve to still further set forth the properties of the curves and their relation to each other.

Let us consider first the curve of speed and that of draw-bar pull, as shown in Fig. 1. The speed is plotted with reference to current in miles per hour, and the draw-bar pull is plotted in pounds, with reference to current also. It is plain that at any ordinate, such as *A C*

$$\frac{A\,B \times A\,C \times 5280}{60 \times 33{,}000} = \text{horse-power at draw-bar.}$$

By drawing a series of such ordinates, the horse-power curve at the draw-bar can be computed and plotted, and compared with the horse-power output curve. If the horse-power curves thus produced coincide, it is plain that a check on all three curves is thus had. It is possible, however, that the horse-power curve thus found by computation will appear considerably below the given curve. This may be due to the fact that the horse-power curve given is the brake horse-power obtained at the motor pinion, whereas the horse-power curve thus computed should be the horse-power curve at the draw-bar.

It is highly important that the draw-bar pull curve be genuine, and one from which practical computation can be made, and hence if it is found that the horse-power curve computed from the draw-bar pull and speed curves coincides exactly with the horse-power curves as given, it is a fair inference to assume that one set was computed from the other, and it then becomes important to learn which way this computation was made.

A common method of curve construction is to test the motor by the usual brake methods, and then by measuring the speed of the shaft, and duly multiplying it by the proper constants, obtain the speed in miles per hour, and in a similar way by measuring the torque with the brake and multiplying by proper constants, the draw-bar pull curve is constructed.

It is plain that to make a fair test by this method, the motor should be fitted with its gears and car axle, the brake readings to be taken therefrom.

In order to determine whether the gear losses have been taken into account in the draw-bar and speed curves, it is convenient to construct a horse-power output curve, and compare it with the input curve, which can be readily drawn as a straight line intersecting the origin, and a computed point corresponding to any given load. Fig. 4 shows two such curves, and it is plain that at an ordinate such as *A C*, the efficiency is equal to

$$\frac{A\,B}{A\,C}$$

If an efficiency curve, constructed from points thus computed, exceeds 85 per cent, it is a fair inference that no account has been taken of any losses beyond the pinion, and that from 4 per cent to 6 per cent should be subtracted from either the draw-bar pull or the speed, in order to get a correct relation between the two.

It is, therefore, evident that if the speed and draw-bar curves are given, the horse-power input and efficiency can at once be computed as a check. The converse, however, is not true, because a point on the horse-power curve may be produced by an infinite number of pairs of values of speed and draw-bar pull, and therefore fails to definitely fix any two of them.

From the losses governing the operation of direct current series motors, it is plain that the draw-bar pull curve must slope most near the origin, and if a tangent of any point of its contour is not steeper than its predecessor, it is safe to assume a mistake somewhere. The horse-power output and input curves must not intersect anywhere, for

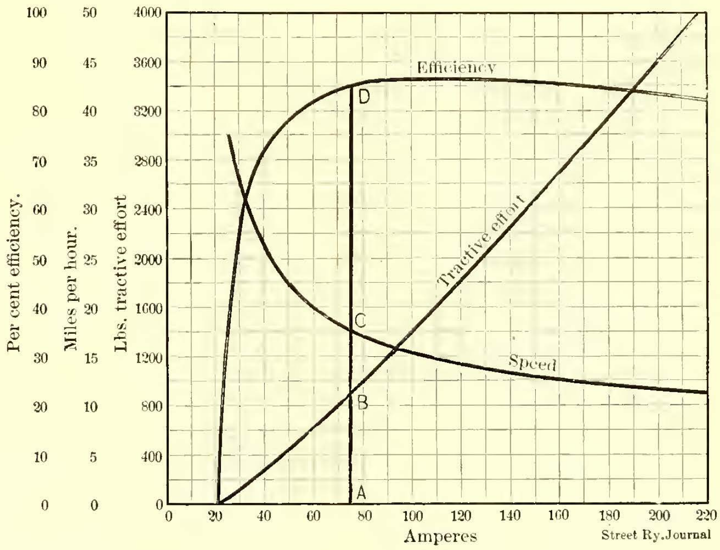


FIG 5.—DETERMINATION OF COINCIDENT VALUES OF MOTOR CHARACTERISTICS

should they do so at that point, the motor would show an efficiency of 100 per cent, and if any portion of the input line lies below the output curve, the efficiency appears greater than 100 per cent, which is manifestly absurd. If the efficiency curve is perfectly flat on the top, having no crest, the horse-power output curve must closely approach a straight line, uniformly diverging from the horse-power input curve. The more marked the crest in the efficiency curve the more concave the horse-power curve must be.

There is, unfortunately, no good way of checking time curves. Even a repetition of the tests which they are supposed to represent might not reproduce them, because of the difficulty of duplicating the conditions under which the original test was made.

The application of a system of railway motor curves to a problem of practical selection is the only proper way by which a railway motor should be chosen for a given service. A survey of the line should definitely establish the grades. An analysis of the traffic conditions should fix the weight of the cars and the desired speed, and with this data and the performance curves, the motor should be selected.

The first steps are easy. Take the required draw-bar pull, as found at any point in the line, and divide by the number of motors per equipment. Draw an ordinate through the curves to correspond, as shown in Fig. 5, and the points of intersection with the various curves give the speed, efficiency, horse-power output and input, respectively, and with precision. A careful scrutiny of the values so found, coupled with a knowledge of the desired conditions, will quickly determine whether a motor is satisfactory in these respects.

The heating of the motor is the problem, and the intersection of the ordinate with the heat curves gives a time value which is true only under a certain condition. It is plain that this condition is only one of a hundred that might arise, and, moreover, a single temperature condition of the motor is of small interest to the chooser unless it assists him in determining whether or no the motor will stand the service.

In respect to heat properties it is convenient to compare a railway motor to a tank with a narrow slot in its vertical side, which comes into play in increasing measure as the water level rises. The water may be fed in at irregular intervals, and variable amounts, but the discharge from the slot is a definite function at the time, and the contained volume of water, and therefore of its level. Similarly in a railway motor, the heat is placed therein in irregular amounts and intervals, but is dissipated according to a determinate law dependent on the time, and the contained amount of heat, and therefore on the temperature.

It is plain that we must not feed heat to the motor or water to the tank so fast that the average input exceeds the maximum ability of either device to dispose of the same, or the motor will burn out, and the tank will overflow. It is further evident that the permissible maximum momentary input is measured by the reserve capacity in heat or water of the respective devices, and becomes less as the tank fills or the motor warms up. It may also be added that the temperature of the motor does not instantly respond to a heat increment, while the water level promptly adjusts itself to the influx, but for the preservation of the analogy be it observed that it is impossible to add a measurable increment of heat to the motor instantaneously without disastrous practical results, and the influx being of necessity gradual, gives the temperature more time to adjust itself.

On these lines may be evolved an interesting method of determining the heat performance of motors with better regard for the complex conditions which surround them in practice.

To this end it is necessary that the following quantities be determined:

C = the capacity of the motor for heat energy preferably expressed in kw-hours.

T = the limiting temperature of the motor when it contains C units of heat.

L = the elapsed time at any part of the run.

R = the radiating rate of the motor at temperature T, and under the most adverse practical conditions. Preferably expressed in watts.

r = the radiating rate at any given time, also in watts.

E = the total heat energy delivered during L, expressed in watt-hours.

i = the losses of the motor at any given time, expressed in watts.

Reference should be had to a loss curve plotted with reference to the current load, and from it should be constructed a curve plotted with losses for ordinates, and time for abscissae, and representing the conditions throughout the length of the run.

If any portion of the volume of this curve be integrated the result will represent E, the total heat delivered to the motor, and if this result be divided by the elapsed time L, the average rate of radiation will be had, which, of course, must never be greater than R on an extended run. This is sufficient for a simple level track problem.

For strict accuracy the elapsed time L should be divided not into E, the total heat delivered to the motor, but into $E + E_1 - E_2$, the subscript E's representing the heat in the motor on the street and at the finish of the run under consideration. This difference $E_1 - E_2$ may be positive or negative, and is always small compared with E if the run, as it should be, be chosen sufficiently long. Therefore, for the majority of calculations, the approximation indicated above is amply sufficient.

On grades and on other situations, however, heat is delivered to the motor at a much greater rate than R, and the thermal capacity, or heat inertia, of the motor, is depended on to take up the surplus to be radiated when the conditions are more favorable.

If this call comes at a time when the thermal capacity is taken up by previous exertion the motor will rise to dangerous temperature.

For the purpose of carrying this matter further, it is assumed that the rate of radiation and the temperature are both proportional to the heat units contained in the motor, both of which are true, if due regard is had to advisable practical modifications indicated beyond.

Let us suppose that it is desired to determine whether or not the motor will heat excessively over a certain heavy grade, which calls for a current so large that the losses considerably exceed R. It is plain if the reserve heat inertia of the motor is not overdrawn, the results will be satisfactory. This reserve comprises the difference between C and the heat contained in the motor when it begins the ascent, and which, therefore, must be determined.

The average rate of radiation during the previous immediate history of the motor may be obtained by dividing the integrated loss curve with respect to time by the elapsed time, and this is proportional to the heat in the motor at the beginning of the ascent, and may be so converted by multiplying by the proper constant, which is equal to $\frac{C}{R}$. Hence as $\frac{E}{L} = r$, then

$$C - \frac{EC}{LR} = \text{the available reserve heat capacity.}$$

If the motor run till the limiting temperature is reached, it is evident that the average rate during this period is

$$\frac{R + \frac{E}{L}}{2}$$

and the addition per unit of time to the heat contained in the motor is

$$i - \frac{R + \frac{E}{L}}{2}$$

which, divided into the reserve capacity, gives

$$\frac{C - \frac{EC}{LR}}{i - \frac{R + \frac{E}{L}}{2}}, \text{ or } \frac{2C(LR - E)}{R(2iL - RL - E)}$$

which is the permissible time the motor will carry the load under the given conditions.

The quantity C, must, of course, be determined for each motor experimentally by the maker. It could most approximately be done by enclosing the motor in a heat-proof box, blocking the armature and sending current through the coils till the limiting temperature was reached. The energy supplied, measured by a recording wattmeter, and duly corrected for radiation, would be the desired C.

After the process becomes duly refined it would probably be better to place a voltmeter across the terminals of the stalled motor, and apply a constant current till the potential difference reached a predetermined value. A more strictly accurate value can be had by running the motor in its heat-proof box, and absorbing the load by means outside the box, and computing the heat given to the motor by the time and the known losses, but it is probable that a modification of the first method could be devised, which would take empirical account of the iron losses, and which would be far more convenient.

R, the rate of radiation at the temperature T, can be obtained by observing the watt input into a blocked motor after it has reached the desired stationary temperature. This test should be made on a moving car on a still, warm day.

With these two quantities determined, the heat performance of the motor can be computed with a sufficient knowledge of the line conditions, for E, i and L are obtained therefrom.

It is, of course, not advisable to apply this method without due regard to the influence of practical conditions. It is easily possible for a load to be so severe that the coils of the motor would burn out long before the heat had a chance to distribute itself according to the foregoing principles.

The situation can be controlled by modifying the value of C, as experience shall dictate, and it may be added that this, in strict accordance with the theory for the heat inertia capacity, is, indeed, reduced if the heat be so suddenly and concentratedly applied to certain parts of the motor that the remainder of the metal has no time to absorb its due share. The more rapidly the heat is applied the less C will become, and the value of C, as determined under different current strengths, will vary accordingly. From a series of experiments a curve can be constructed of C values, with reference to current, and in important calculations that value of C should be selected which corresponds to the square root of the means of the square of the currents about to be applied to the motor. A curve of C thus calculated will be exceedingly interesting, for it is a relative measure of the heat capacity of the motor, and, therefore, of its overload performance.

It is evident that experimental development of this method of computation will disclose other important and advisable practical modifications of the determination of the constants and their application, either for the purpose of abridging the work or increasing the accuracy of the result.

It is believed by the writer that on the foregoing basis a system of heat computation can be evolved which will approach at least the simple and satisfactory methods now employed in determining and applying the other performance data of a railway motor.

The size of engines and generators creeps slowly up. The 8000-hp engines for the Manhattan Elevated Railway power house in New York were the largest electric railway power house engines ever contracted for at the time they were ordered, and now before they are installed another contract is given by the Rapid Transit Subway Construction Company, of New York, for eight engines of 7500-hp. The contract is awarded to the Allis-Chalmers Company. The boiler contract was awarded to the Babcock & Wilcox Company, and is for forty-eight water-tube boilers of 600 hp each.

Street Car Platforms

BY W. E. PARTRIDGE

The simple open platform of the electric car is by no means without variety. The first modification or addition which was made when the platform took the place of the omnibus step was the dasher. Its first piece of apparatus was the brake staff and handle. The simplest form of platform for electric cars is quite complex as compared with that of the old horse car, with which it is supposed to be practically identical. As an example of this we may glance at Fig. 1, which shows the platform of a horse car formerly used on the Market Street line in Philadelphia and built nearly thirty years ago by the J. G. Brill Company. The ancient horse-car platform had no machinery or attachments save the brake staff and handle and the chain for manipulating the coupling pin. In modern cars we find gates have been added on each side. There is a draw-bar, a buffer, rods to carry a headlight, hood supports, besides the controller with its handles. The inevitable gong must not be forgotten, nor the sand box, which is very common and ought to be considered indispensable.

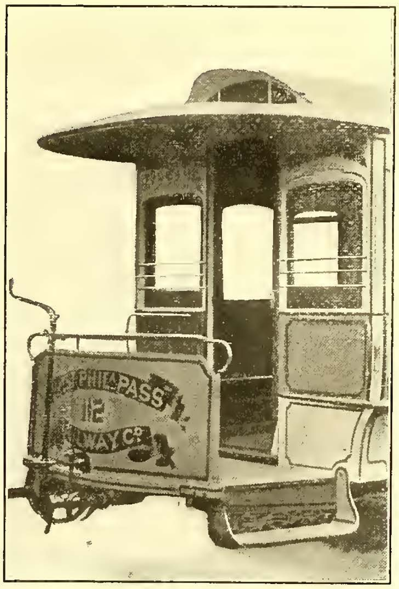


FIG. 1.—PLATFORM OF A HORSE CAR BUILT THIRTY YEARS AGO FOR THE MARKET STREET LINE IN PHILADELPHIA

FIG. 2.—A SIMPLE OPEN PLATFORM OF 1901

The platform shown in Fig. 2 is by the American Car Company, of St. Louis. In many respects it is typical of the modern type of platform, but the gates are carried much higher, so as to make the enclosure as secure as possible. The cars to which these platforms were applied went to the City of Mexico. In both instances the gates were of the folding pattern, which is much liked because of the compact form which they take when not in use.

Fig. 3 shows a platform built by the Jackson & Sharp Company, of Wilmington. The notable constructive feature is the great length of the platform timbers. This materially reduces the stress on the framing of the car, which is of great importance in four-wheel cars. The platform is dropped sufficiently to bring the step within easy reach of the ground, but not enough to make it necessary to insert blocking beneath the end sill. Blocking down under the end sill makes the platform a source of weakness when the thickness of the subsill is greater than 3 or 4 ins.

Fig. 4 is of a type of open-car platform which has almost become standard among car builders for center-aisle open cars. It has one great fault. There is no place, when the car is full, where a passenger can enter without disturbing those already seated. The usual excuse given for this construction is that the turntables are too short to admit of the use of longer cars. Sometimes superintendents excuse themselves for ordering such cars on the grounds that car houses and storage tracks limit the length of their cars. In such cases it is an open question if it would not be better to omit the end seats, and in this way provide passengers with one point at which they may enter and leave the car without incommoding those who are seated. There is an argument made against this lengthening of the platform or providing a regular platform entrance. It is on the ground of quick loading and unloading. It is urged that for the highest speed the passenger should get on or off at the nearest opening. He is not expected to wait until the platform reaches him on entering; neither is he expected to walk down the aisle to the platform before leaving.

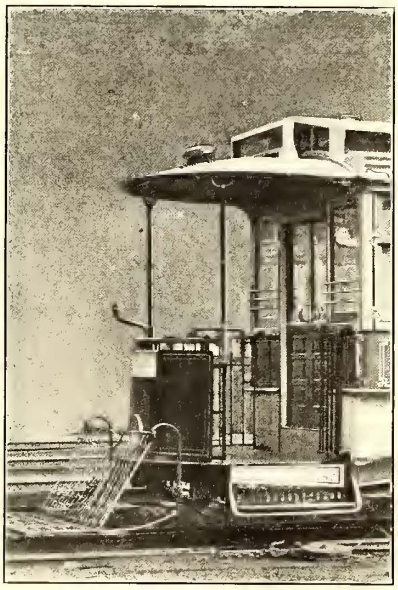


FIG. 3.—PLATFORM AND FENDER WITH SWING GATE

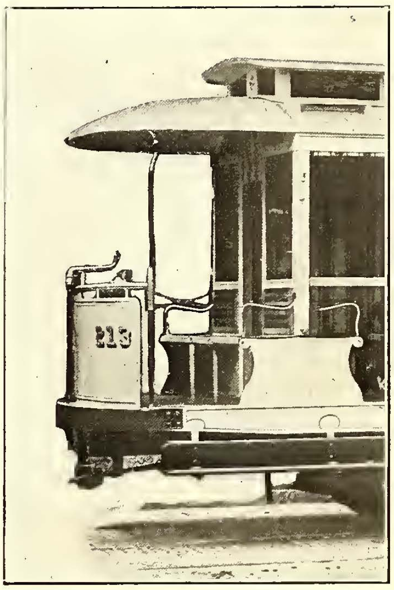


FIG. 4.—AN OPEN CAR PLATFORM, STANDARD TYPE

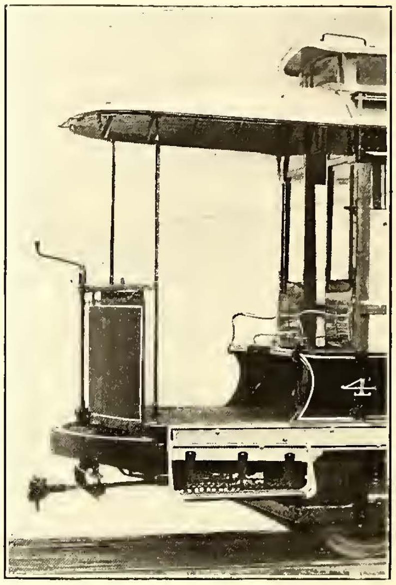


FIG. 5.—AN OPEN CAR PLATFORM, WIDE ENTRANCE

Both of these actions tend to delay the car and make it slow. This argument may have some weight where it is difficult to make a large daily mileage and there is a heavy traffic. In general, it may be assumed that the comfort of the passenger is of greater importance than the small gain in speed.

Fig. 5 shows an extra long platform on a center-aisle open car by the Brill works. Passengers occupying the end seats are not incommoded by passengers who enter or leave. Incidentally, there is a considerable gain in space for those who stand. In the special car illustrated the idea was carried to extremes, and no side entrances were provided. The guard-rails were stationary, and there were no steps or runningboards along the sides.

In the matter of simplicity our European friends at times go a step further than we do in America, as is shown in Fig. 6. The platform is little more than what is indicated by its name. Since the car is used as a trailer, it has air-brake hose connections, but nothing else besides the very open rail. Steps with three risers would be considered somewhat unusual in this country. Since speed is not considered of great importance on most European street railways, the passenger can be allowed ample time to enter or leave, and the steps become an undoubted convenience.

There is one point of construction in this car which is of interest. Possibly it is of sufficient value to be worth careful attention of car builders and street railway men. Practically the car is built without a side sill. The side of the car is carried by a sill which is also the outer platform timber. This is possible because the whole floor frame of the car is of iron. In such cases the sills are usually I-beams extending from crown piece to crown piece. Often the whole structure is of iron, only the interior finish being of wood. The car is used as a trailer, and has the buffing apparatus usual on European roads.

With the introduction of power upon street railways and the great increase in speed which came as a consequence, many important changes in construction were introduced. Larger cars were desirable, and stronger construction became imperative, at the same time a great increase in the comfort of the passenger became possible. The introduction of the vestibule on steam railroad trains, which became quite general about the time that electricity was introduced upon street railways, was soon followed by similar forms of construction on electric railways. Who first enclosed the street-car platform in such a way as to make a "vestibule" is not certain. The cabs of some of the early "dummies," used long before the days of either cable or electricity, were practically vestibules, and for this reason the idea can hardly be said to be new, yet the application appeared decidedly novel to the public.

The vestibule is a platform enclosure, and is structurally a portion of the platform. Some designs make it a portion of the car body. They carry the end frame of the car forward to the front of the vestibule, while others make the vestibule light and almost an independent structure.

The question of the advisability of adopting the vestibule generally upon street cars has had a wide discussion. If vestibuled cars cost no more than those with plain open platforms, probably there would have never been any questioning in regard to the matter, but the vestibules cost money. It therefore becomes necessary to investigate their disadvantages and see if good objections cannot be found to their use.

The standard objection to them is that men enclosed in them cannot see nor hear as well as if they were in the open, and that in case of snow or rain storms and during severe weather, when the windows are closed, hearing, as well as seeing, is impaired, and accidents are likely to follow. It is certainly a good argument that in case of storm a man should be in full possession of his senses and out where he can hear and see everything that is going on;

but it is found, as a matter of fact, that men at work on the unenclosed end of an electric car have to protect themselves. During inclement weather they have to be very heavily "bundled up," and it is a question whether, with heavy caps, mufflers and thick overcoats, the men can see or hear better than in a vestibule. Certainly the advantages of having a man comfortable and in full possession of his physical powers far outweigh the slight disadvantages of the enclosure.

The passenger looks at the vestibule as an important contribution to his comfort. He regards a car with a vestibule as entirely up to date. The vestibule excludes drafts from the interior of the car, and makes riding more comfortable—riding in cold weather becomes pleasurable. A warm car in the winter time is an attraction to the short rider. He is tempted to ride a few blocks to get out of the cold wind. When the car is cold, the pedestrian argues that it will be better to keep warm by exercise for many blocks rather than to sit still in a car. In such cases the company loses the profitable short rider.

The enclosed vestibule makes a car easier to heat in winter, and is a direct advantage to the company. Many of our leading railway companies have become thoroughly convinced of the value of the vestibule, as well as of the desirability of making the men comfortable. They have in some instances provided the vestibules with heaters.

The question of cost appears to be the only one which has any weight in this connection. The more closely the subject is examined the plainer does this become.

The open vestibule, or one having a front but no sides, has come largely into use. It is formed in a great variety of forms. Its advantage is in the fact that it is supposed to give the motorman some protection, and at the same time make it easy for him to hear. It is supposed to comply with the State laws that require the motorman to be protected in winter weather. From the railway man's standpoint they may be a good thing, because they cost less than a vestibule which makes a full enclosure by having doors on side, windows, etc. Practically they have every disadvantage that is urged against the vestibule as well as the most of those of the open platform. They protect the motorman's face from a head wind, but transfer the wind to the back of the neck. They afford no protection to the interior of the car, and none whatever to those who ride on the platform. The limitation of the motorman's sight by framing and glass is quite as bad as that of the vestibule. In addition to this, he has to protect head and body with quite as many coverings as if he had an open platform. Lastly, when a vestibule of this class is used in summer it sends a strong breeze through the car from back to front.

These remarks in regard to vestibules and the protection of the motorman and conductor, of course, apply with greatest force to the central and northern portions of the United States. In Canada and in the colder States of our own country little argument is needed in favor of a complete enclosure for the street-car platform. The vestibule becomes then a necessity about which there can be little question.

Taking up the question of vestibuled platforms, the simplest structures naturally come first. This order will be followed for the sake of convenience, in spite of the fact that the more complex forms were the first which came into use on street railways.

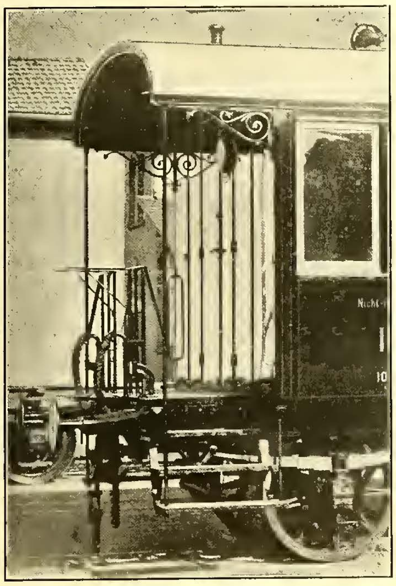


FIG. 6.—PLAIN FORM OF PLATFORM USED ABROAD

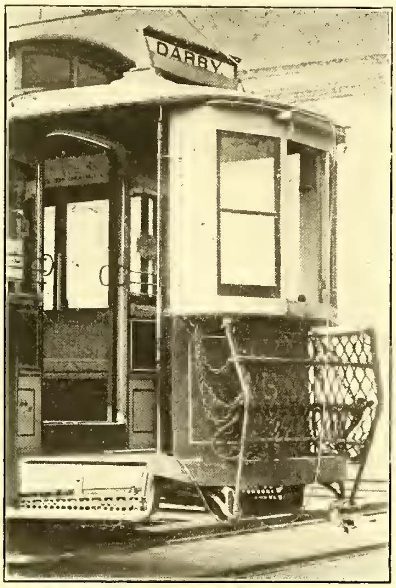


FIG. 7.—PORTABLE VESTIBULE USED IN PHILADELPHIA

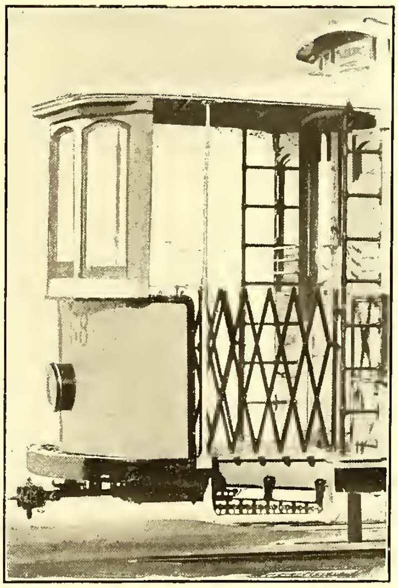


FIG. 8.—PORTABLE VESTIBULE FOR BERLIN

In Fig. 7 we have the Brill portable vestibule, as applied to the cars of the Union Traction Company, of Philadelphia. Its leading features are a light frame sitting upon the dasher rail, and carrying in front three sash. At the sides the frame is connected to and supported by the hood supports. The bottom board of the frame projects so as to permit the brake handle to clear the sash. At the top there is a flexible weatherproof connection with the hood. The whole structure is light and easily handled by two persons. The sash in these vestibules may be arranged in a variety of ways. As shown, the whole of the central sash swing to one side. The glass at the side is divided by a bar in the center. The hood, dasher-hood supports, and in fact the whole platform arrangements, are not changed by the addition of the portable vestibule. It may be noted here that these platforms are largely carried by the side sills. The outer platform timbers are reinforced by angle irons. This platform is also of interest as it shows a folding gate turned back against the body of the car. The side framing of this vestibule may be made much narrower than that shown in Fig. 7 and the projection reduced. In cases where the brake staff is brought well inside the dasher rail, little projection is needed to clear the brake handle.

Fig. 8 shows a slightly modified form of the same vestibule, with much less projection, as applied to a lot of cars which the Brill Company sent to Berlin a year or two ago.

The sides are quite open, and the whole arrangement gives but little protection to the motorman. The long platforms have comparatively short steps. The extra space at the sides was utilized in forming a ladder for reaching the roof. It is altogether a unique arrangement.

Following the mechanical order, we next take up the stationary vestibule without protecting sides. One of these is shown in Fig. 9. This was built by the St. Louis Car Company for the Chicago City Railway. The short platform timbers are reinforced by metal. The gates are made very high, but are not carried to the floor. The arrangement of the sash is such as to give the effect of very large glass, while the individual lights are small. The vestibule arranged in this way is a wind brake. The subdivision of the glass and the opening of a small sash opposite the motorman's face is a good idea. It gives a clear vision when snow or rain accumulates on the glass, but does not expose the whole body to the wind. A favorite arrangement of glass and sash is to divide the upper half of the front sash into three small sash; the central one, which comes opposite the motorman's face, is made to swing. Usually all of the sash are made to drop, so that the platform may be practically open in warm weather. During rain or snow, when there is trouble in keeping the glass clear, the small central window is opened, and the motorman has an unobstructed view. Under such conditions, with a completely enclosed platform, a better view is obtained than is possible on the open platform when the motorman's head, including ears and face, is bundled as a protection against the weather.

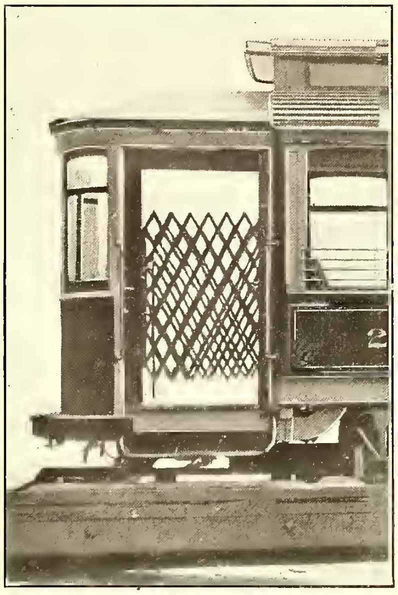


FIG. 9.—VESTIBULE USED IN CHICAGO

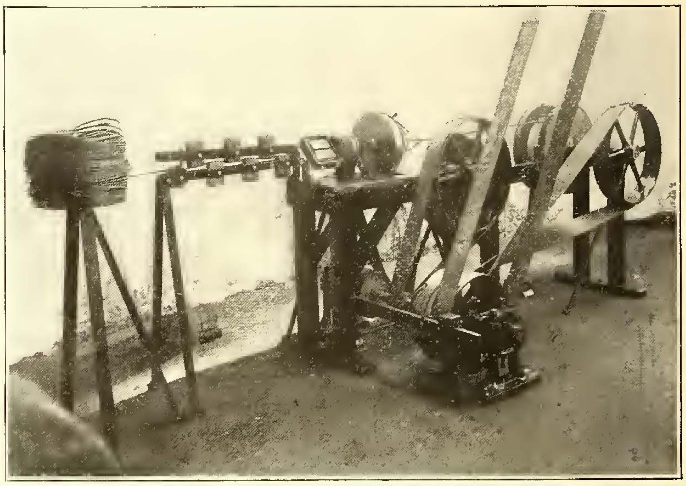
The common practice is to keep the sash closed in stormy weather, merely opening it for a moment, at intervals, to clear away the snow, etc. A movable arm or rubber working from the inside could easily be fitted to accomplish this. Occasionally the central opening is divided into five parts. There is a small central sash which swings. The larger part below the small sash drops in the usual way.

In most of the enclosed platforms, whether of the portable vestibule or completely enclosed type, the brake staff has to be carried well inside the dasher in order to obtain space for the brake handle to swing clear. This makes it necessary to use long brackets to support the staff bearings. The arrangement takes up much valuable room, and at the same time is annoyingly in the way of passengers. On the front platform it occupies quite as much space as two passengers, and on the rear nearly as much. This may be avoided to advantage by the use of a vertical wheel with bevel gears, the type much used on steam roads. When the air brake is used for regulation stops there appears to be no valid objection to the vertical wheel.

The Toledo Railway & Light Company, of Toledo, Ohio, is to use new transfers. Abuse of the present transfer, which has a liberal time allowance, is said to have caused the change.

A New Automatic Wire Rejuvenator Used in Brooklyn

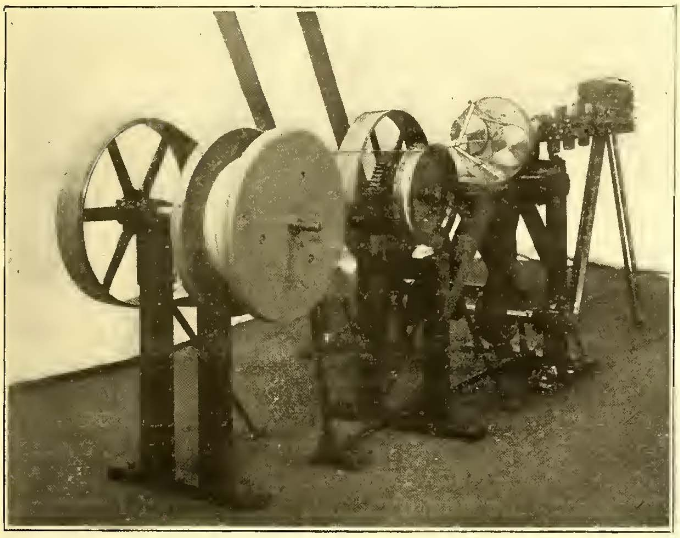
The great difference in the market value of new insulated wire and scrap results in a great expense to all street railway companies. It has been practically impossible to rewind field coils after they have once been burned out, although such rewinding at a much less price than must be paid for new wire would decrease enormously the expense item for copper in keeping up the equipment of rolling stock. Superintendent of Equipment E. Chamberlin, of the Brooklyn Heights Railroad Company, realizing the possibility of obviating this outlay, has, in company with his general foreman, George C. Murray, invented and patented the device illustrated in the accompanying engravings. The object of this ingenious piece of machinery is to transform an old burned-out field into a new coil of what is practically bright, new wire, carefully insulated and ready for rewinding in a new field. The apparatus cleans, polishes, straightens and insulates, with a single or double covering of linen tape, either with or without liquid insulation, and can, of course, be used for any form of wire. The machine has been running for some months in the Fifty-Second Street repair shops of the company, and has given most excellent service, some remarkable results in the way of speed having been obtained. One machine will clean and insulate from 800 lbs. to 1000 lbs. of No. 3 wire per day, which, if brought down to a cash basis and referred to the relative cost of new field wire and scrap, corresponds to a saving to the company per day of $40 to $50 for one machine, after deducting a liberal amount for labor, power, new material, etc. When working at normal speed, the wire is wound upon the spool at the rate of one foot per second.



NEW MACHINE FOR CLEANING AND INSULATING OLD WIRE

Before being placed on the gypsy stand, from which the wire is delivered to the machine, the field coil is first thoroughly roasted in an oven, the heat being just sufficient to char the insulation. This process not only thoroughly disintegrates the insulation and renders its ready removal possible, but it partially anneals the wire, a result which it has been demonstrated is beneficial electrically to the new field. The coil, after having been roasted in the oven for about ten minutes, more or less, according to the temperature obtained, is then removed and placed upon the gypsy stand at the end of the cleaning and insulating machine. After its end has been drawn through the cleaners, insulating head, etc., to be described below, the machine is started and the following sequence of operations takes place as it is uncoiled: Hard wooden blocks are placed on a frame between the insulating machine and the coil of wire.

These blocks are adjustable for wear, and are arranged so that just sufficient pressure is brought upon the wire. In passing between the blocks it is stripped of its charred insulation, thoroughly cleaned, and at the same time straightened. After leaving the frame containing the cleaning and straightening blocks, the wire passes through a pair of buffers which are attached to the hollow shaft of the insulating head. These buffers consist of several soft wire brushes, which give an additional polish to the cleaned wire. It then passes through the center of the insulating head and on to the binding drum, which serves to pull it through the apparatus. It is given four or five turns around the binding drum, and is then carried to the winding spool, upon which it is tightly coiled in the usual manner. Before it reaches the winding spool an automatic shifting guide operated on a screw, which is not shown in the illustrations, is used to lay it in even layers upon the spool.



MACHINE FOR CLEANING AND INSULATING OLD WIRE

The face of the revolving insulated head contains one or two bobbins of linen tape, according to whether it is desired to wind with one or two layers of insulation. Where two layers are used, the tapes are wound in the same direction with lapped joints. The tape is carried from the spools over tension pins, by which its tension may be adjusted, and then over a hollow pin near the periphery and directly to the wire. The head is made hollow, and has a capacity of about one gallon. The hollow pins over which the tape passes before being wound on the wire connect with the interior of the head, and when the machine is in operation the centrifugal force of the revolving parts throws the liquid out through the hollow pins, in which are openings. These openings lie along the under side of the tape, and a thumb nut at the end of the pin adjusts their size so that any desired quantity of insulating material may be allowed to escape to the face of the tape. As the insulated wire goes over the binding drum, which is deeply grooved, the coils are pressed closely together and the insulation given a most satisfactory "set."

The size of the tape used in the Brooklyn shops is $\frac{3}{4}$ in., which has been found to be the most satisfactory for general purposes. When the end of a field coil is reached, the beginning of the next one is soldered to it by a long diagonal joint, without binding wires, so that a coil of continuous wire is the result. The machine illustrated has been in service for more than a year under the direct supervision of the inventors, who have thus had an opportunity to discover any improvements which were possible in the original design and perfect its details while under operating conditions. Although as yet none of these cleaners are in use outside of the Brooklyn shops, it is intended to place them on the market at an early date, now that their satisfactory working is assured.

CORRESPONDENCE

Rail-Bonds on the B. & O. Belt Line

THE BALTIMORE & OHIO RAILROAD
BALTIMORE, Md., Nov. 21, 1901.

EDITORS STREET RAILWAY JOURNAL:

I have noticed the article in your last monthly issue in regard to the behavior of copper bonds on the Baltimore & Ohio Belt Line, and would say that this was not an official statement of the conditions and results secured.

The squeezing out of the bond strands was unquestionably due to the fact that the type of angle-bar used does not give sufficient clearance at the top, between the inside of the angle-bar and the web of the rail, for the introduction of the bond. This trouble is further aggravated by the wearing of the angle-bar, which allows its surfaces to approach nearer and nearer to the web of the rail, thus forcing the upper strands of the bonds out by mechanical action. I believe that if greater space should be left between the angle-plate and the web of the rail that this difficulty would be entirely avoided.

The section of rail to which these bonds have been applied is that used by the greater number of steam railroads, the rails and angle-bars being the standard established by the American Society of Civil Engineers, 100-lb. section, and in the design of this no consideration has been given to the matter of combining with these sections the necessary room for application of bonds.

Inasmuch as the growing tendency is to more and more use in common for electrical traction, either wholly or in part, the existing steam railroad tracks, it seems very proper that the necessary modifications, as above outlined, should be seriously considered, and as this is purely a mechanical modification of the angle-bar it can be easily overcome.

I do not consider the type of bond at fault, and, so far as I know, if this change is made the bond would be satisfactory.

I wish to commend the manufacturers of the bond for the promptness with which they are taking up this problem with a view to making such changes as are necessary to meet the existing conditions.

W. D. YOUNG, *Electrical Engineer.*

The Service Capacity of Railway Motors

BROOKLYN, N. Y., Nov. 13, 1901.

EDITORS STREET RAILWAY JOURNAL:

In your latest monthly issue (Nov. 2, 1901) I notice an editorial, entitled "The Service Capacity of Railway Motors," in which you comment on some recent papers dealing with the subject. In this editorial appears the following reference to Lundie's proposed method of rating motors: "He gave a rule which virtually means that a railway motor should be rated by the steady current it will carry at full pressure for an indefinite period without exceeding the limiting temperature elevation."

By referring to Lundie's original article in the *Electrical World and Engineer,* Oct. 21, 1899, or either of his subsequent papers, you will note that the method in question is described by its author as follows;

"The power rating of an electric railway motor under actual conditions of operation on frequent intermittent load should be directly proportioned to the average current input, independently of variations in current, except as the current may be governed by the limitations of satisfactory commutation." (See also STREET RAILWAY JOURNAL, October, 1900.)

It is evident, of course, that such a condition as "steady current at full pressure for an indefinite period" is very different from "actual conditions of operation on frequent intermittent load," and this condition of a steady current for an indefinite period is not one to which railway motors are subjected, nor is it in any way indicated in Lundie's statement of his proposed method of rating motors, the average specified by Lundie being the "average current input" "on frequent intermittent load."

J. D. KEILEY.

[It was our intention to give full credit, and no disparagement, to Mr. Lundie in our editorial article referred to. We think that a little examination will show that there is no material difference between Mr. Lundie's definition of his rating as quoted by Mr. Keiley and the brief paraphrase of that definition which we gave. Since "the average current input" to the motor "on frequent intermittent load" is the current which will bring the motor to its temperature when the motor is operated at its full rating, and this would correspond to the "steady current which it will carry for an indefinite period" in order to bring it to the same temperature elevation, the two statements are essential equivalents. It is here assumed, as was taken for granted by Mr. Lundie, that the energy wasted in the motor is proportional to the current input, and that the variation of the current input, within the working limits, had no appreciable effect upon the final temperature elevation.—EDITORS.]

Loop Terminals for Elevated Railways

BOSTON, Mass., Nov. 14, 1901.

EDITORS STREET RAILWAY JOURNAL:

The loop terminal is the only practical method conveniently and rapidly to handle trains on short headway. This has been demonstrated clearly wherever tried, and particularly at the Brooklyn Bridge terminal of the Brooklyn Elevated Road. The necessary arrangments to handle two or three trains at same time were judiciously provided for on either track of this loop, which has two tracks. The terminals on Boston Elevated Road, however, are arranged to handle but one train at one time, using the same platform to discharge and receive passengers and making but one stop, which undoubtedly saves a little time and the expense due to an extra stop. But this is a small item compared to the importance of maintaining a regular interval between departure of trains, and this cannot be done with such terminals unless every train runs almost absolutely on time. In case of delays (and delays will occur), when the delayed trains do arrive, it is out of the question to try and equalize the interval properly without confusion and forcing trains to wait outside before they can pull into station and discharge passengers.

Of course, in cases of lengthy delay this will occur at any terminal. But to overcome the ordinary short detentions (which occur frequently every day) is quite an easy problem, and there is but one method, and that is to provide for standing time at one or both terminals. The length of time necessary is governed entirely by local conditions, which contribute to or cause unavoidable delays of three or four minutes to various trains, and by arranging for the necessary standing time you insure trains departing on a regular interval, even though they arrive irregularly, which practice proves they are almost sure to do, for numerous reasons. To do this it is necessary to have terminals so arranged as to permit a following train to arrive and discharge passengers while preceding train may still be waiting for time to start.

The East New York Loop of the Brooklyn Elevated Railroad was undoubtedly constructed with the idea that necessary standing time would be provided for at both Bridge terminals, but on account of the trains being stored and taken out and placed in service at this point, its operation is sometimes attended with slight delays.

No doubt the engineers of the New York Subway have taken into consideration the disadvantages of such terminals, and will govern themselves accordingly.

Another important feature for such service is the necessity of a platform gate on cars, which will slide open and shut, similar to side doors, disappearing when open along the side of car, but designed to be operated by trainman between cars same as at present. The gate which is employed at present causes considerable delay and annoyance on crowded trains on account of being unable to operate it when platforms are crowded. M. B. LAMBERT.

The Operation of Alternators in Parallel

THE UNION LIGHT, HEAT & POWER COMPANY
COVINGTON, KY., Nov. 5, 1901.

EDITORS STREET RAILWAY JOURNAL:

I was very much interested in your issue of November in the discussions of Messrs. Steinmetz, Emmett, Rice and others relative to the operation of the engine-type alternators in parallel. It is a question which is being considered by more than one central station manager at the present time.

Lately we have made extensions which have necessitated the installing of two 400-kw and one 1000-kw, three-phase revolving-field alternators, and we have had considerable difficulty in getting the engine builders and generator builders to meet on common ground relative to the operation of these units in multiple. The engines are of the cross-compound condensing type.

When the contracts were first up, the generator builder submitted the following paragraph, which he requested should be placed in the engine builders' contract: "The maximum angular displacement in one revolution of a point on the periphery of the engine fly-wheels should not exceed 7-100 of an angular degree from the position of a reference point upon the periphery of a wheel revolving with absolute uniformity at the normal generator speed of 150 r. p. m. This departure from the uniform rotation corresponds to an electrical phase displacement of 2½ degs."

Now, when this is all figured out in everyday parlance, we find that it means that there shall not be a variation of the two points of reference on the two fly-wheels of more than ½ in., whereas the peripheral speed is a mile a minute. Now, it is certain that no engine builder's specification at the present time covers this requirement, although it appears that it has been met by engine builders many times successfully.

The engine builders' specifications require that the engines shall regulate within 2 per cent, but as has been pointed out in the articles of your last issue, and as stated before, the two specifications do not bring the generator and engine builders on to common ground, and meanwhile the customer is held up and hopes for the best.

After considerable correspondence, the generator builder advised as follows: "The generators covered by this contract will be so devised that they can be operated in parallel as Y-connected generators, 60 cycle, 4500 volt, if the engines driving the generators are properly adjusted for parallel operation." On submitting this paragraph to the engine builder, he replied: "We propose to build the cross-compound units so that they will satisfactorily operate properly designed and constructed alternating generators in parallel."

You will see the utter absurdity of all of the propositions, particularly the paragraph relative to the maximum angular displacement in one revolution of the engine fly-wheels, and it is a point which the engine builder does not cover in his specification, and I doubt very much whether by a mechanical means such a variation could be measured. In other words, an agitation in your journal could well be made to bring leading builders of steam and electrical machinery on to a common footing, so that the purchaser may be protected adequately in making his contracts.

It is not often nowadays that we hear of any difficulty in the parallel operation of engine-type alternators, and the difficulties of the surging of the current between parallel-operated generators seems to be well in hand.

E. Darrow, *Chief Engineer.*

Brake Tests in Electric Interurban Service

J. S. Hamlin, master mechanic of the Union Traction Company, of Indiana, at Anderson, Ind., has made some very interesting tests on the distances required for service and emergency stops on the interurban cars of that company. While perhaps the figures given are somewhat better than one could expect always to realize in practice with the condition of brakes existing in everyday work, they, nevertheless, show what the possibilities are, and also demonstrate that better stops can be made with single interurban motor cars on which brakes are carefully looked after than with trains of passenger or freight cars, such as are run on steam roads, and where the adjustment of braking apparatus cannot be made so carefully as on interurban electric cars.

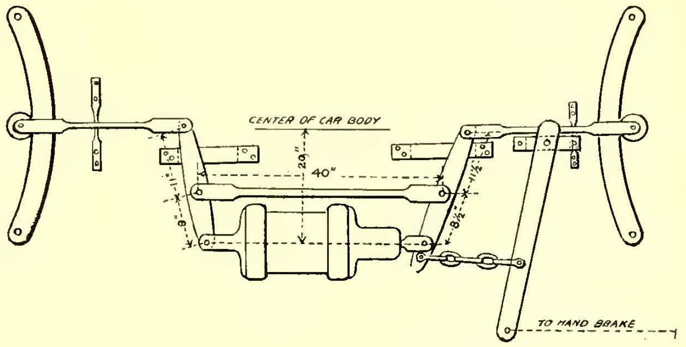
These tests were made on the Muncie division of the road on level track. The speed was recorded by a speed recorder of the Starrett type, and these results were also checked by timing the rate at which cars passed a given number of poles. The overhead line is equipped with poles set exactly 100 ft. apart. Every fifth pole on the system is a numbered pole, painted black, with white numbers. When maximum speed is obtained the number of poles passed in a given length of time gives the rate of speed. The controller is then thrown off, and the application of the air brakes made at the instant one of the black poles is passed. The number of poles passed in making the stop, plus the fractional distance between the car and the last pole, gives the distance in which the stop is made. This fractional distance is measured by tape line, measuring from the pole to the tip of the pilot of the car. This method was used as a check in each test to confirm the accuracy of the speed recorder.

On July 12 forty emergency stops were made from a speed of 58 miles per hour, all within a distance of from 503 ft. to 522 ft. The cars are equipped with the Christensen Engineering Company's straight air brake, with 10-in. brake cylinders, storage reservoir, 16 ins. x 48 ins., engineer's valve, ½ in., and independent motor-driven compressors. The Christensen system of levers is the one used on these cars. The cars weigh a little over 32 tons, without load.

The rear trucks have no motors. The front trucks of each car are equipped with two Westinghouse, 50-C, 150-hp motors, and to allow for the momentum of the motor armatures, a higher ratio of brake-shoe pressure is used on the front trucks than the rear. The brake-shoe pressure in an emergency stop upon the rear trucks is 75 per cent of the weight upon the wheels of that truck, and the corresponding brake-shoe pressure on the front trucks is 90 per cent of the weight on the wheels on that truck. The emergency stops are made with a piston travel of 5½ ins., reservoir pressure, 85 lbs., and train-line or brake-cylinder pressure, 40 lbs. per sq. in. These stops were made without sliding wheels or using sand.

A service stop made on the same date was made in 750 ft. from a speed of 58 miles per hour. The piston travel in this case was 5½ ins.; reservoir pressure, 85 lbs., and train-line air-brake cylinder pressure, 20 lbs. per sq. in.

Mr. Hamlin has given special attention to the brake equipment of these cars, because of its great importance in high-speed interurban service of this kind, where stops must frequently be made in a short distance. In his opinion the secret of efficient air brake rigging, which uses a minimum of air, is to have no slack in the pins or holes in the levers. If this is the case, the brakes are in effect from the instant the application of air is made, and it is possible to keep the piston travel at a maximum of not more than 6



BRAKE RIGGING USED ON CARS

ins., whereas, should the pins and pin holes become worn, the slack would be equal to probably 2 ins. more travel of the piston before the shoes become in contact with the wheels. Mr. Hamlin thinks that pins in levers and rods on air brake equipment of this size should not be smaller than ⅞ in. in diameter. In the sketch it will be noticed that there is a clip fastened to the car body, which holds the pull-rod running to each brake stationary, as far as the lateral movement is concerned, thus compelling the roller on the end of the pull-rod to roll on the truck quadrant. This avoids setting the brakes on curves, on account of the rollers sticking, and being carried with the quadrant when the truck is going around a curve.

Mr. Hamlin's instructions to men in his employ regarding braking apparatus are something on this order: That almost anyone, even a child, can start a car, but it requires a cool and deliberate man at the engineer's valve to stop the same car, and in order that the master mechanic's department may maintain the confidence which the motormen have in the brake rigging, the department must at all times have the braking apparatus as near a standard before described as possible before the car leaves the shop. The labor of maintenance of the brake apparatus is low, as two men keep in repair and adjust thirty-two of these large equipments. The material expense is confined to carbon brushes for the motor of the compressor.

STREET RAILWAY JOURNAL

DECEMBER 7, 1901.

PUBLISHED WEEKLY BY
THE STREET RAILWAY PUBLISHING COMPANY
Main Office:
NEW YORK, Beard Building, 120 Liberty Street.
Chicago Office: Monadnock Block.
Philadelphia Office: 929 Chestnut Street.
London Office: Hastings House, Norfolk St., Strand.

Long Distance Telephone, "New York, 4044 Cortlandt."
Cable Address, "Stryjourn, New York."—Lieber's Code used.

TERMS OF SUBSCRIPTION.

In the United States and Canada..............................$4.00 per annum
Single copies, first issue of each month, 35 cents; other issues, 5 cents.

To all Countries outside of the United States, Canada and Mexico..... $6.00 / £1-5-0 / M25 / 31fr

Subscriptions payable always in advance, by check (preferred), money order or postal note, to order of C. E. Whittlesey, Treasurer.

Entered as second-class matter at the New York Post Office.
Copyright, 1901, The Street Railway Publishing Co.

NOTICE.

Papers and correspondence on all subjects of practical interest to our readers are cordially invited. Our columns are always open for the discussion of problems of operation, construction, engineering, accounting, finance and invention.

Special effort will be made to answer promptly, and without charge, any reasonable request for information which may be received from our readers and advertisers, answers being given through the columns of the Journal *when of general interest, otherwise by letter.*

Street railway news and all information regarding changes of officers, new equipment, extensions, financial changes, etc., will be greatly appreciated for use in our news columns.

All matters intended for publication in the current issues must be received at our office not later than Wednesday of each week.

Address all communications to
The Street Railway Publishing Co.,
Beard Building, 120 Liberty Street, New York.

We are able to present elsewhere in this issue some figures which are of value to the large number of city and interurban railway companies contemplating the installation of a system of alternating-current distribution through sub-stations. These figures are on the actual cost of power production and distribution and efficiency of distribution on the system of the Union Traction Company of Indiana. These results are of even more general interest and application than the data on the efficiency of the large alternating-current power house and distribution system of the Metropolitan Street Railway of New York in our Souvenir October issue of this year, because the Anderson plant is of a size which will be commonly used over the country by interurban electric roads in the future. The figures from Anderson give exact data on a point which has heretofore been largely a matter of speculation—namely, the cost of the power delivered at the sub-station bus-bars of an interurban system as compared to the cost of power at the generating station bus-bars.

While the figures given show that the cost of distribution is a very large proportion of the total cost of power, as the cost of the energy at the bus-bars at the power house is only about 57 per cent of the cost of the bus-bars at the sub-stations, it must be remembered that the possibilities are that were this power generated by a number of direct-current plants the cost of the power at the bus-bars of those plants would be higher than it is now at the sub-station bus-bars. Indeed, with the size of the units that would necessarily have to be employed, if a number of small direct-current stations had been built, and with the high cost of labor and incidental expenses at such stations it would be practically impossible to show any such economy as the present polyphase distribution shows.

As the electric interurban line gradually approaches nearer and nearer in many of its characteristics to a steam railroad it becomes a matter of speculation how far this tendency to adopt steam railroad practice will be followed by the electric interurban roads of the future, and how far they will retain characteristics distinctly their own. That electric interurban railway practice is gradually drawing away from street railway practice and closer to steam railroad methods is a matter of common knowledge. That the electric interurban line is not going to adopt steam railroad methods entirely is evident from the fact that the electric lines were built to supply, and are supplying, a place not filled by the steam railroad service. To this its success is due. That the electric interurban line in its various forms is supplying a place hitherto unfilled has been demonstrated in too many ways and places to admit of argument. The existence of so many prosperous electric interurban lines paralleling steam railroads proves that clearly. It was argued at first that one reason electric interurban lines were successful was because they followed the highways, where they could pick up passengers near their homes and where the right of way and construction expenses were light. While that argument probably applies to many roads now in operation, what shall be said of such a road, for example, as that of the Union Traction Company of Indiana, some notable features of which are reviewed elsewhere in this issue? Here is a road which seems to be but a sample of what is being done at numerous other centers of population in the central States. The sample is an excellent one, to be sure, and will be studied with profit by the numerous engineers and managers engaged in promoting and equipping similar lines. But it certainly cannot attribute its marked success to running on the highway, for, save in the towns, it runs most of the distance on its own purchased right of way, graded and ballasted like the old-established steam road which it parallels. Its cars stop, to be sure, at the country road crossings, at which the company has seen fit to establish platforms, but the traffic picked up in this way is small. The greater part of the traffic comes from the towns and cities along the way. On such a road as this it is largely a matter of frequency and convenience of service which attracts passengers, combined with the cleanliness of the electric cars in summer. On the system just spoken of the running time between cities is slightly more on the average than that of the steam railroad trains, solely because of the necessity of slow speed on the city terminals of the electric lines, but this slight difference is compensated for by the inconvenience of going to the steam railroad depots.

The existence of such electric interurban systems as this raises the question whether existing steam roads could not, if they would, supply the character of service that some of the recent most costly interurban lines furnish in many of the locations where such interurban lines have been or are being built. The answer to this is one that may well be sought after by steam railroads now operating in all the populous centers of this country. That it has heretofore been answered in the negative by the majority of steam railroads which have faced prospective competition of electric interurban lines is shown by the rarity of the instances in which electric service has been put on steam roads. But electric interurban service is sure to be given by some company in every well populated district, and it is mainly a question whether the steam railroad companies want to equip for this kind of business or whether they prefer to let some new company give the new service.

In connection with the subject of the rating and performance of railway motors, which was discussed last month by Mr. Storer, an interesting communication by Mr. Hanchett appears in this issue. The conclusions which are pointed out show that the only definite way of determining beforehand the size and type of motor for a given car equipment is to take the profile of the roadbed, together with the proposed schedule, and compute the drawbar pull and horsepower required from the motor or motors, in order to effect the required schedule, with the given weight of car passengers over the given profile. The current strength required for each motor from moment to moment thus becomes known, and the total heating effect of this current, together with the heating in the iron by hysteresis and eddy currents, must be within the power of the motor to dissipate without exceeding a safe temperature. It seems as though any other method of choosing a motor for a new road must be mere guesswork. It goes without saying, however, that once a given type of motor has been tried in practice over an established road, and its behavior under service conditions in regard to acceleration and temperature have become known, it becomes an easy matter to select new motors for the same road. Similarly, if the schedule speed and profile of a new road is very similar to the schedule speed and profile of a known road, then an engineer can readily apply the experience gained with motors on the old road to the selection of motors for the new, without going through the arithmetical process indicated.

Mr. Hanchett carries the computation of the motor temperature elevation somewhat further than is usual by taking into account the capacity of the motor for heat. It is usual merely to compute the total heat expended or lost in the motor during a cycle of running operations, and then find the steady current which at a mean terminal pressure of, say, 300 volts, would expend the same total quantity of heat in the motor in the same time. This mean current continuously supplied to the motor on constant test in the factory should not raise the temperature of the motor more than 75 degs. C. above the surrounding air. Where the loads on the motor during a cycle of running operations are distributed with a reasonable degree of uniformity, this approximate computation is reliable. Where, however, the loads are very heavy in one portion of the running cycle and very light in the rest of the cycle, the heating of the motor might be dangerously excessive at the end of the heavy load by reason of the want of sufficient thermal capacity in the motor, even although the average heat waste for the whole run might be well within the thermal dissipation power of the motor. In such cases the line of reasoning followed by Mr. Hanchett's article, by taking into account the thermal capacity of the motor, might be serviceable.

It seems likely that the thermal capacity of a motor might be obtained with sufficient accuracy for practical purposes by multiplying the weight of the motor in grammes by 0.11, since the specific heat of iron is usually given as 0.114 and that of copper as 0.095. This will give approximately the quantity of heat in gram-calories which will raise the temperature of the motor by 1 deg. C. If 60 degs. C. be the limiting temperature elevation of the motor under practical conditions of service, then sixty times this thermal capacity will be the energy in therms that must be given to the motor, without any escape in convection or radiation, in order to bring the motor to the limiting temperature, and, since there are approximately 860 therms in a watt-hour, we may obtain the approximate thermal capacity of the motor in watt-hours by dividing the product in therms by this constant. This means a thermal capacity, for a 60-deg. temperature of elevation, of about 3.4 watt-hours per pound of motor. A motor weighing a short ton would, therefore, be raised to the limiting temperature by about 7 kw-hours of energy, assuming that no escape of heat by radiation or convection could take place.

Arbitration Extraordinary

We have been reading with some profit and more amusement the proceedings in the arbitration hearing in London over the electrical equipment of the so-called Inner Circle. The technical nature of the questions involved and the novel features of the propositions contained in the lowest tender give the affair more than usual interest. The general nature of the issues in question are well known to our readers, and the digest given elsewhere of the hearing, which has taken place during the past month, summarizes the situation up to date. The whole question has now been summed up by counsel on both sides, and is awaiting the decision of the distinguished arbitrator chosen, as a London contemporary cheerfully puts it, "Because he is supposed to know nothing about electricity or traction." On one side or the other some of the most distinguished scientific spellbinders of the United Kingdom and elsewhere have testified, and it is safe to predict that if the referee had even any tentative beliefs on the subject under discussion they will be thoroughly muddled before the witnesses get through with him.

The question really on trial is whether the parties interested would, considering the work to be done and the state of the art, be justified in installing the polyphase traction system advocated by Ganz & Company, as against the usual form of continuous current traction specified in the other tenders. The whole polyphase traction system is thus involved in its broadest aspects.

We must suggest in the beginning that it is the veriest imbecility to submit such a question to a non-technical referee. To decide the matter upon its merits requires a profound knowledge of its technical aspects and an extraordinary grasp of the commercial conditions to be met. Whatever the decision, and whether it is or is not in accordance with our personal convictions, we shall consider it as absolutely inconclusive, as representing only the relative success of the two contestants in befogging the judicial mind.

Now, to look at the matter purely from an engineering standpoint, the burden of proof lies assuredly upon the Ganz proposition. The equipment of the Inner Circle is closely akin to the problems already successfully dealt with on American elevated lines. It involves the handling of an immense passenger traffic at good speed on a line with frequent stops. There is absolutely no doubt whatever that the continuous current mutiple-unit system installed on canonical lines would do the work, so far as operative properties are concerned, in a thoroughly satisfactory manner. On the other hand, there is some doubt whether the Ganz proposition, if carried out, would lead to equally good results. Some of this doubt arises from certain intrinsic difficulties in adapting alternating motors to heavy electric traction, and is worthy of serious discussion. Other objections raised are merely regarding trivial details, which have no material bearing on the final result, and still others are only the usual quibbles urged against every new development, unworthy the attention of any sensible man.

The fundamental difficulty with induction motors for traction lies in the fact that no method of speed control as yet devised for such machines is the full equivalent of the series-parallel control familiar in continuous current practice. The nearest approach to it is the so-called "concatenated" connection of the motors, which has been tried with rather indifferent results in experiments conducted several years ago. As Mr. Blathy pointed out, however, one cannot get good results by putting in concatenation two motors individually unfitted for such use, and certainly the process would be vastly more successful with motors of very low inductance than with those on which it was originally tried. Rheostatic control is effective, but inefficient if it has to be used to any great extent, and it is only fair to note that electric traction of the kind necessary on the Inner Circle is a constant succession of starts and stops. Now, if the statements of Mr. Blathy regarding the results obtained from the concatenated control with suitable motors and at rather low frequency (25 periods) are borne out by experience, there is little doubt that the only material difficulty in polyphase traction has been overcome, and that the rapid acceleration usually desired in heavy suburban service can be obtained without difficulty. Here is a question of fact which could be settled once for all by experimental runs with motors such as Ganz & Company propose to furnish, and it should be so settled without delay. There is no need here of long-winded polemics—either Ganz & Company have solved the problem of practical speed control in polyphase traction motors or they have not. If they have, the sooner engineers in general understand this the better it will be; if not, then Ganz & Company will have wrought their own destruction in the pending issue. The burden of the proof is upon them, and it should promptly be shouldered.

It may prove that, while measurably successful, the scheme of control will not permit an effective rate of acceleration quite so great as is considered desirable in continuous current practice. In such case it is for Ganz & Company to prove that the required speed can be made with the acceleration readily attainable without increasing the cost of the energy per round trip. There has been considerable nonsense talked about this matter of rapid acceleration. While it is self-evident that energy wasted in brake friction is energy lost, it does not necessarily follow that the quicker the acceleration the greater the efficiency. The most economical rate of acceleration is determined by the design of the motors and the effect of the current demanded upon the load factor of the station, as well as by other minor considerations. If, as has been claimed, larger motors are needed to give the required train service upon the polyphase system, it is certainly competent to inquire whether this either increases the price of the plant as a whole or the cost of power per trip.

In heavy traction, such as is being tried at Zossen, where acceleration is only an incident and the motors run normally at full speed, the polyphase system has certain very marked advantages that will hardly be denied by anyone competent to judge; but the Inner Circle is a very different matter, and success there depends largely upon the effectiveness of the proposed speed control, which is, as we have just intimated, a matter in which no evidence save that of experiment is worth taking. We attach very little importance to the claim set up by Mr. Blathy of material gains from energy returned to the line by electrodynamic braking. If it be feasible with alternating currents, it will also prove to be feasible with continuous currents.

On the other hand, we take little stock in the criticism of the minor details of the Ganz scheme—the resistances, the trolley, the motor suspension, and such like things. Theoretical objections to what the other fellow is doing are not usually very important, and so far as can be told at this distance there is nothing in the entire auxiliary equipment of the Ganz scheme on its face so entirely unlikely to work properly as the ordinary multiple-unit control which is in regular everyday use. Against no successful device which we know could so many plausible and logical objections be urged—but it works, and that is the end of the matter. Obviously in installing a new system some unforeseen troubles are likely to appear, but it has been the ordinary experience that such troubles have proved to be temporary. If the conduit system here in New York had been abandoned because of trouble with the plows, electric traction of that character would have made precious little headway, but persistent effort told, and the difficulty gradually faded away. In the present state of electric traction it is not sufficient to say that a thing is new or untried in order to condemn it. Every advance in the art has been a new and untried thing within ten years or so, and has been decried by somebody as theoretically bad and practically unworkable. The only real question at issue, then, is, have Ganz & Company worked out a system of concatenated control which enables the necessary acceleration to be furnished with a smoothness and efficiency comparable with that secured by the series-parallel control; if so, it must be recognized that their system can be made to include all the operative facility hitherto attainable only by continuous current motors. This claim cannot be proved or disproved by a group of experts testifying as to their preconceived notions regarding apparatus which they have not personally tested or conditions which they have not yet experienced. A series of actual tests on a car fitted with the Ganz control, made by a joint committee of engineers, and submitted without comment to a board of technical experts serving as arbitrators, before whom no *ex parte* evidence should be laid, would settle this, the vital point of the controversy, in short order.

Notable Features in the Operation of the Union Traction Company of Indiana

To the projector and operator of interurban electric railways the operation of the interurban lines of the Union Traction Company of Indiana should have many lessons of value. This company is now operating an interurban system connecting the cities of Indianapolis, Anderson, Muncie, Elwood, Alexandria and Marion, making in all 97 miles of interurban line, over which a service on 1-hour intervals is given, all of which is operated on a plan which probably represents as advanced electric interurban practice as can be found anywhere by a road using the overhead trolley. Nineteen interurban cars are called for by the regular schedule. It may be said in general that these interurban lines approach very close to steam-road practice in many particulars. For example—in the matter of roadbed and right of way, the greater part of the mileage is on the company's own right of way, and it is graded and ballasted after the manner of the most approved steam railroad practice. (See Fig. 1.) It has not been found necessary in most cases to purchase as wide a right of way as is common with steam railroads, because the character of the country through which the Union Traction Company's lines run is so level that extensive grading and filling is not needed, and hence no great amount of room is necessary for the right of way.

In the larger cities reached by these lines the cars run over the tracks of the local city systems. These latter, however, are also owned by the Union Traction Company of Indiana, which operates the 56 miles of the various city systems as well as its interurban lines.

The population served outside of Indianapolis is about 175,000. Indianapolis has 169,164.

DESPATCHING SYSTEM

As the lines are mostly single tracked, a thorough system of train despatching is a necessary part of the operation of a railway of this kind. The general lines followed are

FIG. 2.—METHOD OF RECEIVING DISPATCHERS' ORDERS. TELEPHONE IN CAB

those employed on the steam railroads, with the important exception that the telephone instead of the telegraph is the means of communication, and that it is not necessary to place operators to receive despatches at the various switches along the line. The company has on its poles on one side of the road over the entire system (Fig. 2) two pairs of telephone wires. One pair of these wires is for the exclusive use of the train despatcher. The other pair is for the general use of the officers and employees in transacting the company's business. The train despatcher's telephone line runs over the entire system. The only telephone instruments permanently bridged across this pair of telephone lines is the despatcher's telephone at headquarters. At every turnout is placed a pair of telephone connection boxes, as shown in Fig. 2. These boxes are so placed as to be within easy

IG. 1.—TYPICAL VIEW OF A SECTION OF TRACK

reach of the motorman's vestibule on the car, whether on main line or siding. When a motorman stops opposite one of these boxes, he has only to take a connector, which is attached by flexible cable to the telephone instrument hanging in his cab, and hang it over the pair of terminals in the telephone box on the pole. He can then talk directly to the despatcher without ringing up or any preliminary time-consuming operations. Of course, if some other motorman is talking with the despatcher, the others must await their turn. Fig. 2 shows a car receiving a message from the despatcher. By having the telephone connection boxes so easily accessible from the car, messages can be received promptly, with very little delay in securing connection with the despatcher. As the despatcher's instrument is the only one that is bridged across the line, there is no trouble from poor operation of the despatcher's line on account of too many instruments being on the line at once. The road is provided with turnouts every 2 miles, but as at present operated, these are not all used. The time table is arranged so that cars running on regular time meet at certain turnouts, indicated by bold-faced type on the employees' printed time table. If the despatcher wishes a car crew to report to him at any point between the regular reporting points, he has simply to give orders to that effect when the car crew reports at one of the regular reporting points. When a car waits more than five minutes to meet an opposing car at a turnout, the crew reports to the despatcher for orders. The despatcher uses a regular train sheet, made up and ruled in the same way as a railway time table, in keeping record of the position of each car. To assist him in keeping in mind the points at which extra or delayed cars are to report, it is necessary on a system of this kind, where there are so many work trains and extras, to use what is known as the peg system; that is, on the board in front of the despatcher is a diagrammatic map of the lines, with all the turnouts indicated thereon. At each turnout are holes for several pegs. When the despatcher gives orders to the car crew to report at a certain turnout he puts a peg representing the car at the turnout at which it is to report. There is thus kept before the despatcher at any time a record of the cars which are to report to him and their locations at the time they will report.

With the telephone it is advisable to take precautions against errors—especially errors in numbers. Orders are

UNION TRACTION COMPANY OF INDIANA.

TRAIN ORDER BLANK, FORM A.

Order No. .... *Date* .... *19* ....

To Conductor and Motorman,

Train No. .... *Motor No.* .... *at Siding No.* ....

Meet Train No. .... *Motor No.* .... *at Siding No.* ....

and report at Siding No. ....

....

....

....

....

....

Complete .... *M* ....

Dispatcher.

FIG. 3.—TRAIN ORDER IN BLANK

written out as they are given by both despatcher and train crew, the blank used being reproduced herewith in Fig. 3. In receiving the order the motorman reads it back to the despatcher, two or three words at a time, as he writes it. When the order is finished, the motorman reads over the entire order to the despatcher, and the despatcher underlines each word as the motorman reads it. When a car is on time and is to report only at its regular reporting points, it is necessary only to give the verbal order to go ahead. Cars are considered on time unless more than five minutes late.

GENERAL TELEPHONE SERVICE

As stated before, in addition to the despatcher's telephone line there is a line for general service over the whole system. This line has instruments at the company's car houses and offices in all the cities to which it runs, and on its line there is placed every half-mile a connection box (Fig. 4) on one of the company's poles. These boxes are like those used on the despatching system, except they are placed directly on a pole and not on an arm. They are also painted a different color from the despatcher's circuit connection boxes. When a work train is on the line or any employee along the line wishes to communicate with headquarters or any other part of the system, he has simply to connect a portable telephone at one of these connection boxes. In case of a wreck or derailment of any of the cars, these boxes can also be used by a car crew. As they are placed every half-mile, it is, of course, impossible for a wreck to be more than a quarter of a mile away from a connection box. The company employs one man who puts in all his time maintaining telephone lines and instruments. The instruments, it is stated, have given very little trouble. One of the chief defects has been that of broken wires or wet insulation in the flexible cable which is used to connect the portable instruments to the connection boxes. The connector used is simply a handle with two hooks placed like horns. When connection is desired these hooks are hung over the two terminals in the connection boxes. The telephone circuits are both of No. 12 hard drawn copper wire, and are run on a four-pin cross-arm on the poles along one side of the road. The high-tension and low-tension feeders are run on higher poles on the opposite side of the road, as seen in Fig. 1, the high-tension feeders being run above everything else.

SPEEDS

In matter of speeds the interurban cars of this company make about the same time as the trains of the steam railroad, but make a great many more stops. For example, between Muncie and Indianapolis, a distance of 53 miles, the running time for cars making all stops is 2¼ hours. Recently an express service has been put on between Muncie and Indianapolis, in which cars stop for passengers only at Anderson. The time of these express cars is 2 hours. The fastest limited train on the Big Four Railroad, which parallels the Union Traction Company, is 1 hour and 13 minutes. The slow local trains consume 1 hour 50 minutes in making this run. In this connection it must be remembered that 25 minutes is consumed between the city limits and the center of Indianapolis, as the interurban cars cannot make any faster schedule than the city cars between which they run. Considering this, the time made by the interurban cars is certainly excellent, and, taken together with their operation on 1 hour headway, captures for them the business. The maximum speeds attained run as high as 60 miles an hour, while speeds of 40 and 50 miles an hour between stations are common. Of course, in order to make a speed of this kind safely a good track and roadbed is necessary, and this the Union Traction

FIG. 4.—TELEPHONE CONNECTION BOX FOR GENERAL SERVICE

FIG. 5.—A GOOD TRACK FOR 50 MILES AN HOUR

Company has, as can be seen from Fig. 5, taken from the rear of a car at 50 miles an hour. The rails are 70-lb. standard section T, rolled in 60-ft. lengths, and perhaps the best illustration of the condition of the track is the fact that it is impossible to count the joints when riding in the middle of a car going at full speed. It is only on the platforms that the click at the rail ends can be detected. It is considered on this road that the speeds above mentioned are nearly the limit at which it is practicable to work the

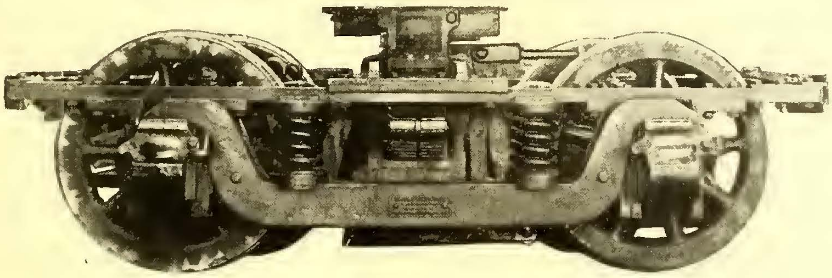


FIG. 7.—STANDARD MOTOR TRUCK, M. C. B. LINES

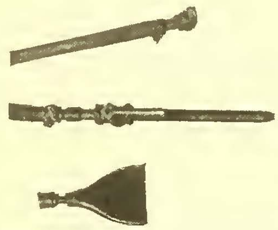


FIG. 8.—NOZZLES AND HOSE CONNECTION FOR CAR AND MOTOR CLEANING

overhead trolley. Since the track ballasting and surfacing has been completed so that the track is smooth, there is extremely little trouble from the trolley coming off at high speeds. While at the speeds so far attained there is no practical difficulty with the trolleys, for higher speeds and greater length of trains the trolley would be out of the question. The trolley wheels used are 6 ins. in diameter, and, of course, wear out very rapidly in this service, not only on account of the wear in the bearing of the wheel, but because of the volume of the current that is conducted from the wheel to the wire. At full speed the current required on a level is about 150 amps. The maximum current taken during acceleration when the motors are thrown into multiple is from 300 to 350 amps. Considering the volume of the current which must be taken by the trolley-wheel, it is not surprising that the wear is rapid, although, as stated before, it is within reasonable limits.

INTERURBAN CAR EQUIPMENT.

The cars which are on the interurban lines (Fig. 6) are 52 ft. 6 ins. long over all, and weigh, complete with motors, 64,000 lbs. The motors are on the front truck, and are No. 50-C Westinghouse, rated at 150 hp each. Both front and rear trucks (Fig. 7) were built on the general lines of a M. C. B. truck by the Baldwin Locomotive Works. These trucks are very satisfactory, not only in the way they ride at high speeds, but in the matter of maintenance and repairs. The motor truck has 36-in. steel-tired wheels on axles of open-hearth steel 6½ ins. in diameter. Some cars equipped with four motors of the same total capacity as the present are to be tried for the sake of comparison with the two-motor equipments in the matter of maintenance. The four-motor equipments will be of a somewhat higher maximum speed than the present ones, and this probably means that over 60 miles an hour will be reached. The car bodies used in this interurban service were described in the STREET RAILWAY JOURNAL of Dec. 1, 1900.

SHOP AND SHOP PRACTICE

In the operation of heavy interurban cars the introduction of changes in shop practice from that common with the light city and suburban cars is, of course, advisable, and owing to the newness of the art of interurban railroading, such practice is worth special notice. Perhaps the nearest approach to it found in previous practice is that on the elevated lines of Chicago, and in this connection it may be noted that J. S. Hamlin, the general master mechanic of the company, acquired a part of his experience in the shops of the Metropolitan West Side Elevated, of Chicago.

As the present shops are somewhat cramped, a new shop and car house is to be erected next spring. These shops will be 500 ft. x 135 ft., nine tracks wide. These tracks will run clear through from one end of the shop to the other, so that entrance can be had from the main line to either end of the shop. Two tracks will be devoted to erecting purposes.

The plan Mr. Hamlin contemplates for removing the trucks is of special interest. In one of the repair-shop tracks will be a section of track the length of a truck, which can be lowered into a pit. This section will be raised and lowered by compressed air, with an air piston under each corner, and all four air pistons controlled by a regular air-brake engineer's valve. When not in operation, the platform on which the short section of track is laid will rest on

FIG. 6.—STANDARD INTERURBAN CAR

removable timbers. When a truck is to be removed from a car, the car will be placed so that the truck to be removed will be run over the platform track; the platform will then be raised slightly by means of compressed air, and supporting timbers will be placed across underneath the car body. The timbers which supported the platform when it was at rest will then be taken out, and the platform with the truck on it will be lowered part way. The motor leads can then be disconnected. The platform will then be lowered to the level of the pit floors. In the pit is to be a track of standard gage, and there will be room in the pit on each side of the platform track for a truck. When the platform with the truck upon it is lowered to the pit, the truck to be repaired will be run off one end of the platform, and a new truck to replace it will be in readiness at the other end of the platform. As soon as the old truck is run off the new truck will be run on in its place and the platform hoisted to its highest level, so that the new truck can be put under the car. This plan is a modification of that employed by the Metropolitan Elevated shops at Chicago, the principal difference being that in the present case the repair-shop tracks are to be on the ground level, with pits underneath, whereas in the elevated shops the repair tracks are on the second floor of the building and trucks are lowered to the ground floor. The plan will be a great time saver, and this time saving will not only include the wages of the men working on the car trucks, but it will enable a car to be replaced on the road in a very short time, since as long as there is a truck in good condition in the repair shop it is only a matter of the time it takes to change trucks until a car can be made ready for service again if the trouble is confined to the truck or motors thereon. There is also likely to be less strain on the car body than if jacks or block and tackle are used to hoist the car body. It is extremely unlikely in the latter case that at some time in the tedious operation of the removing or replacing of a truck one corner of the car will not be lifted higher than the opposite corner, with the result that there is considerable strain on the car body and working of the joints. Although this may not be noticeable at first, it is sure to cause badly fitting sash and other trouble in time.

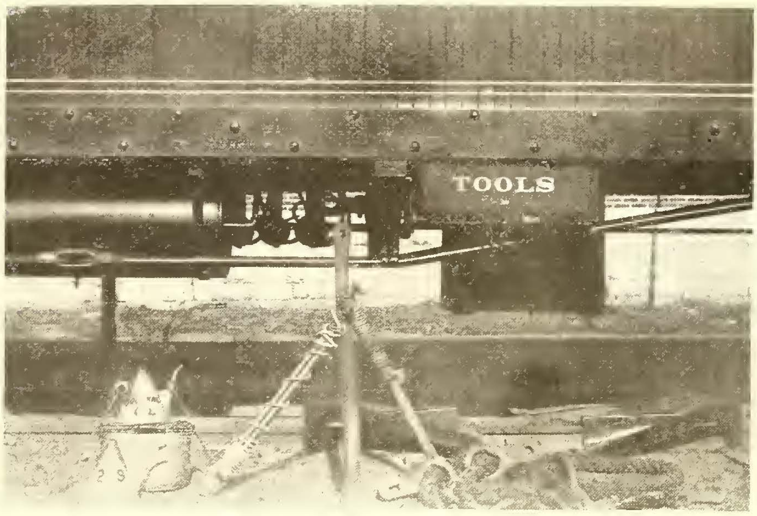


FIG. 9.—TOOLS AND TOOL BOX

FIG. 10.—COMBINATION SIGN AND SHIELD FOR ARC HEADLIGHT

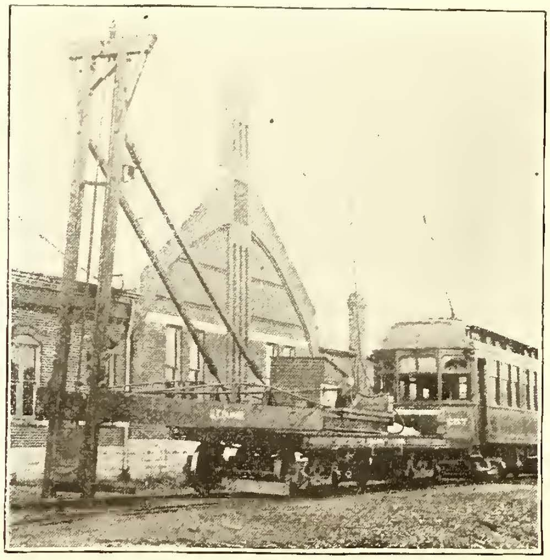


FIG. 11.—ELECTRIC PILE DRIVER

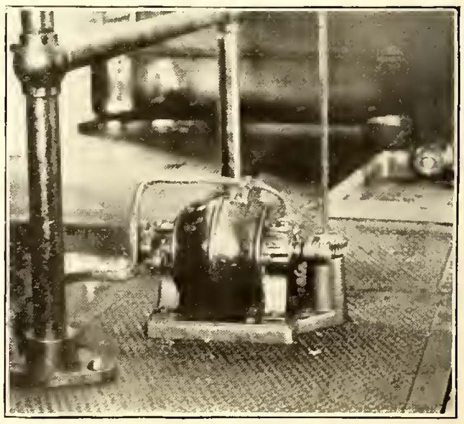
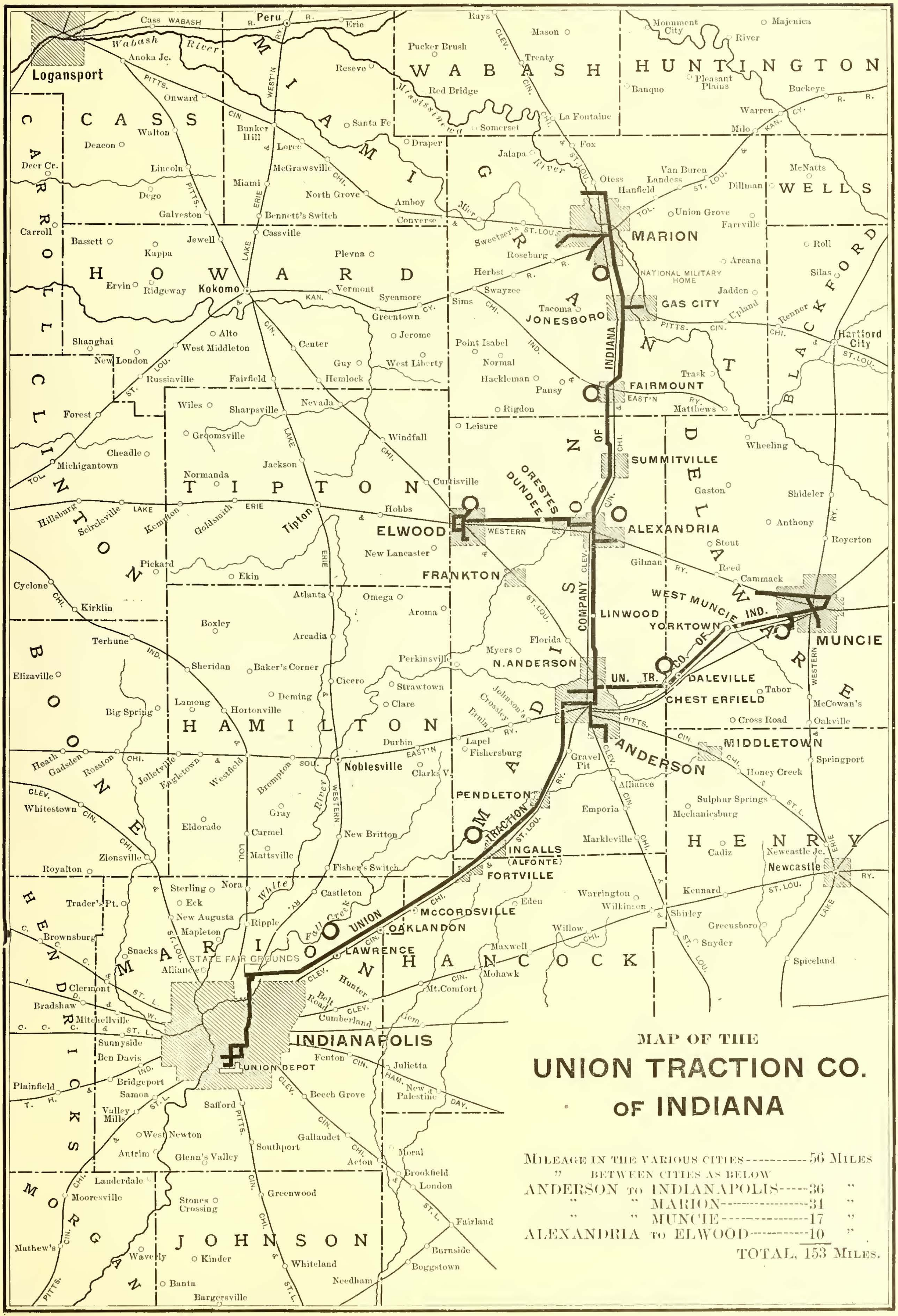


FIG. 13.—MOTOR FOR SYNCHRONIZING ON ENGINE GOVERNOR SPRING

Christensen air brakes with independent motor compressors are on all the interurban cars. An automatic switch for starting and stopping the air pump is not used. Instead of this, a pop valve is placed in the train pipe in the motorman's cab, and when sufficient air pressure is reached this will begin to blow off and announce to the motorman that it is time to shut off the compressor motor. The compressor motor is started and stopped by a jack-knife switch in the motorman's cab, and it is part of the motorman's duties to see that his compressor is started and stopped to maintain a sufficient air supply. The pressure carried is from 60 to 80 lbs. in the storage reservoir. In making ordinary service stops about 20 lbs. pressure in the air-brake cylinder is common. The brake leverage is so adjusted on these cars that the total brake-shoe pressure on the wheels in emergency stops is equal to 90 per cent of the weight upon the wheels of the rear truck, it being assumed that the car is not loaded. The higher percentage of the front truck is to allow for the momentum of the motor armatures. In connecting motor leads to the car truck the General Electric jack-knife connectors are used, and the hose is slipped over the connectors for protection. The ends of the hose are taped over. It is the general practice to clean cars and motors by compressed air supplied directly from the storage air reservoirs on the car. On each car is a connection to which a hose can be attached for cleaning purposes. The form of nozzles used is illustrated herewith in Fig. 8. The plain round nozzle is for cleaning out motors and the flat nozzle for cleaning car floors and cushions. The flat nozzle has a slit 1-64 in. wide and about 3 ins. long. This slit was made by sawing clear across the end of the nozzle, filling up the ends of the slit with solder, and hammering the slit partly shut, until it was reduced to the width of 1-64 in. The use of the air-brake compressors and storage reservoirs to supply air for cleaning is extremely convenient, especially where cars are cleaned in small local shops, away from the main or general repair shop. It is, of course, usually necessary to run the compressor on the car while the cleaning is going on, as the storage reservoir is not of sufficient capacity to supply air for cleaning for a great length of time.

Under the center of each car is a tool box, in which is carried tools for use in emergencies. As the distances are so great, it is very desirable that train crews have at their disposal means of getting a car on the track or temporarily repairing the trolley or trucks. The tools carried in the box consist of a heavy hog rope, a long coupling link, 5 ins.



O, indicates sub-stations.

long, a standard Van Dorn coupling link, a pair of wrecking frogs for derailed cars, and a pair of trolley pick-ups. The latter consist simply of tongs with wooden handles so arranged that the trolley wire can be picked up with them, and they can then be tied together to keep the wire clear of the ground until the repair car arrives.

The tool box and the tools enumerated, as well as some other things carried by each car, is illustrated in Fig. 9.

Compressed air is also used for feeding sand to the rails from the sand boxes. The sand box is placed directly on the truck frame, so as to spring with the wheels. The compressed air from the motorman's valve is taken to the sand box by a simple rubber hose. The sand box used is the Nicholas-Lintern air sander. In this the sand drops by gravity into a crooked pocket, and the compressed air also enters this pocket to drive it on into the track hose. The pocket is of such a shape that the sand will not of itself work through without the application of compressed air. In order to keep dust and sand from the axle bearings of the motors a sheet-brass sleeve is placed over the axle to bridge the space between the motor axle bearings. This sleeve is made in halves.

Like all interurban roads, this system is limited in the width and depth of wheel flange employed by the requirements of the city lines over which it runs. The flanges have, however, been made recently somewhat heavier, to allow for a greater wear before the minimum allowable factor of safety is reached. The new standard flange is $\frac{7}{8}$ in. deep and $1\frac{1}{8}$ ins. wide at the throat. Steel-tired wheels are used on the motor trucks, and in turning down these wheels it is the practice to give them a bevel equal to that of new wheels rather than leave the tread flat, as is sometimes customary in turning down wheels of this kind.

SIGNS AND HEADLIGHTS

It is the general policy to have the background of destination signs of a color that will indicate the destination independently of the lettering of the sign, so that the destination of the car can be determined by those familiar with the service before the lettering on the sign can be read. The signs are hung on both sides of the vestibule dash (Fig. 2) and also just in front of the rear step on one of the side panels, for the convenience both of passengers hailing the car and those boarding it while it is standing at its regular stopping place in a city. As the requirements of the law in Indianapolis are for an illuminated sign at night, and as it is also necessary to shade the arc headlight in some way when operating in that city, the company has accomplished a double purpose by having a cap (Fig. 10) which fits over the front of the arc headlight when in town. This cap consists of canvas painted white, with the lettering on it in black, and when it is placed on the headlight the effect is not only to tone down the light, but to afford an excellent illuminated sign as to the car's destination. The Wagenhals electric headlight is used, with an attachment for automatically starting the arc, which is made in the company's shops. The headlights originally had to have the arc restarted by a hand lever when the current failed momentarily. That is, after the current had been interrupted once, the arc had to be started when the current came on again. This was found to be a considerable inconvenience in going over section insulators, because the arc would always go out and the motorman would be obliged to let down the front window of his vestibule and start the arc—the car perhaps going 60 miles an hour against a strong wind. The attachment which has been put on is a magnet which starts the arc automatically just as soon as the current is flowing. With these headlights it is possible to distinguish objects several hundred feet ahead. It would be difficult to operate an interurban road of this kind without an arc headlight, because of the high speed and the necessity of stopping for passengers

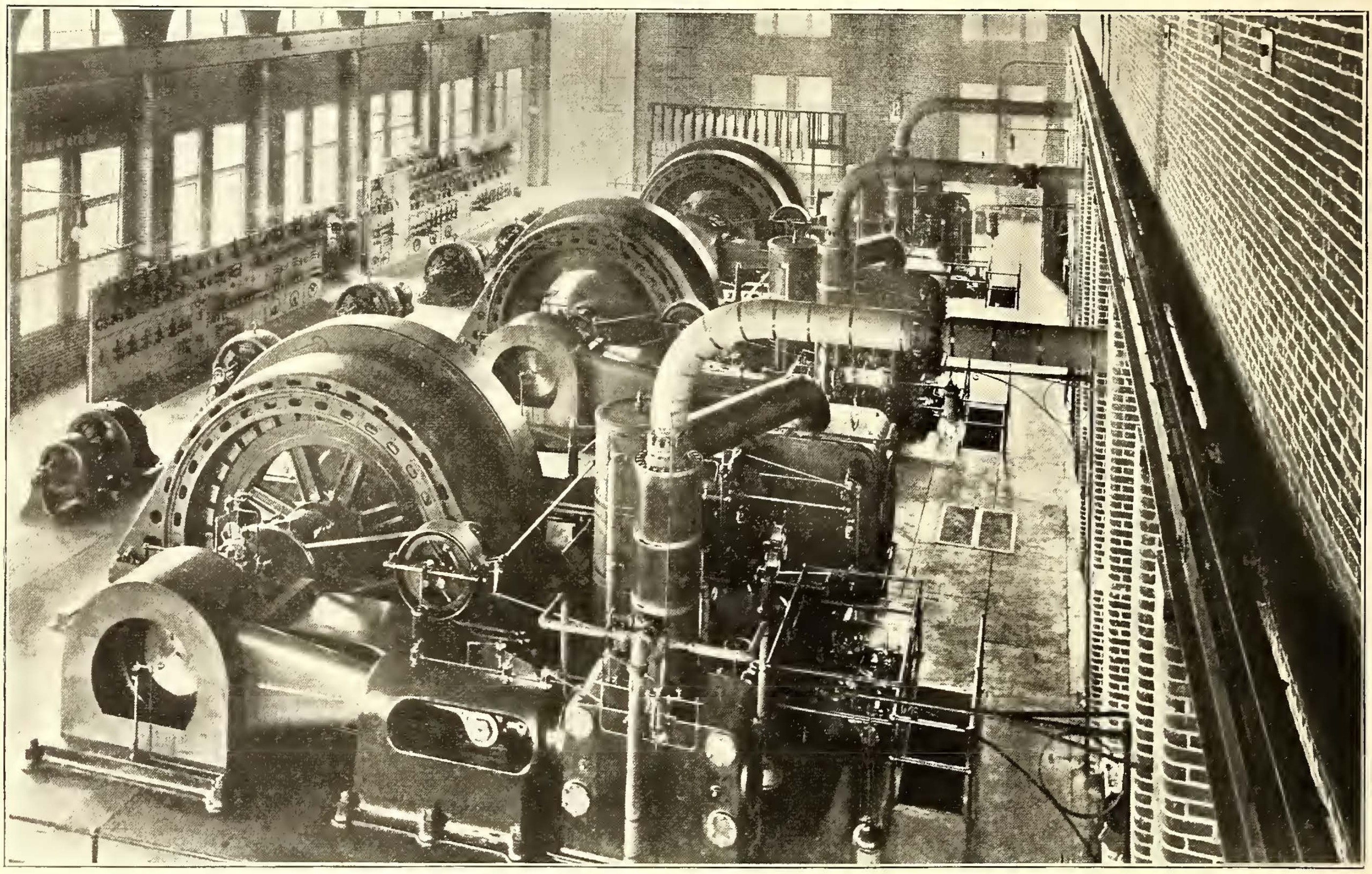


FIG. 12.—ENGINE ROOM OF POWER HOUSE, UNION TRACTION COMPANY

who may be waiting at any highway crossing, and which it would be impossible to see without an arc headlight.

ELECTRIC PILE DRIVER

The company has what is probably the first electrically operated pile driver to be brought in use (Fig. 11). In this pile driver the electric motor forms the part usually performed by a steam engine. It is found of great use in construction work, especially in straightening the line. The company has done much work since it started in straightening out its original route, which in some cases was very circuitous because of the difficulty of obtaining the consent of property owners or of purchasing property at anything but unreasonable figures. The Indiana Legislature at its last session passed a law enabling electric roads to condemn land after the same manner as steam roads. This has made it possible to straighten the road and give very much faster and better service at a number of stations, especially in and near small towns. In such cases power from the trolley circuit is always near, so that the electric pile driver can be used to advantage.

FIG. 14.—SECTION OF TRACK LIGHTED BY ARC HEADLIGHT

FIG. 15.—PORTABLE SUB-STATION

TABLE SHOWING COST OF POWER AT LOW-TENSION BUS-BARS AT GENERATING STATION, ALSO TOTAL COST AT SUB-STATION DIRECT-CURRENT BUS-BARS. UNION TRACTION CO. OF INDIANA.

[The figures of generating station cost being in italics.]

MONTH, 1901	Kw-Hours for Month	Total Cost Fuel	Cost Fuel per Kw-Hour	Total Cost Labor	Cost Labor per Kw-Hour	Total Cost Lubrication and Misc.	Lubrication and Misc. per Kw-Hour	Total Cost Repairs	Cost Repair per Kw-Hour	Total Cost	Total per Kw-Hour
April, power house	*$837,000*	*$2,272.20*	*$.00271*	*$1,014.91*	*$.00121*	*$301.74*	*$.00036*	......	.....	*$3 588.85*	*$.00428*
April, total	649,542	2,272.20	.00349	1,878.91	.00292	301.74	.00046	500.00	.00076	4,958.85	.00763
May, power house	*820,600*	*2,070.59*	*.00250*	*928.68*	*.00113*	*254.94*	*.00032*	*514.95*	*.00065*	*3,769.16*	*.00459*
May, total	645,431	2,070.59	.00321	1,933.08	.00299	254.94	.00039	1,014.95	.00157	5,273.56	.00816
June, power house	*825,900*	*2,672.54*	*.00323*	*1,012.17*	*.00123*	*297.70*	*.00035*	*244.42*	*.00029*	*4,226.92*	*.00510*
June, total	647,490	2,672.54	.00412	1,921.09	.00296	297.70	.00046	744.42	.00114	5,635.75	.00868
July, power house	*953,000*	*1,714.97*	*.00179*	*1,102.88*	*.00116*	*377 98*	*.00039*	*477.50*	*.00050*	*3,673.33*	*.00384*
July, total	756,650	1,714.97	.00227	1,995.68	.00264	377 98	.00049	985 01	.00130	5,073.64	.00670
August, power house	*1,003,300*	*2,566.44*	*.00255*	*1,130.08*	*.00112*	*327.99*	*.00033*	*354.81*	*.00036*	*4,397.32*	*.00436*
August, total	791,041	2,566.44	.00325	2,022.88	.00255	327.99	.00042	854.81	.00108	5,772.12	.00730
September, power house	*983,700*	*2,503 75*	*.00254*	*1,086.42*	*.00110*	*283.49*	*.00029*	*493.13*	*.00050*	*4,366.79*	*.00443*
September, total	769,820	2,503.75	.00325	1,952.42	00254	283.49	.00036	993.13	.00129	5,732.79	.00744

Average for six months { Power house cost .... .00443
Power house and distribution cost ...... .00765

POWER GENERATION AND DISTRIBUTION

The distribution of power by high-tension, polyphase alternating current for interurban lines is of sufficiently recent introduction so that any figures which throw light on the cost of distributing energy in this way are of practical interest. The cost of generating power is now known by the majority of companies operating modern power houses in the United States. The cost of the alternating-current distribution through sub-stations, however, is a point upon which there is not much information available, and the figures on this furnished by A. S. Richey, electrical engineer, are very acceptable.

The accompanying tables give the cost of power for six months at the bus-bars of the Anderson power house, both in totals and per kilowatt hour, and also the cost of power delivered at the direct-current bus-bars of the sub-stations. The output of the sub-stations in kilowatt-hours and that of the main generating station are shown. The difference, which is in the neighborhood of 21 per cent, represents the loss in step-up transformers, 14,000-volt, high-tension line, step-down transformers and rotary converters. The item of repairs to sub-stations consists mainly of a charge of $500 per month paid for the maintenance of storage batteries at the sub-stations, the batteries being maintained under contract at 6 per cent of first cost.

The power house is at Anderson, near the center of the system, as can be seen from the accompanying map, and the company has eight sub-stations, as indicated by the map, in addition to the sub-station located in the generating station at Anderson. The current is generated at 400 volts, three-phase, and transmitted at about 15,000 volts. The Anderson power house is a fine piece of engineering, equipped with Babcock & Wilcox boilers and stokers and Mead automatic coal and ash conveying machinery. Part of the year natural gas is burned under the boilers, and when the gas supply is low coal at $1.50 per ton is used. The natural gas is obtained at a figure which brings it nearly equal to coal at the foregoing price. In the engine room, which is so well illustrated by Fig. 12, three Westinghouse revolving-field generators are driven by Rice & Sargent engines built by the Providence Engineering Works. These engines are cross-compound, condensing, 26 ins. and 56 ins. by 48 ins. stroke, running 100 r. p. m. The massiveness of the fly-wheels is noticeable, and this, combined with the weight of the revolving generator fields, gives a great deal of inertia to the moving parts, which is important in the successful operation of alternators in synchronism on varying loads. The fly-wheels are 18 ft. in diameter, and weigh 120,000 lbs. The shaft is 24 ins. in diameter in the middle and 22 ins. at the bearings, which are 38 ins. long. The governor is the Rites, which revolves in a vertical, instead of a horizontal, plane, and can be seen plainly on the unit in the foreground in Fig. 12. To raise or lower the speed for synchronizing a generator with no load upon it, a spring is attached to a lever on the cross-connecting rod, which connects the governor motion of the high and low-pressure cylinders. The tension of this spring is adjusted by a small induction motor working a worm gear, Fig. 13. The induction motor is controlled by a switch at the switchboard, so that the engine speed can be raised or lowered by the switchboard attendant whe nsynchronizing. In ordinary work it is found to be quicker to have one man take hold of the governor spring by hand, and by watching the synchronizing lamps, bring the generator to synchronism.

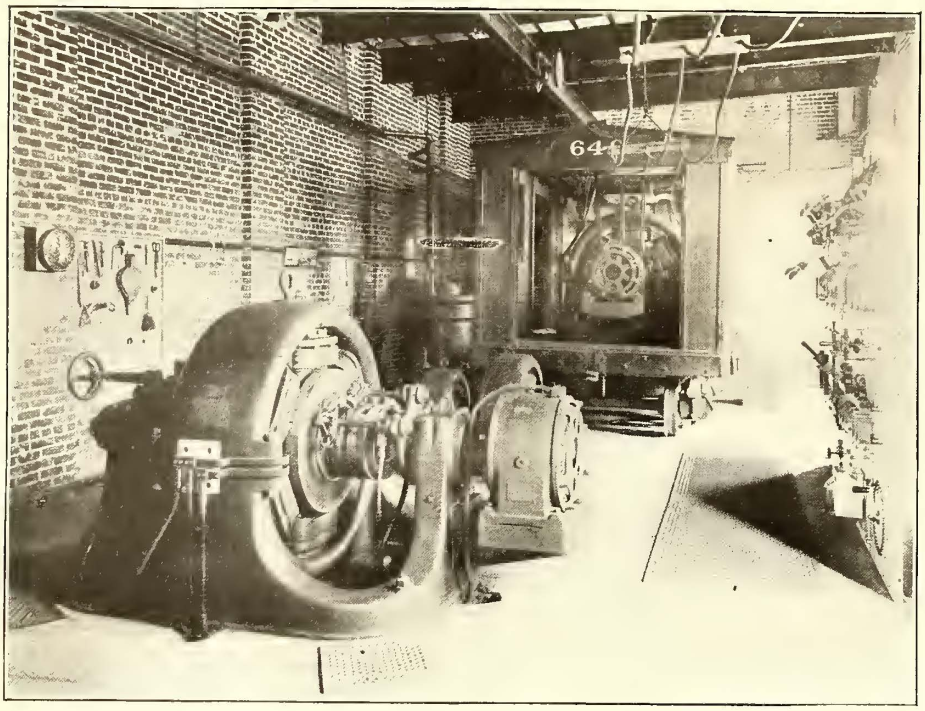


FIG. 16.—PORTABLE SUB-STATION IN USE

Three of the sub-stations have two 250-kw rotary converters and a 16-kw storage battery booster differentially wound. The five others have one rotary converter and an 8-kw booster. Each sub-station has four step-down transformers, one of which is held as a reserve. The converters and transformers are Westinghouse make. The converters are started by induction motors on the same shaft. All of the sub-stations are alike in arrangement, one of which is shown in Fig. 17. In the three larger sub-stations a chloride battery of 264 cells, 168 kw-hours capacity on one hour rate. At the five smaller sub-stations a battery of 264 cells and 84 kw-hours capacity is put in. The battery at the Anderson power house is of 211 kw-hour capacity at the one-hour rate of discharge.

The portable sub-station is an important part of the sub-station equipment of the road. This sub-station (Fig. 15) is contained in a box car 21 ft. 6 ins. long by 8 ft. 8 ins. wide. In this car is a 250-kw rotary converter and three 87.5-kw transformers. In all of the sub-stations there is a track in one end of the converter room, into which this portable sub-station can be run. A sub-station of this kind is a great saving in investment because it practically takes the place of a reserve unit in every sub-station on the road, because it can be used as a reserve in any.

FIG. 17.—A TYPICAL SUB-STATION, TRACK FOR PORTABLE SUB-STATION IN FOREGROUND

The company is now under the general management of George F. McCulloch. J. S. Hamlin is general master mechanic; A. S. Richey, electrical engineer, and W. H. Bloss, chief engineer and roadmaster. The operation of cars comes under Charles A. Baldwin.

The Proposed New York and Portchester Railway

Considerable interest is being excited in New York at present by the proposal of the New York & Portchester Railroad Company to install a high-speed electric line between Portchester, N. Y., and 132d Street, New York City. The route of the line is shown in the accompanying map. Owing to Section 59 of the Railroad Law of New York State, the company must prove to the Railroad Commissioners of the State the convenience and necessity of the railroad. Under this obligation hearings have been held during three weeks of October and four days of November. The experts who have thus far testified have been W. C. Gotshall, president and chief engineer of the company; Frank J. Sprague, William B. Potter, C. O. Mailloux, the technical electrical director of the company; Robert A. Parke, of the Westinghouse Air Brake Company; Edwin Thatcher, bridge expert; William Barclay Parsons, chief engineer of the New York Rapid Transit Subway, and others. So far all the time has been occupied in presenting the case of the New York & Portchester Railroad Company. The opponents consist of the New York, New Haven & Hartford Railroad Company, the Union Railway Company and the Stamford Railroad Company. Hearings are to be recommenced Dec. 9.

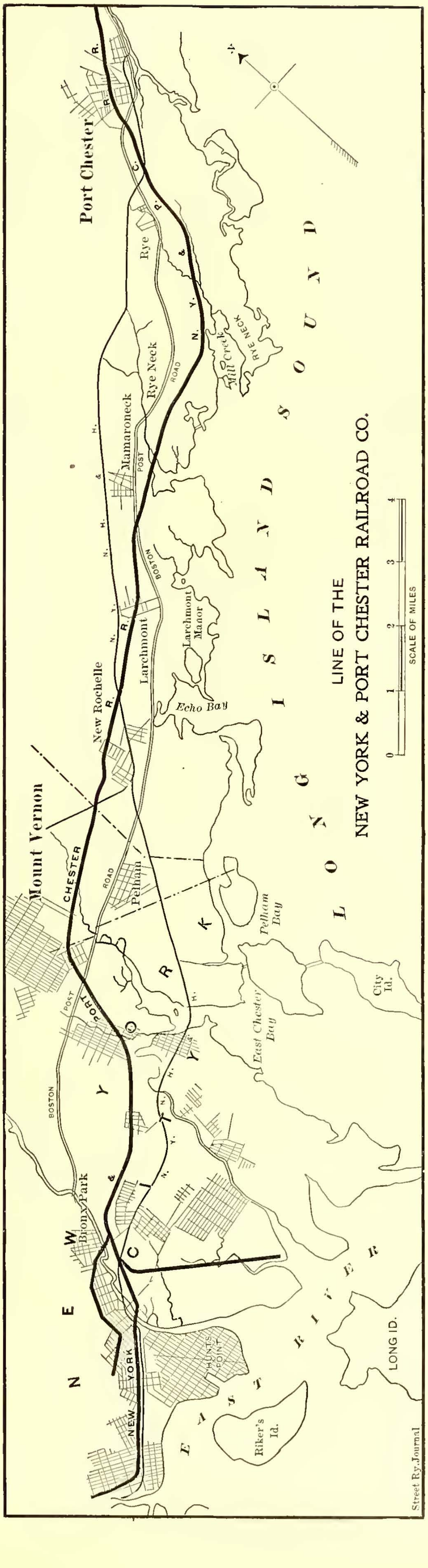
In view of the fact that the road, as proposed, is the most important example of high-speed electric railroading in this country, as the plans presented are most complete, and as the testimony of the experts on the technical features of the proposed installation are of the greatest interest, some particulars of the plans and extracts from the testimony are given herewith. It must be remembered that the petitioners had not only to prove that their plans were technically correct and the road could be built along the lines laid down by them, but they had also to show that the road would be financially successful.

The road as planned will start at 132d Street and Willis Avenue, Borough of the Bronx, New York City, will run for 8 miles through New York City on the main line, with a branch 2 miles long to the East River, and then for 13 miles more through Westchester County, to Portchester, N. Y. It is to have four tracks, and will be built on private right of way throughout. There will be no grade crossings at any point along the road. All streets, avenues, highways and other railroads will be crossed either above or below the grade. There are about seventy-eight of these crossings. All bridge construction will be concrete arches.

The service consists of express and local trains. The express trains will make ten stops between termini, and cover the distance between termini of 21 miles in 31 minutes. The maximum speed of the express trains is slightly over 60 miles an hour, while the schedule speed of the express trains, that is, the speed including stops, is 39.9 miles per hour. The minimum headway on the express, as now determined, is 10 minutes. Fifteen-second stops at stations will be made, the same stop as allowed on the schedule of the Rapid Transit Railway now building.

EXPRESS STATIONS, WITH DISTANCES

New York to	Distance	Time
Willis Ave.	0	... ——
149 Street	1.625	2 minutes 32 seconds
Bronx Park	4.376	6 " 12 "
Bronx & Pelham Parkway	5.805	8 " 28 "
Mount Vernon	8.919	12 " 22 "
Pelham	9.608	13 " 52 "
New Rochelle	11.451	16 " 53 "
Larchmont	13.304	19 " 32 "
Mamaroneck	14.524	21 " 40 "
Rye Neck	17.357	25 " 23 "
Rye	18.805	27 " 43 "
Portchester	20.900	31 " — —



LINE OF THE NEW YORK & PORT CHESTER RAILROAD CO.

The new road will connect with the Rapid Transit line at 177th Street and Boston Post Road, and with the same railway at its new East Side extension at 132d Street. The running time by the former route from Portchester to City Hall station will be 54 minutes, and through trains will be run. At 177th Street, where the connection will be made with the Rapid Transit line, which at that point is on an elevated structure, the express tracks of the Portchester road, which are the inside tracks, will gradually rise and cross the local tracks above grade to join the Rapid Transit tracks. The second connection, at 132d Street, with the Rapid Transit line is with the proposed new East Side line, which will leave that now building at Forty-Second Street and will run up Madison or Third Avenue. It is expected to cross the Harlem River very near the Willis Avenue Bridge, making connection with the new line at that point, thence up Willis and Jerome Avenues. Through trains will be run this way also.

The local trains on the Portchester Railroad will cover the distance from Portchester to 132d Street in 49 minutes, making twenty stops between termini, and allowing 15 seconds for each stop. The maximum speed of the local service is about 48 miles an hour, while the schedule speed, that is, speed including stops, is 25.6 miles an hour. The local service will be run on a 5-minute headway from 7:30 to 10:30 a. m. and from 3:30 to 7:30 p. m. The total car mileage of the road is planned to be 4,500,000 car-miles per year.

The tracks will be built with 12 ft. 6 in. centers, and will consist of 90-lb. T-rail laid on white oak ties 6 ins. x 8 ins. x 8 ft. The roadbed will consist of 10 ins. of broken stone under the ties, and the ballast will be brought up between the ties to the level of the top of the ties. The third-rail system will be used, the rail to be located at the side of the track, with its base about 2 ft. above the surface of the tie and its head about 1½ ft. above the head of the service rail.

The rolling stock will consist of seventy cars, each having a 50-ft. body with 5-ft. platfroms and 1-ft. bumpers, making the car 62 ft. over all. The width of the car will be 9 ft. 3 ins. Each car will comfortably seat about eighty four people, and will carry a load of about 150 people. Each car will be a motor car, and will be equipped with four 400-amp. motors, that is, one on each axle, and operated by automatic multiple-unit control. It is the intention to run the local service consisting of units of one or more cars, as the public needs may demand, while the express service will consist of units of two or more cars. The gear ratio employed will be 56 to 41. This will give a maximum acceleration of 2 miles per hour per second. It was originally thought that a 300-amp. motor might be able to do the work, but it was found just insufficient. The acceleration curves of both types of motors are given herewith, from which the differences can easily be determined.

The power station will be near the electrical center of the system, and will have a total capacity of about 12,000 kw. Three-phase current will be distributed at three substations, each of 3500 kw, and both main and sub-stations will be balanced with storage batteries.

Complete information in regard to the financial interests behind this line has not yet been made public, although a statement on this point has been submitted to the Commissioners in executive session to prove to them that the road is sufficiently backed; so far the only gentlemen known to be associated in the project are the president, W. C. Gotshall and John B. McDonald, the contractor for the New York rapid transit subway. The contract for the construction of the road, if it is authorized, will probably be taken in the name of Mr. McDonald, and it has

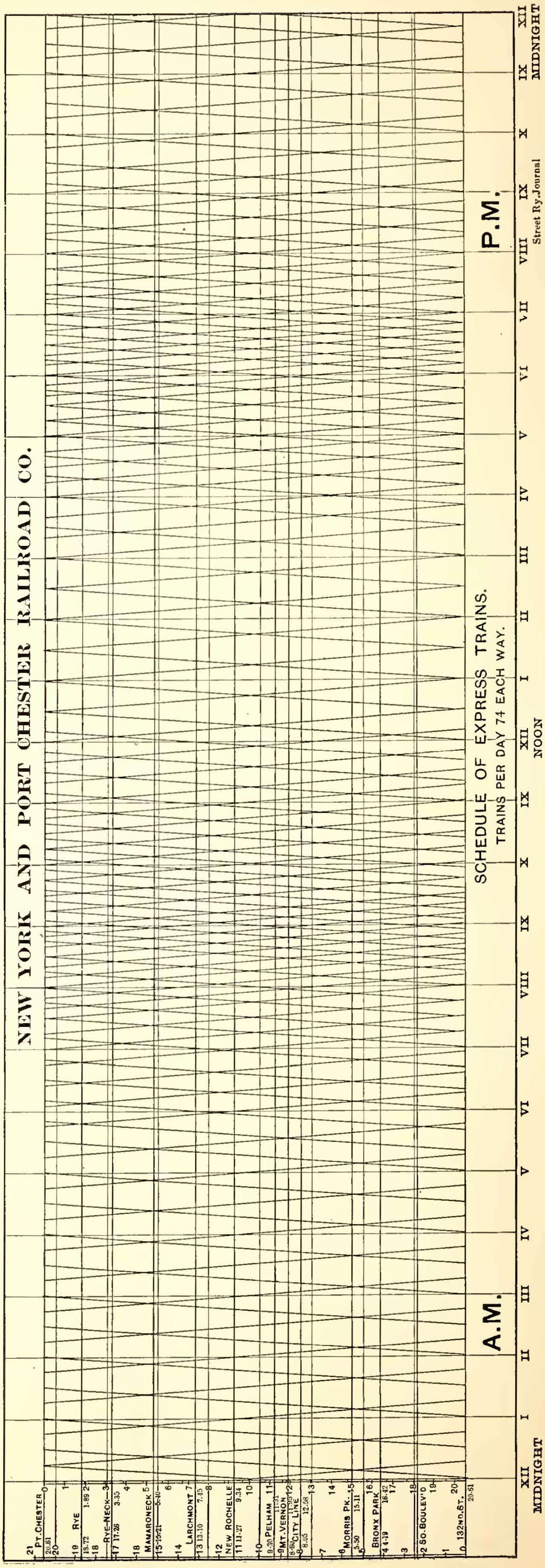


FIG. 2—TRAIN SHEET OF EXPRESS TRAINS

been announced that through trains will be run on the road, if it is built, to City Hall by way of the rapid transit subway. All of the electrical engineering of the line has been entirely in charge of C. O. Mailloux and W. C. Gotshall, the well-known electrical engineers, and to them is due the credit for solving the intricate electrical problems connected with this work. Mr. Gotshall, the president and chief engineer of the company, is prominent in electric railway circles, having been in 1895 and 1896 chief engineer and general manager of the Union Depot Railroad in St. Louis, and previous to that time chief engineer of the St. Charles Street Railway of New Orleans. While in St. Louis he installed a three-wire system on the Union Depot system. In 1897 he came to New York at the request of F. S. Pearson, of the Metropolitan Street Railway Company, and had complete charge of the equipment of the Second Avenue line when it was changed to electric conduit. In 1899 he went to Europe at the request of the Electric Vehicle Company, to organize its British and French corporations, then went to Paris as a railway conduit expert at the instance of French capitalists, in connection with the installation of conduit electric railways in Paris.

Part of the testimony submitted to the Commissioners consisted of a set of very elaborate charts prepared by Messrs. Mailloux and Gotshall, and some of which are reproduced herewith. They undoubtedly form the most complete set of drawings ever prepared of the speeds and power consumption of any road either proposed or in operation. All of these charts and records are drawn on millimeter paper, the fineness of the divisions of which render the charts and the readings taken therefrom of great accuracy.

The graphical methods adopted by the engineers of the New York & Portchester Railroad Company have been applied by them throughout, even to the cases of the representation in this manner of the varying earnings and varying rates of fare. The advantages of the systems used and devised by them, and here employed, are at once apparent when compared with the usual incomprehensible method of long rows of figures. The graphical method appeals to the senses at once, and can and should be applied to all engineering, and even commercial, data.

Fig. 1 shows the line of the company as proposed. The train sheet, Fig. 2, shows in the usual way the movements of the express trains of the New York & Portchester Railroad Company. The lines sloping from left to right from the bottom of the diagram indicate movement and instantaneous times of trains from New York City to Portchester, while those sloping from right to left from the top of the diagram show the movements and instantaneous times of trains from Portchester to New York City. As stated, the original records are on millimeter cross-section paper, on which each of the above hourly spaces are divided into sixty equal parts, each of which parts represents one minute. The instantaneous time for any position of any train can be accurately and instantaneously ascertained by such diagrams.

The curves on Fig. 3 show the relations between speed in miles per hour and time, and corresponding distances, in miles, covered in the same time for any grade. The two full, heavy lines represent the speeds and distances covered for any time *on the level.* The dotted lines represent corresponding speeds and distances for ascending and descending grades. The nearest dotted line below the heavy speed-time line shows the relations between speed and time on a one-half per cent up grade; the next line below, the conditions for a 1 per cent up grade; the next two are the 1½ per cent and 2 per cent up-grade acceleration curves. Intermediate grades are obtained by interpolation. The dotted lines above the full speed-time line show the conditions for ½, 1, 1½ and 2 per cent down grades.

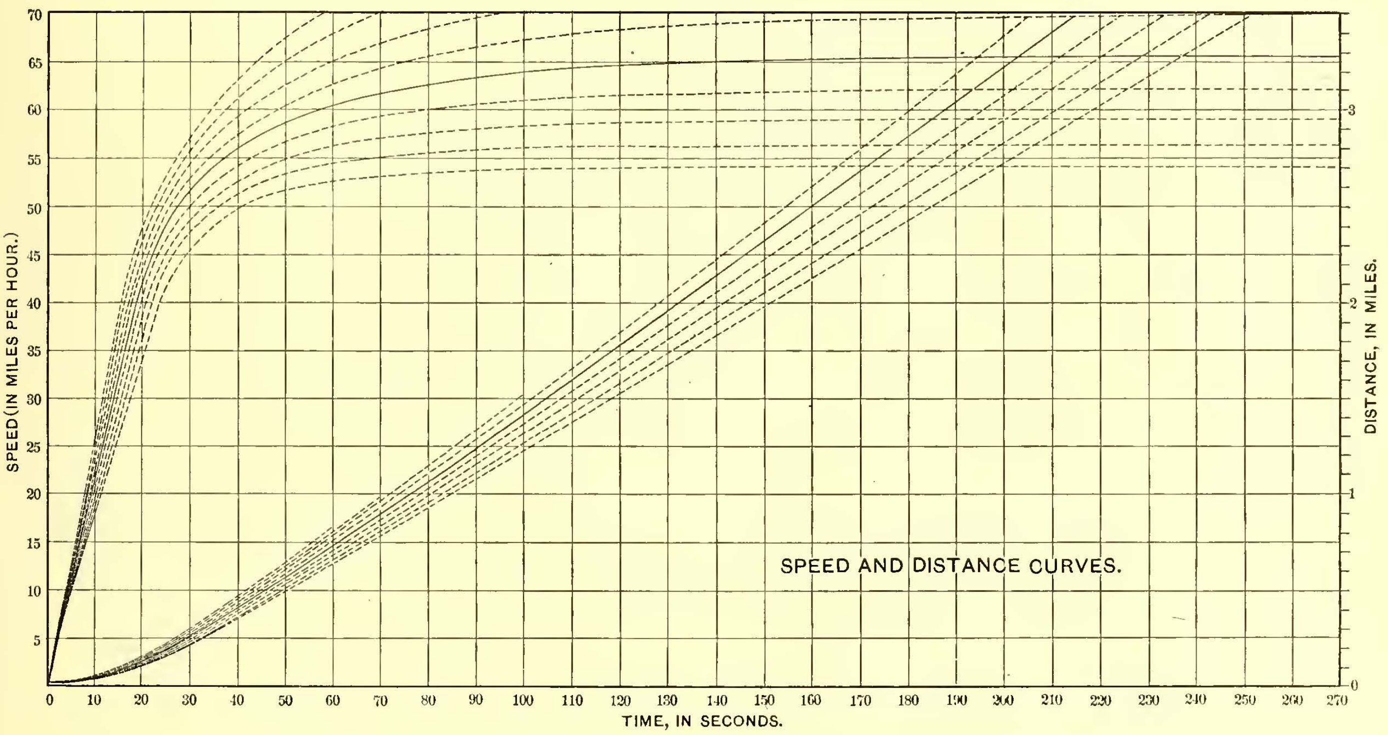


FIG. 3—SPEED AND DISTANCE CURVES FOR A 400-AMPERE MOTOR EQUIPMENT

These are the curves for the 400-amp. motor determined upon for use. The distances covered are ascertained by reference to the correspondence distance-time curve.

Fig. 4 shows corresponding speed-time and distance-time curves plotted for a 300-amp. motor. This motor was found not quite large enough to do the work, and the 400-amp. motor was consequently selected.

Fig. 5, the coasting and braking curves, shows the relations between instantaneous speed and distances covered for any corresponding time. The full line at the right of the diagram shows the braking curve for an average retardation of 150 lbs. per ton, which is equivalent to a negative acceleration of about 1.6 miles per hour per second. The full curved line joining it at the lower right-hand corner is the distance curve for this braking curve. The dotted lines braking effort is taken at 150 lbs. per ton, and the average traction coefficient is less than 12 per cent. The wind resistance is based on the experiments recently made on the Buffalo & Lockport road on speeds up to 67 miles an hour, and at this speed was taken at about 39 lbs. per ton. The

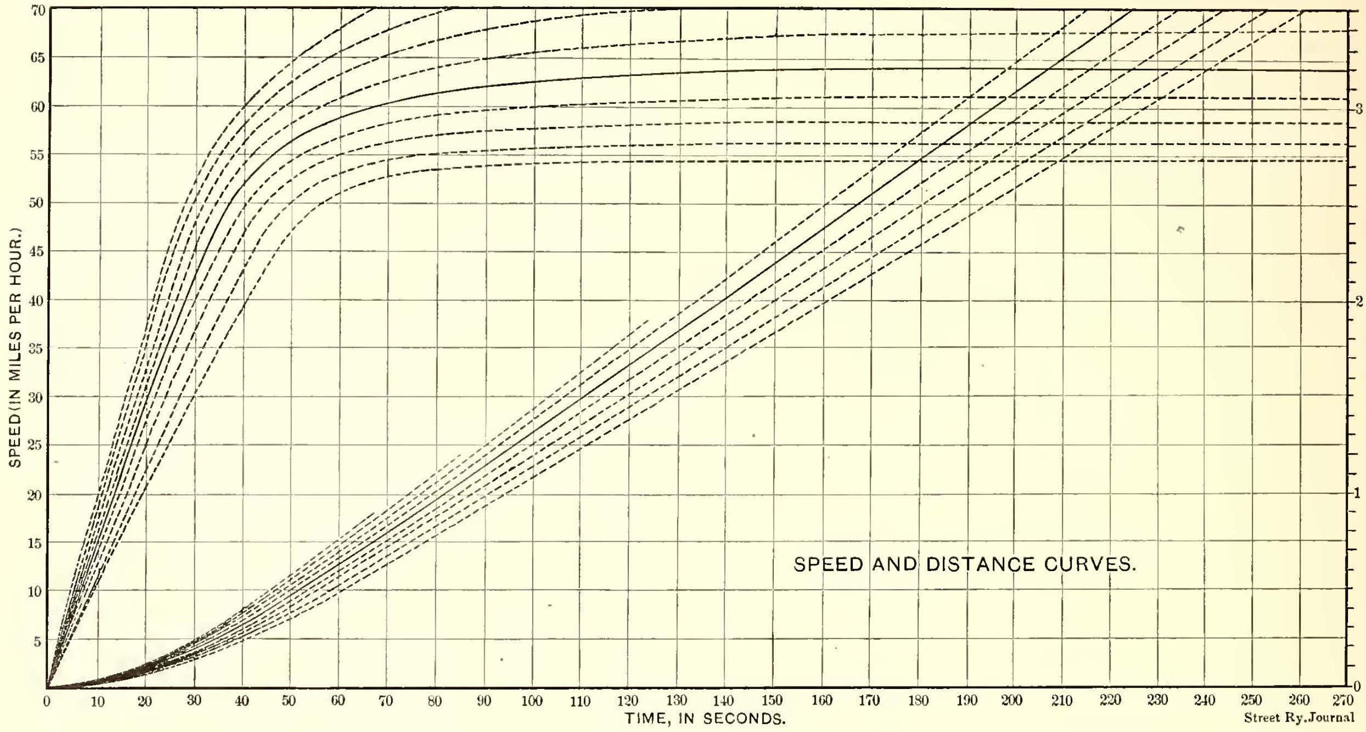


FIG. 4—SPEED AND DISTANCE CURVES FOR A 300-AMPERE MOTOR EQUIPMENT

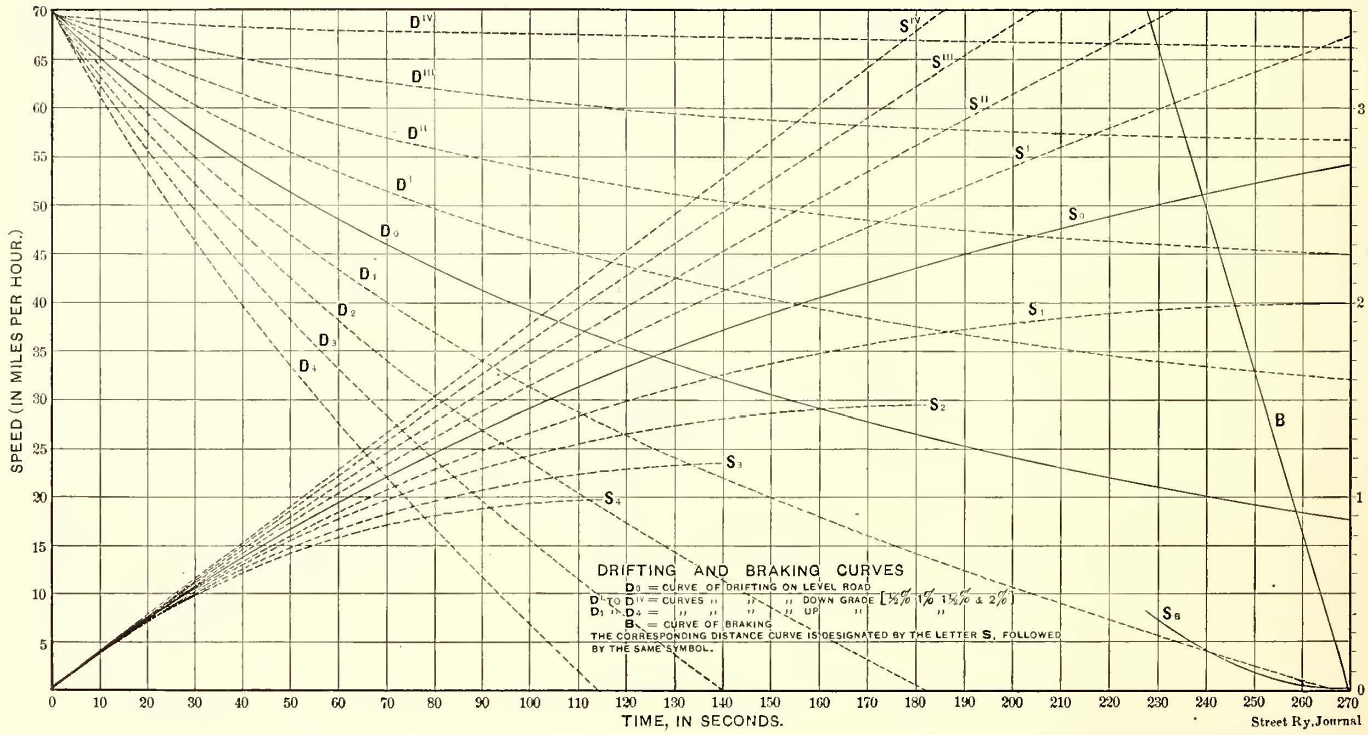


FIG. 5—DRIFTING AND BRAKING CURVES FOR 400-AMPERE MOTOR EQUIPMENT

indicate corresponding curves for different percentages of grades, as stated.

Figs. 6 and 7 are comparative graphical representations of performances of the 400-amp. and 300-amp. motors, respectively, for different gear ratios.

Figs. 8 to 12 show parts of a combined speed and power diagram covering each run between each station for both express and local service, and comprising four run sheets, each some 40 ft. in length. In these diagrams the average extra power for curves was figured at 0.9 lb. per ton for each degree of curvature.

On this basis the maximum average energy consumption for the express service has been found to be, as shown by the chart, 130 watt-hours per ton mile; that for the local service to be about 150 watt-hours per ton mile. These results are what have been arrived at from the energy curves which have been thus far prepared. It is apparent, however, that this average would be very materially reduced by altering the respective amounts of acceleration and of coasting and braking, which matter is now being done. These changes will reduce the watt-hours per ton-mile required, but will not affect the size of the motor required, as the same acceleration will be needed. They tenance, and estimated earnings of the New York & Portchester Railroad Company, which details are taken from his report to the New York & Portchester Railroad Company. Further details of the operating costs and estimated earnings will be given in another article.

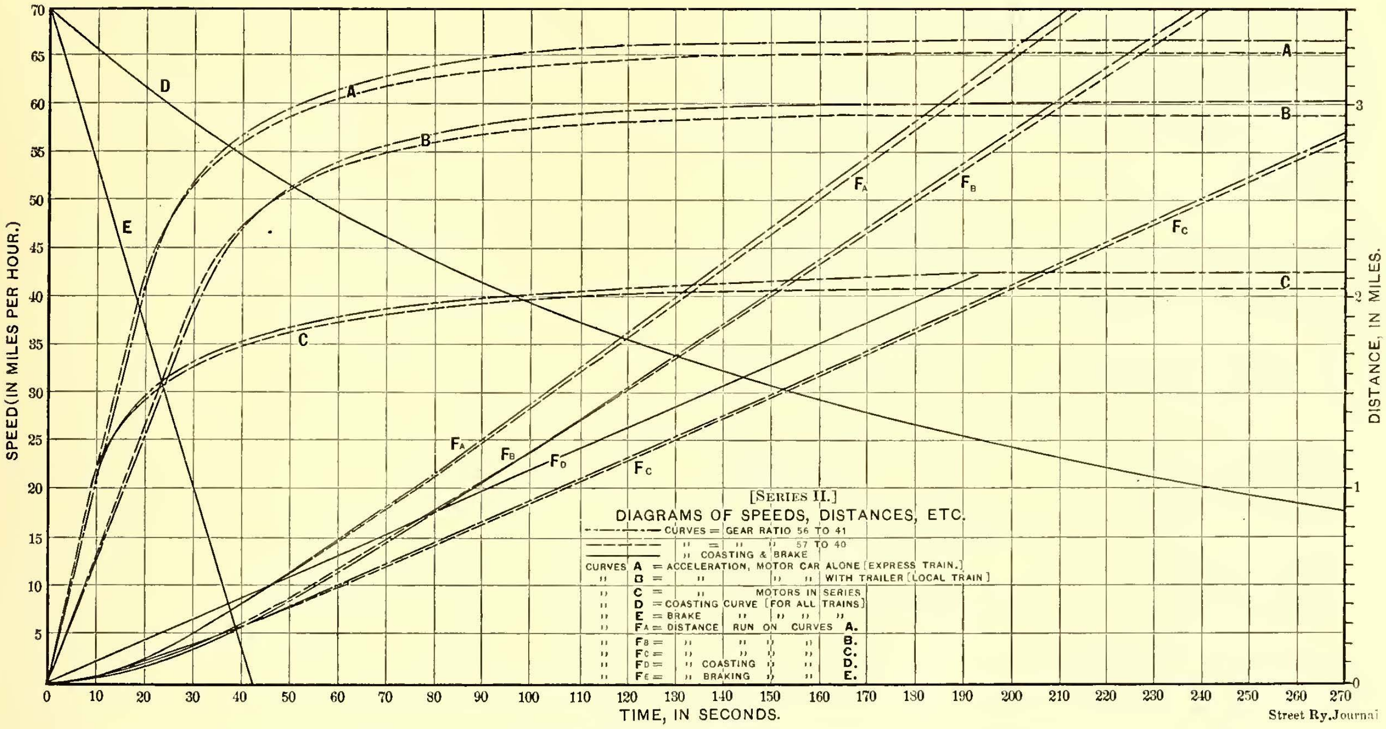


FIG. 6—COMPARATIVE GRAPHICAL REPRESENTATION OF PERFORMANCE OF 400-AMPERE MOTOR EQUIPMENT

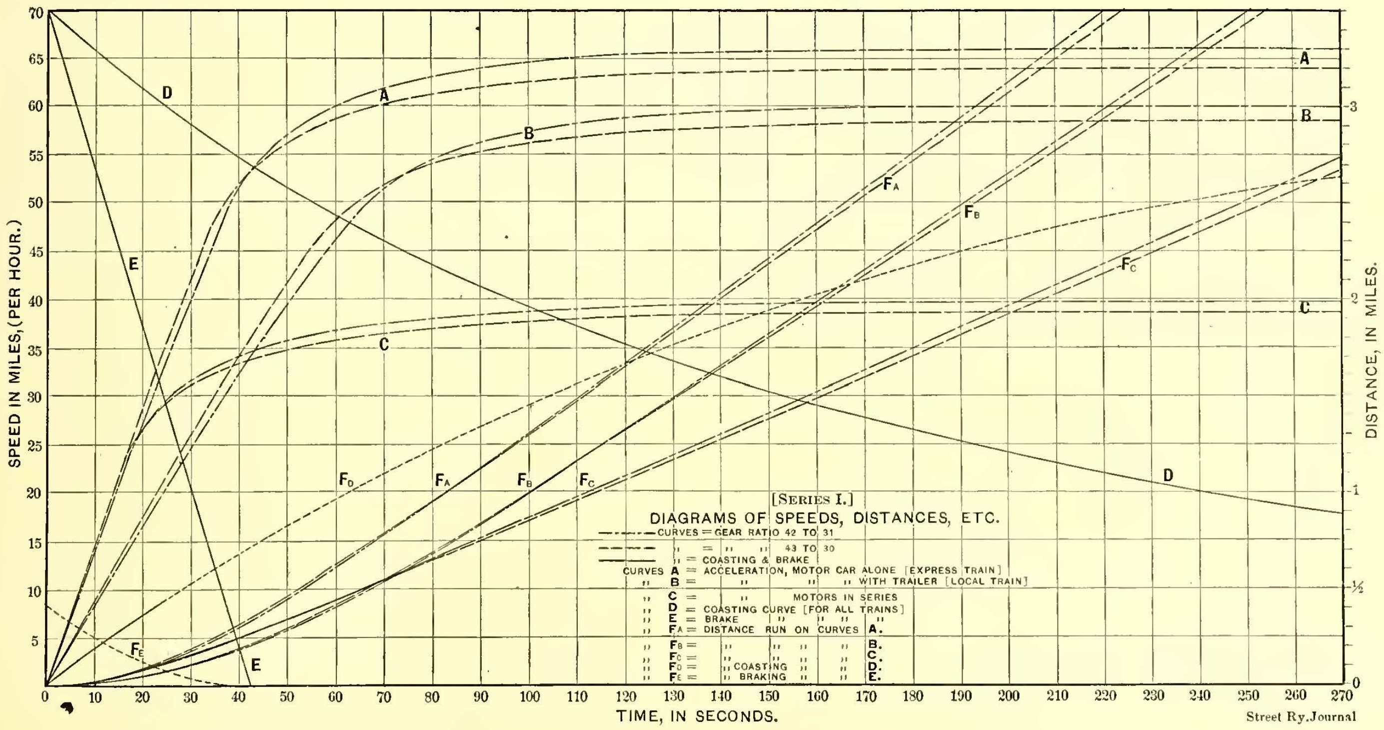


FIG. 7—COMPARATIVE GRAPHICAL REPRESENTATION OF PERFORMANCE OF 300-AMPERE MOTOR EQUIPMENT

were drawn primarily to determine the size of the motor, the possible running time and the approximate size of the power house. Subsequent changes will be purely for the purpose of effecting the economy in the amount of energy required per run.

William C. Gotshall, president and chief engineer of the company, presented the following details of the costs of construction and operation, including repairs and main-

FINANCIAL SUMMARY

COST OF CONSTRUCTION.

Construction and equipment	$7,200,516
Right of way, real estate, terminals, etc.	1,600,000
Interest during construction	300,000
Engineering	250,000
Contingencies	500,000
	$9,850,516

COST OF OPERATION.

Maintenance of way and structures	$0.020	per car mile
" " equipment	.020	" " "
Cost of power	.058	" " "
Conducting transportation	.040	" " "
Officers and general expense	.015	" " "
	$0.153	per car mile

4,500,000 car miles × $0.153 = $688,500 per annum.

FINANCIAL STATEMENT.

Receipts per annum	$1,500,000
Operating expenses	688,500
Balance	$811,500

DETAILS OF COST OF CONSTRUCTION

A—Earth cut and fill and surfacing (3,000,000 cu. yds., at $0.35)	$1,050,000
B—Rock work (220,000 cu. yds., at $1.50)	330,000
C—Rock ballast, 82 miles (2750 cu. yds. per mile, $1.00 per cu. yd.)	225,000
D—Ties, 92 miles (2640 ties per mile, at $0.70 per tie)	170,016
E—Rails, fish-plates, bolts, splices and laying (see note below)	552,000
F—Highway crossings (see note below)	663,000
G—Bronx bridge	60,000
H—Mamaroneck bridge	60,000
I—Bridge over New Haven at Bronx River and Pelham	100,000
J—West Farms, New Rochelle, Portchester and New Haven Crossings	75,000
K—Elevated structure (see note below)	416,000
L—Block signal system	125,000
M—Telephone and telegraph system	25,000
N—Third-rail installation and material (92 miles, at $4,000 per mile)	368,000
O—Fencing (50 miles, at $500 per mile)	25,000
P—Conducting circuit	200,000
Q—12,000-kw main power station (at $100 per kw)	1,200,000
R—Building for main power station (at $10 per kw)	120,000
S—Three sub-stations, of 3500 kws each (at $35 per kw)	367,500
T—Buildings for same (at $6 per kw)	63,000
Y—Seventy cars and trucks complete	367,500
Z—Fifty motor equipments (four motors each)	400,000
AA—Fifty series parallel control equipments ($2,300 each)	115,000
AB—Seventy brake equipments	35,000
AC—Twenty-two stations, at $4,000 each	88,000
AD—Engineering	250,000
	$7,450,016

NOTES ON ABOVE

E.—*Rails.*—90-lb. T, at 141.4 tons per mile, cost $28.80 per ton at mill, and $2 freight = $30.80 delivered.

Rail cost per mile	$4,355.12
Splice plates	140.80
Bolts	38.72
Spikes	135.00
Drilling	423.00
Handling	100.00
	$5,192.64

Cost	$5,200 per mile
Laying	800 per mile
	$6,000 per mile

92 miles × $6,000 = $552,000 = total cost of rail.

F.—*Crossings.*—78, at $663,000 total cost:
Masonry—400 cu. yds. at $8 per cu. yd. = $3,200.
Ironwork—2500 lbs. per lineal foot at $.03½ per lb. = $87.50 per foot.
$87.50 × 60 = $5,250
3,200
$8,450

K.—*Elevated Structure.*—
(5200 lineal ft., including 3400 ft. over Mamaroneck Bay.)
Cost—$.03½ per lb. erected, equals at 2200 lbs. per lineal foot of structure, 2200 × $.03½ = $77 per lineal foot.
Foundations, each, 75 = $150 per 50 ft. = $3 per foot of structure. $77 + $3 = $80 per lineal foot of structure.
5200 × $80 = $416,000 total cost.

Since the estimates for the highway crossings and viaducts have been made, which was about a year ago, the concrete arch construction has been determined upon, the details of which will be given in another article.

DETAILS OF OPERATING COST

A—Train crews	$84,080.89
B—Station men	80,300.00
C—Maintenance and inspection of cars and equipment	90,000.00
D—Maintenance of roadway and structures	96,000.00
E—Cost of power	253,116.55
F—Rotary stations	16,425.00
G—Salaries of officers	50,000.00
	$669,922.44

A.—*Train Crews.*—
124 local trains each way per day; single trip time, 49 minutes.
74 express trains each way per day; single trip time, 31 minutes.
124 × 2 × 49 ÷ 60 = 202.5 car hours per day of 24 hours for local service.
Local service to consist of one car having a crew consisting of:
1 motorman at $3 per day of 10 hours,
1 conductor at $2.50 per day of 10 hours.
Total, $5.50 per day of 10 hours; or $.55 per car hour.
202.5 × $.55 × 365 = $40,751,875, cost of local train service per year.
74 × 2 × 31 ÷ 60 = 75.4 train hours per day of 24 hours for express service.
Express service to consist of two car units carrying the following crew:
1 motorman at $3 per day of 10 hours,
1 conductor at $2.50 per day of 10 hours,
1 conductor at $2.50 per day of 10 hours,
$8 per day of 10 hours, or $.80 per car hour.
76.4 × $.80 × 365 = $22,308.80, cost of express train service per year.
$40,751.875 + $22,308.80 = $63,060.675, total cost.
Adding one-third of above for extra men—$21,020.22—we have $63,060.675 + $21,020.22 = $84,080.895, total cost train men, etc., per year.

B.—*Station Crews.*—22 stations using 5 men each = 110 men at an average of $2 per day each = $220 per day. $220 × 365—per year = $80,300.

C.—*Maintenance and Inspection of Cars and Equipment.*—Total car mileage equals 4,169,760 per year, and allowing for extra occasions will equal 4,500,000, at $.02 per car mile = $90,000.

D.—*Maintenance of Roadway and Structures.*—96 miles single track, including sidings, etc., at $1,000 per mile per year = $96,000.

E.—*Cost of Power.*
Local Service.—124 × 2 × 21 = 5208 local car miles per day.
3108 × 2 = 6216 car miles per day.
At 160 watt-hours per ton mile = 270,816 × 160 = 43,330,560 watt-hours per day for local service.
Express Service.—74 × 2 × 21 = 3108 train miles per day for express service.
3108 × 2 = 6216 car miles per day.
6216 × 52 = 323,232 ton miles per day for express service.
323,232 × 130 = 42,020, 160 watt-hours per day for express service.
42,020,160 + 43,330,560 = 85,350,720 total watt-hours per day of 24 hours, or 85,350.7 kw-hours.
Add 18 per cent for loss from main station to third rail and 5 per cent for heating and 2 per cent for lighting—25 per cent = 21,337.7. 85,350.7 + 21,337.7 = 106,688.4 kw-hours. This at $.0065 per kilowatt-hour = $693.47 per day for producing the power and maintaining the power station. 365 × $693.47 = $253,166.55 per year.

Power Station Detail.

1 chief engineer	$10.00 per day
3 assistant engineers at $5 per day	15.00 "
30 oilers at $2.50 per day	75.00 "
3 switchboard men	10.50 "
3 electric helpers	7.50 "
6 cleaners	9.00 "
6 condenser men	15.00 "
Machinists and two helpers	9.00 "
24 boiler men at $2.50 per day	60.00 "
Boiler cleaner and two helpers	6.00 "
4 laborers	6.00 "
	$223.00

Coal at $2.40 per ton; 106,684 kw at 2¾ lbs. coal per kilowatt = 293,381 lbs., or 146.69 tons coal per day.
146.69 × $2.40 = $352.057, cost of coal per day. $223 + $352.057 = $575.057, cost of labor and coal per day of 106,684 kw-hours.
$575.057 ÷ 106,684 = $.00538 per kilowatt-hour. $.0065 — $.00538 = $.00112, for repairs and maintenance per kilowatt-hour.

ESTIMATES OF EARNINGS

Between	Population carried per year	Average fare per trip	Annual income
Port Chester and New York	7,000 x 120	15 cents	$126,000
Harrison, Rye and New York	2,000 x 120	15 "	36,000
Mamaroneck and New York	5,000 x 120	12 "	72,000
New Rochelle, Larchmont and New York	20,000 x 150	10 "	300,000
New Rochelle and Port Chester	30,000 x 60	5 "	90,000
Mt. Vernon, Pelham and New York	28,000 x 150	6 "	252,000

New Rochelle and Mt. Vernon	35,000 x	30	5 cents	52,500
Mt. Vernon and Portchester..	62,000 x	20	7 "	86,800
Bronx and Mt. Vernon.......	100,000 x	50	5 "	250,000
Annual summer and recreation business of the road............	1,500,000		15 "	225,000
Total passenger income per year....................				$1,490,300

NOTES ON THE ABOVE

The estimates of the earnings were made after a careful study of existing conditions in the territory to be served by the New York & Portchester Railway. These investigations extended over many months and had for their objects:

(1) A careful study, after personal observation, of the habits of the people along the line. That is, ascertaining how, when and where they traveled;

(2) The existing inducements which would cause people to travel between the various cities and towns;

(3) Ascertaining the occupations of the people and the probable stability of their employment;

(4) Careful study of the national censuses, together with careful study of the various ward, precinct and school censuses;

(5) Personal observations at the various points at which the public boarded trolley cars, at all hours of the day and night for many months, to colunt and ascertain the amount and division of the existing travel.

A careful study of the business of the existing trolley and elevated roads in the district was made, together with a study of the nearest existing approximations now operating elsewhere, and all data thus obtained was plotted, and therefrom the deductions herein shown were drawn.

By carrying out the multiplications in the detail of the estimates of the earnings, it will be found that this estimate contemplates carrying the population served approximately 100 times per year. The estimate contemplates 18,000,000 fares per annum. As these 18,000,000 fares are based upon 4,500,000 car miles, it will be seen that there must be carried but four passengers per car mile.

The total population served is about 300,000, of which 180,000 are within half a mile on either side of this railroad, and are at present devoid of rapid transit facilities.

18,000,000 divided by 365 = 49,300 passengers per day of 398 trips, or an average of 124 passengers per complete trip of 21 miles.

There are twenty-two local stations and twelve express stations, which would give, on an average, six passengers per station for the local service, and ten passengers per station for the express service.

The New York & Portchester Railroad will be in a higher degree to the eastern part of Westchester County and the Bronx what the elevated railroad has been to New York City. The elevated system, operating five cars per train, carried in 1890 4.1 passengers per car mile. There is no doubt but that the elevated business could have been done with a much smaller car mileage. The elevated train units applied to the New York & Portchester Railroad schedule would give a car mileage of 15,000,000 car miles per year, instead of 4,500,000 car miles, which the New York & Portchester Railroad will have. By comparing the elevated car mileage and that of the New York & Portchester Railroad, it is apparent that four passengers per car mile for the New York & Portchester Railroad is a conservative estimate.

The elevated roads of Manhattan and the Bronx are carrying the population of these districts about 100 times per annum. It is conservative to take the same figure for the New York & Portchester Railroad which will serve a population now practically devoid of rapid transit facilities.

The Union Railway Company, together with the Westchester Traction Company and the Southern Boulevard line, carried in 1900 a total of about 31,000,000 passengers. Mr. Maher states that they will carry about 37,000,000 during 1901. At this rate of increase, they would be carrying in 1903, when the New York & Portchester Railroad will be ready to operate, about 56,000,000.

Should the New York & Portchester Railroad carry but the same proportion of this total business which the elevated roads are now carrying of the business of Manhattan and the Bronx (that is, about 35 per cent), it would receive 56,000,000 x .35 = 19,600,000 fares.

On account of the remarkable conditions and circumstances, I believe that the New York & Portchester Railroad Company will receive a considerably greater percentage of the total fares.

The New York & Portchester Railroad will be to the eastern part of Westchester County and the Bronx what the Illinois Central suburban service is to the south side of Chicago.

Referring to the matter of cost of operating, attention is called to the statements of such properties as the Union Traction Company of Indiana, operating about sixty miles of interurban track at 51.6 per cent of the gross receipts; also to the fact that the Union Traction Company is making 39¼ cents per car mile. The Southwestern Missouri Electric Railroad Company is operating for 55 per cent of its gross receipts. The Lorain & Cleveland at 47 per cent of its gross receipts. The Lynn & Boston interurban system is carrying five passengers per car mile and earning 31 cents gross per car mile.

The earnings may also be estimated as follows:

1st. Allowing 30 cents per car mile as the gross receipts, 4,500,000 x $0.30 = $1,350,000.00 gross annual receipts on car mile basis.

2d. Allowing $8 per capita per annum, 180,000 x $8.00 = $1,440,000.00 gross receipts on population basis.

3d. The voting population is taken at one-fifth of the entire population. It is this voting population, or the business men, which makes daily use of the transportation systems. Allowing one round trip or two fares per day per unit would give, taking 100,000 as the population thus directly dependent upon this road, 100,000 ÷ 5 = 20,000. 20,000 x 2 x 365 = 14,600,000 rides per annum of what may be called permanent business, which at an average of 10 cents per ride = 14,600,000 x $0.10 = $1,460,000.00.

Based upon an estimated annual gross earning of $1,500,000 and an annual car mileage of 4,500,000 car miles, the gross earnings per car mile will be $1,500,000 ÷ 4,500,000 = $0.33 1-3.

With gross annual operating expenses of $700,000, the cost per car mile will be $700,000 ÷ 4,500,000 = $0.155.

Earnings of 30 cents per car mile are now being attained on good interurban roads, and will certainly be maintained here, which is an exceptionally high-class enterprise from a commercial point of view.

MR. POTTER'S TESTIMONY

Mr. Potter, chief engineer of the Railway Department of the General Electric Company, was the first electrical expert called. His testimony related to the possibility of the operation of the line from an electrical standpoint, which he considered entirely feasible. He also stated that he had gone over the drawings and calculations of Messrs. Gotshall and Mailloux, which are published herewith, and they had agreed with his own figures. He also testified as to the method of testing motors by the General Electric Company, the method of plotting the characteristic curves and the torque of G. E.-65, or 400-amp. motors, the rating of which he stated was 225 hp, but that it would develop in an emergency at 300 hp to 400 hp. In reply as to the question as to whether a braking effort of 150 lbs. per ton was practical and feasible, Mr. Potter said: "One hundred and fifty pounds per ton is the amount that we have frequently used in estimating the service, and while the apparatus and rate of braking is slightly better than commonly attained in the operation of trains, it is a thoroughly feasible amount."

Q. In conversation with me at one time you made some comparisons between such a braking effort at 150 lbs. per ton and that on the street-car service. Do you recall that conversation and your observations at that time? A. I think I remarked that the rate of braking which was frequently attained in street-car service would, to say the least, be exceedingly disagreeable, as the adhesion of wheels to the rail might roughly be taken as 25 per cent. The braking of the ordinary street-car carried up to the practical slipping point of the wheels would represent nearly 250 lbs. per ton.

Q. Have you estimated the kilowatt capacity of the generating station to carry the maximum load of the proposed service of this railroad? A. Taking the average kilowatt obtained by Mr. Mailloux in his calculations, and which I believe to be correct, assuming seven trains in operation on the express service and twenty-one in the local service, and allowing about twenty per cent for the losses in transmission from the generators to the motor, and about 5 per cent for electrically heating the cars, the total without reserve apparatus is about 15,000 kw* in the generating station.

Q. Now, what will a station cost, including a complete steam and electric plant, but excluding the real estate? A. About $1,500,000.

Q. About what do you say would be the cost of building such a station? A. Eight dollars to $10 a kilowatt.

Q. Now, you know of the plan of the engineers of the road to install three local converters sub-stations of 5000 kw each? A. A total of 12,000 kw would appear sufficient in the sub-stations. I had estimated 12,000 in the sub-station apparatus, and 15,000 at the generating stations, representing the excess power necessary.

Q. At a capacity of 4000 kw each, what would the cost of these

* This was based on the theory that the local service consisted of trains of more than one car, and that the express service consisted of three-car units. This conception was corrected later in the testimony.—[EDS.]

stations be, exclusive of real estate and building? A. Probably $35 per kilowatt.

Q. What would be the cost of the sub-station buildings? A. Approximately $5 a kilowatt.

Q. What would be the cost of the four G. E. motors proposed per car? A. Probably $13,000 per car. This covers electrical equipment per car and air pump.

Q. What would be the cost of a car with 50 ft. body such as proposed? A. Including trucks from $5,000 to $6,000.

Q. What would be the cost per mile and piece of single track for the third rail installation, using 90-lb. rails? A. Approximately $4,000 per mile of single track.

Q. And $340,000 would be the cost of the third-rail installation? A. Assuming a single track mileage of 85 miles. That mileage would probably be nearer ninety. I should say $360,000 for the third rail.

Q. With the installation as proposed, that is, the main high potential station, generating current at about 12,000 or 15,000 volts, and three rotary converters at sub-stations, what would be the cost of the copper for the conducting circuit, including installation of such a conducting circuit? A. This would depend upon the location of the power station and the sub-stations. I understand that you have estimated on $250,000, and I consider that to be a reasonable amount. Probably this is in excess of what would actually be required.

Testifying as to, and speaking of other roads, Mr. Potter said that on the Aurora, Elgin & Chicago road, a maximum speed of 65 miles per hour was to be attained, or a schedule speed of 40 miles an hour with the stations 3 miles apart. The cars weigh 40 tons. On the Lorain & Cleveland road, the maximum speed attained is 50 miles an hour, and on the Buffalo & Lockport road 50 miles, with an average outside of Buffalo of 33 miles with stops averaging 2 miles apart. The Albany & Hudson road attains a maximum of 60 miles an hour and the Nantasket Beach approximately 40 miles an hour. The General Electric Company has submitted estimates on apparatus for operation on the Buffalo & Lockport road to attain a schedule speed of 75 miles an hour.

MR. MAILLOUX'S TESTIMONY

Mr. Mailloux's testimony related principally to the method which he and Mr. Gotshall had adopted in preparing the charts and the average time taken by the elevated trains in New York City for receiving and discharging passengers. He stated that the average stop is less than 11 seconds. The total number of observations which he had made on this point would doubtless exceed 600 or 700.

MR. SPRAGUE'S TESTIMONY

Q. You have also examined the speed time charts prepared by the New York & Portchester Railroad Company? A. I have. They are the best charts of the kind that I have ever seen.

Q. Can the proposed express service, allowing a headway of 10 minutes between trains, and the proposed local service, allowing a headway of 5 minutes between trains, be made as proposed? A. Unquestionably.

Q. Given the location and profile maps of a railroad, will you kindly state how you would proceed to construct a speed time chart such as has been prepared for the New York & Portchester Railroad Company? A. The final expression would be practically the same as that prepared by the engineers of the railway. The beginning of a work of that kind is a cut-and-try process. It is a series of approximations until you get what is wanted. The first thing that I would do would be to take a representative cycle of operation. I should go over the plan of the road and carefully note its profile, the running time that is proposed, and pick out what would be a fairly average station run. I would then plot out by curves, which are familiar to every electrical engineer or engineer dealing with electrical machinery—in fact, to anyone occupied with transportation. I should first determine what is a safe rate of acceleration. That, of course, would be based upon practical experience. A 2-mile per hour second rate is a safe one, and if it is properly made is a comfortable rate of acceleration. In this particular case I believe that is the rate that has been adopted for part of the run, and it is one that is perfectly feasible. I would then determine the average rate of braking, and allow a margin for emergency stops. I should take a rate which is something less than the possibilities. Those two rates determine in the construction of a curve the two lines of departure. It is known by all electrical engineers that the proper method of operating electric motors, and in fact the almost necessary method of operating them, is as follows: If we take a pair of motors, and as regularly as possible through the controlling apparatus raise the electrical pressure at the terminals of those motors until all changes in the regulating resistance and in the grouping of the motor have been effected, and the working pressure on the line has been reached (supposed in this case to be 600 volts), that will give what is called a straight-line acceleration. There will be a

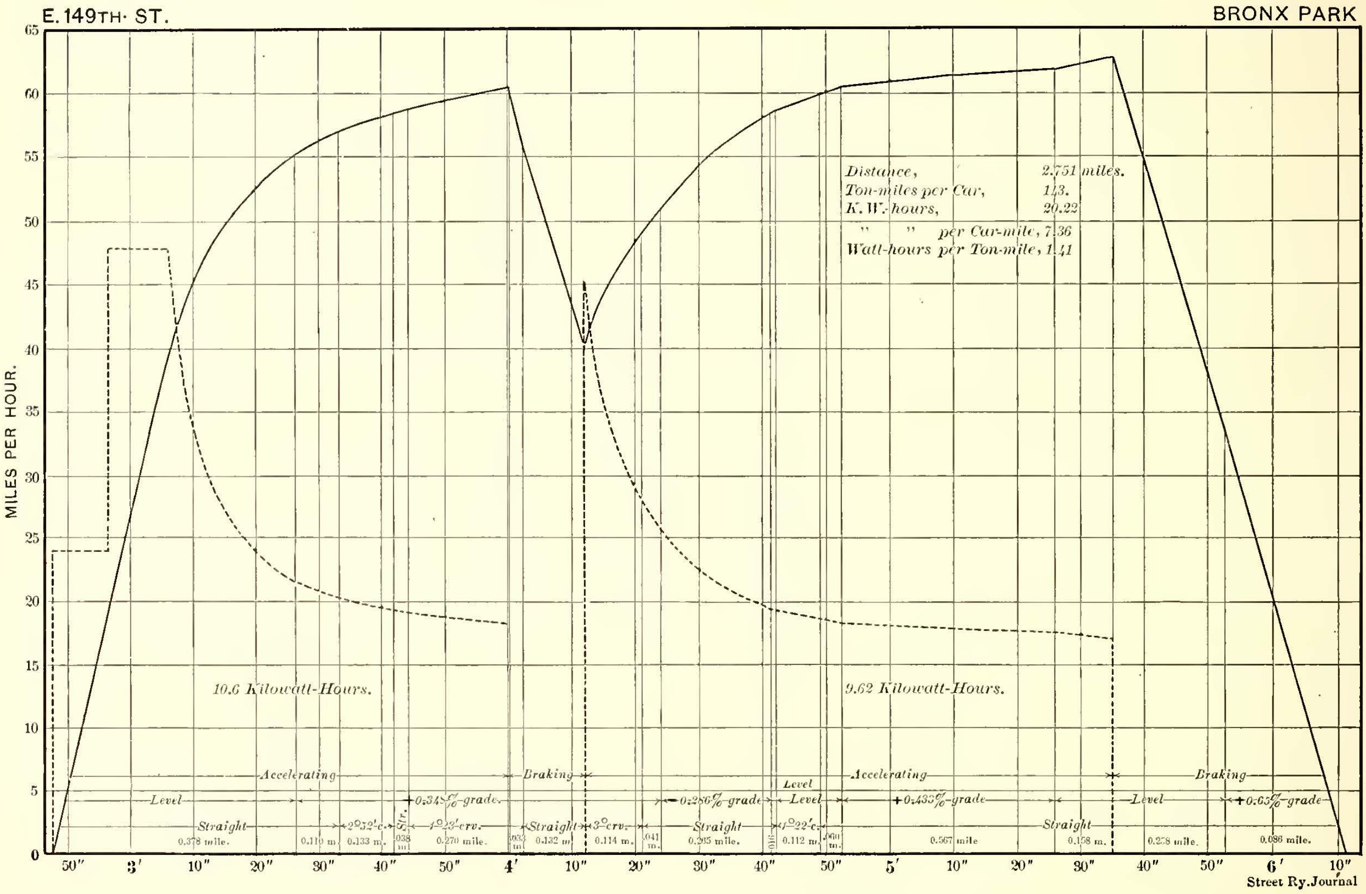


FIG 8 —RUN SHEET FROM EAST 149TH STREET TO BRONX PARK constant torque, the equivalent of a constant draw-bar pull. Having gotten to the full potential of the line a motor is allowed to accelerate on its curve, which it does automatically, at a decreasing rate, until finally the current going through the motor will just balance the work required by the train at that particular speed. That gives a curve of acceleration which is made up of a straight line up to about seven-tenths of the maximum speed which is reached; the line then leaves the tangent on to a curve of increasing radius, almost parabolic in character, until it is decided to coast or brake the train. The curves determined in that way and referred to a parallelogram which is made up with reference to the schedule time gives the approximate data for a motor, and at the same time the amount of current that is required can be determined. This is the theoretical motor which is required. The process also determines the theoretical imput of current which is required to make that particular schedule with any stations because of curvatures, the time-speed curves will show the proper amount of coasting and braking, and then any new acceleration before coming to a braking point for stops.

* * *

Q. Are you able to state what is the maximum electrical power per ton now in use and how it compares with steam equipment? A. Well, in Boston we are using 9 hp to 10 hp per ton, because the cars there weigh when loaded about 36 tons, and there is 300 hp per car, but this does not affect the control in the slightest. By putting a motor truck in place of a trail truck, the power would be run up to about 14 hp per ton, and it would be possible to raise that by a difference in mode of construction to 21 hp or 22 hp per ton. There is no difficulty in handling any number of these units, no matter how they are distributed throughout the train. In Boston every car is equipped with motors and operated on the multiple-unit plan, the same as proposed for this road.

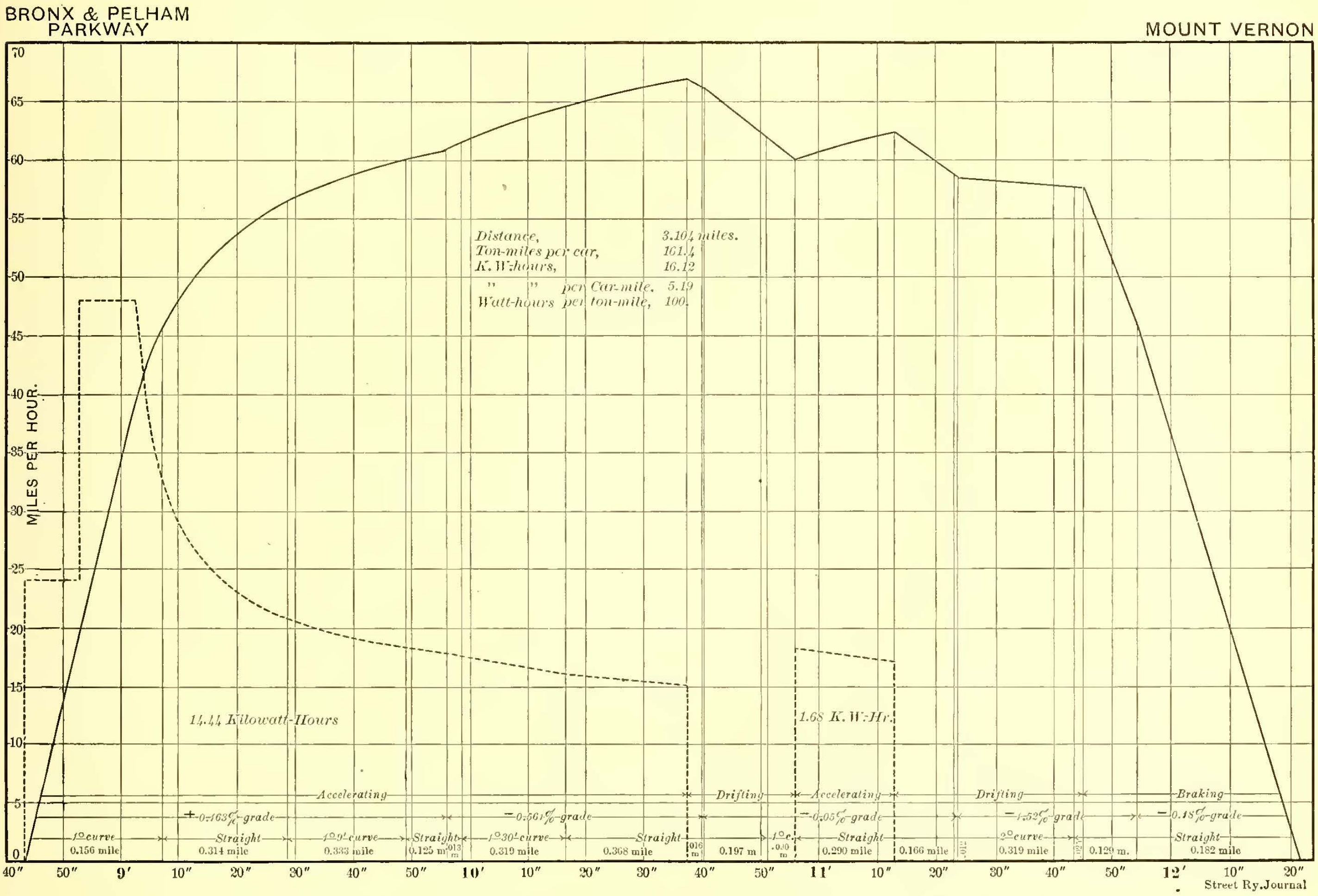


FIG. 9.—RUN SHEET FROM BRONX AND PELHAM PARKWAY TO MOUNT VERNON

given weight, whether 1, 10 or 100 tons. I would look among the records of all existing motors to find if there was a motor having the general capacity of the motor indicated by this theoretical investigation, and if I found it, then I would take up the details of that motor. If not, I should simply require such a motor to be built, and any electrical manufacturing company will build such a motor. The probabilities are that a motor would be found in stock. Then I would draw a series of time speed curves and torque and current curves of this motor. I would determine these in the first place for different gears. Then I would select the proper gearing, and construct a series of curves for the performance of that motor under different conditions. Those conditions would be, first, on a dead level; and then on ½ per cent, 1 per cent, and 1½ percent up grades, etc., and also the performance on a down grade, varying in ½ per cent's. With such curves the operation of the motor on any road which is properly diagrammed can be determined, and the time-speed curves plotted for every run and every condition. It is the ordinary process which any electrical engineer would adopt. When you have got through you have a pictorial illustration of the exact performance of a machine. In other words, one can determine from the time-speed curves the speed at which the motor or the car is moving at any point of the road under any conditions of grade. If there are conditions on the road which require slowing up between

Q. How does the power in the Boston road compare with the power on locomotives? A. Our contract requires that we should actually develop more power than any locomotive that goes out of Boston. The Empire State Express has not as much power as we have on Boston trains. In fact, it is impossible to put on a locomotive as much power, localized as it must be, on two, or at best four drivers, as we can on ten or a dozen axles.

Q. About how much total power, in kilowatts, is required at the cars at the time of the maximum service on the New York & Portchester Railroad Company, as shown by this time schedule? A. Assuming that that time schedule gives the same tonnage which I instanced in an earlier answer—which is about 1900 tons—there would be required an average during the time of maximum service of a little over 8000 kw at the car axles for the motor cars.

MR. COVERDALE'S TESTIMONY

The testimony of Mr. Coverdale, of J. G. White & Company, related principally to the cost of construction, not including the cost of right of way or real estate. It amounted to about $7,000,000 divided as follows:

Ballast	$227,000
Track superstructure	715,000
Overhead and under grade street and road crossings, river bridges, miscellaneous bridges, and culverts, and steel trestle work	1,391,000

Fences	25,000
Telegraph and telephone	25,000
Block signal system	100,000
The main power station—the building only—and the buildings for three sub-stations and repair shops	250,000
Stations, including tracks, terminal stations and intermediates	100,000
Power house installation	1,200,000
Sub-station installation	270,000
Repair shop installation	50,000
Cars and equipments for cars, including motors and trucks	785,000
Third-rail constructions, including high-tension transmission line..	480,000
Air-brake equipment	35,000

Q. Does your estimate for bridges and street railway crossings include piling? A. Yes, it includes all necessary construction work.

Q. And masonry sufficient to bear the load, as well as meet the thrust where there is a fill? A. Yes sir.

Q. Mr. Coverdale, at what speed can a car safely pass the highest degree of curvature upon the road, namely, 7 degrees? A. That, of course, depends upon the way the track is put up. Every railroad curve is put up with a certain superelevation of the outer rail. This superelevation is limited in practice to a maximum of 9 ins.; without going as high as the 9 ins., and with the knowledge that a 7 deg. curve is a maximum curve on this road, assuming a superelevation on that curve of 7½ ins., the track would then be put up for a speed of between 40 and 45 miles an hour, and a train or vehicle can pass around that curve with perfect safety at a speed of at least 50 per cent greater than 45 miles an hour, about 65 miles an hour, without any danger of overturning.

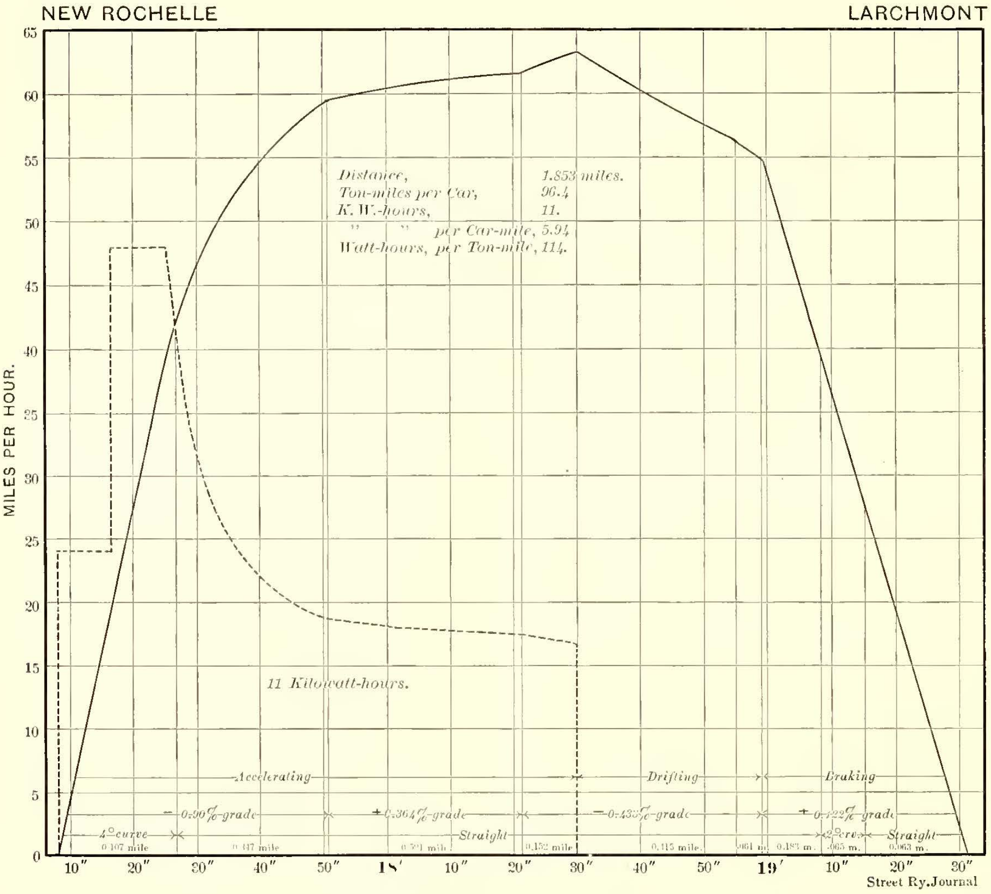


FIG. 10.—RUN SHEET FROM NEW ROCHELLE TO LARCHMONT

MR. THATCHER'S TESTIMONY

This related to the cost of bridge construction on the road in question. An abstract follows:

Q. What will be the cost of seventy-eight bridges upon the line of the New York & Portchester Railroad, of which fifty are 60 ft. span, twenty-one, 50 ft., and seven, 100 ft. span, and 3400 feet of structure across Mamaroneck Bay? A. The total is $703,000 for steel concrete structures.

Q. Describe the kind of structures on which you have based your estimate? A. Either the Melan system or my own system, but I have made these estimates on the Melan system.

Q. What is the proportion of concrete to steel? A. In my specification it is governed by three different ways. One is that it shall take the entire bending moment of the structure; two-crown. That generally governs the area of steel in the structure. Of course you can make it any area you wish; there is nothing to limit that area, and it should be enough to take the entire bending moment.

Q. Will you take up in detail your estimate of the cost of the structures to which are called your attention. What do you estimate the cost of a bridge with 100 ft. span upon the line of this road? A. The cost of one span of 100 ft. I estimate at $12,300 that is up to a subgrade, ready for the track.

Q. What would be the cost of an 80 ft. span? A. Eight thousand three hundred dollars.

Q. And for a 60 ft. span? A. Six thousand and eleven dollars.

Q. And for a 50 ft. span? A. That would be $4,916.

Q. Does that include the bridge complete. A. Yes ready for the ballast and the rails, with the exception of the piles which cost $5 each, put in place.

Q. Describe the kind of structure you have designed for the Mamaroneck flats? A. That is a succession of 50 ft. spans, 55 ft. from center to center of piers; 50 ft. wide to width of bridge.

Q. Are these structures which you have mentioned calculated for the rolling and static loads for this road? A. Yes, sir.

Q. What is the effect of time and air upon the concrete? A. It improves it anywhere up to six months or eight years.

Q. And there is no deterioration certainly up to that time? A. It is better in six months than it is in three months and it is better in two years than in one year. For instance, the concrete that would be good for 2400 lbs. would be good for 3800 lbs. in six months.

Q. What is the cost of the maintenance of such work? A. Nothing at all.

MR. PARKE'S TESTIMONY

This was on the effect of quick action and emergency braking on high-speed trains. Important improvements have been made in this direction in the past few years and Mr. Parke's estimates in his direct examination of the average distance required to stop the express trains on the Portchester line was 1227 ft or 248 ft. less than the companies estimated. On redirect examination Mr. Parke reduced this distance to about 1000 ft. He also described the most desirable and quickest method of braking to be that of gradually reducing the pressure on the brake-shoes as the speed decreases. A digest of the testimony follows:

Q. Are you familiar with the result of any experiments in stopping a train running at a speed of say about 60 miles per hour? A. I am. A few years ago the Pennsylvania Railroad conducted a series of experiments for the purpose of determining the stopping capabilities of the ordinary quick-acting brake, and also of the high-speed brake, which was at that time about being produced, in order to determine the relative distances in which trains could be stopped by the two brakes at certain speeds. These stops were made and the experiments were conducted near a place called Shiproad, about 20 miles west of Philadelphia on the main line of the Pennsylvania Railroad. The experiments were made with a train consisting of a locomotive, tender and six heavy passenger cars. The grade at that point was about 29 ft. descending to the mile, and the track was straight at the point where the stops were made. The conditions were those of ordinary regular service and the braking apparatus was, as stated before, an ordinary high-speed brake apparatus in a portion of the tests. A portion of the stops were made from speeds very close to 60 miles an hour, and a portion of them were only 45 miles an hour.

Q. What was the result of these high-speed tests? A. The average distance in which the train will stop with a quick-action brake at a speed of 60 miles an hour, upon that grade of 29 ft. to the mile, was 1620 ft., which corresponds to the distance of 1514 ft. on a level. With a quick-action brake, at a speed of 45 miles per hour, the average stop was 686 ft., which corresponds to a distance of 652 ft. on the level. Stops with the high-speed brake were uniformly about 72 per cent in length of those made by the quick-action brake. At 60 miles per hour, the average stop was in 1168 ft., which corresponds to a stop on a level of 1111 ft.

Q. Which is the brake ordinarily in use on railroads and what are its chief characteristics? A. The brake which is customarily in use on railroads is the quick-action air brake. In fact, it is the one that is almost universally used. The high-speed brake has been so far used chiefly upon high-speed express trains—trains covering a long distance of high speed. It consists of an air pump and a main reservoir for storing air on the locomotive; a line of pipe running through the length of the train under each car unit, by means of a flexible hose and couplings between the cars, forming a continuous conduit from the locomotive clear back to the rear end of the train. Upon each car there is an auxiliary reservoir for storing air, for the application on the brakes upon that car, a brake cylinder, a piston of which is connected by suitable levers and rods with the brake-shoes, for the purpose of applying the brakes, and a triple valve which controls the communication between the train pipe and the reservoir and the brake cylinder and the atmosphere.

Q. What is an emergency application of brake, and how does it differ from an ordinary application? A. The term "emergency application" is a technical term which refers to the kind of application of the brake rather than the condition under which it is to be used. It may be used in an emergency and usually has been reserved for that purpose, but it is an application of the air brake in which the air pressure in the train pipe is discharged into the brake cylinder, in addition to the air from the auxiliary reservoir, for producing an application of the brakes. The ordinary application whereby your pressure in the brake cylinder of 50 lbs. results in an emergency application includes the use of air from the train pipe, and results in an air pressure in the brake cylinder of 60 lbs., about 20 per cent greater. Therefore an emergency application differs from an ordinary service application in that, first, it is about 20 per cent more forcible than a service application. And it has one other feature of difference, and that is, the brakes are applied to each car in a very much shorter period of time, so that the application of the brake is really from car to car throughout the train in a very much shorter length of time. That is of importance on long trains but not so much so on short trains.

Q. What is the difference between a high-speed brake and a quick-action brake? A. The Westinghouse high-speed brake differs from the quick-action brake simply in the addition of an automatic reducing valve attached to each brake cylinder, and in addition a very much higher air pressure is carried in the train pipe, and therefore in the auxiliary reservoirs. In its application it differs from a quick-action brake inasmuch that a very much greater pressure can be obtained in the brake cylinder, and also that the pressure is automatically reduced as the speed of the train declines. So that a very high pressure of the brakes used upon the wheels is attained upon the early portion of a stop, until it is reduced and it comes to that produced by the quick-action brake toward the close of the stop. The reason why that is done is because it is a well-known fact now that the co-efficient friction between wheels and rails which causes the wheels to persist in their rotation is practically the same at all speeds. The friction between the brake-shoe and the wheel varies greatly with the speed. It is low and high speed, and increases as the speed declines. For instance, at 60 miles an hour the co-efficient of friction between the brake-shoe and the wheel is about 11 per cent of the pressure. At 20 miles an hour it is about 19 per cent or 20 per cent of the pressure. It is therefore evident that a much greater retardation can be secured and a much greater pressure of the brake-shoes can be applied to the wheels to secure high speeds than can be secured at low speeds; that is to say, a much greater retardation is secured at high speeds by using a greater pressure. If that pressure is subsequently reduced so as not to increase the friction between the brake-shoes and the wheels so as to cause them to slide at the low speeds, this high-speed brake produces for that the utilization of a high pressure and much increased friction between the shoes and the wheels at high speeds, that pressure being reduced as the co-efficient between the brake shoe and wheel increases as the speed decreases.

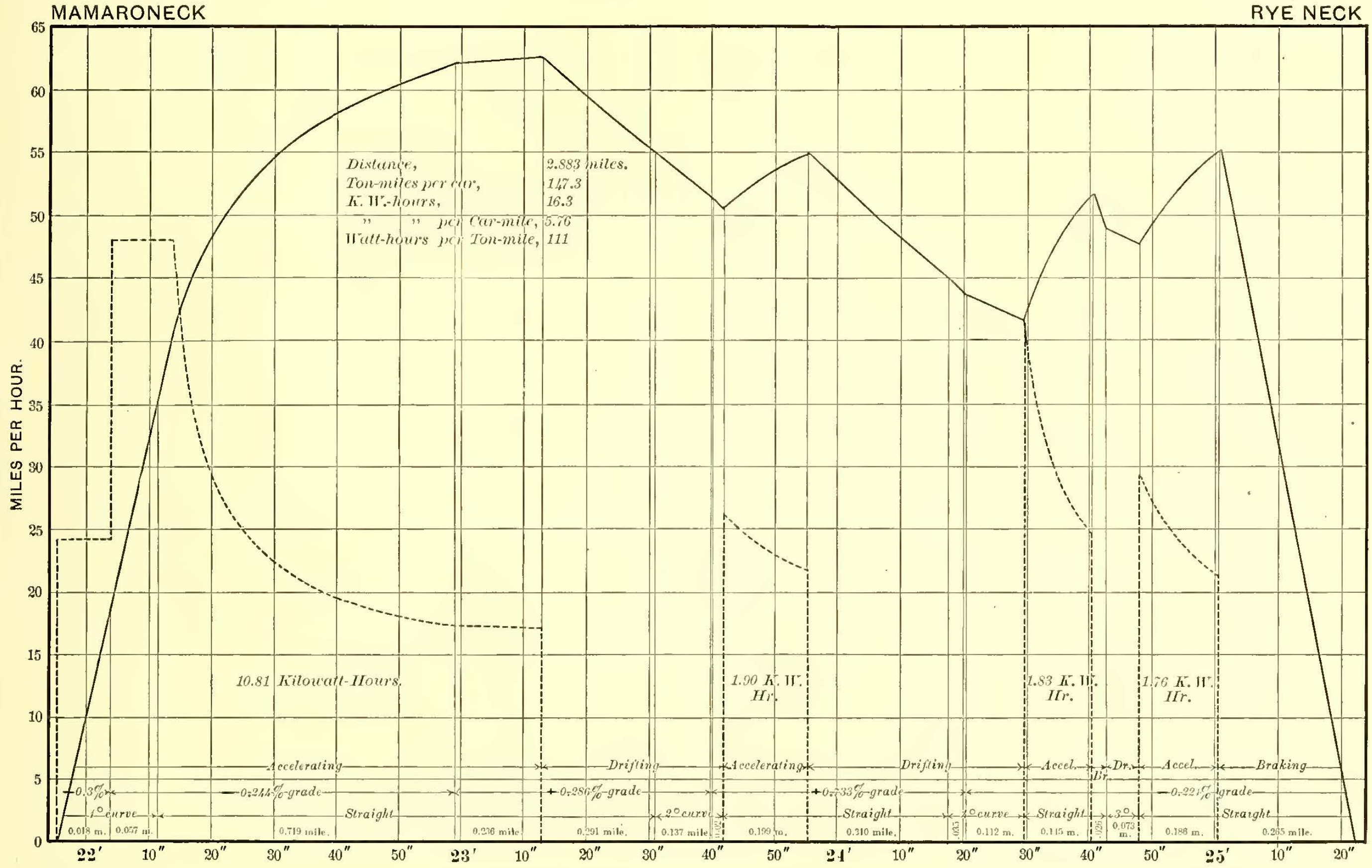


FIG. 11.—RUN SHEET FROM MAMARONECK TO RYE NECK

Q. The high-speed brake can be applied to any train? A. Yes sir.

Q. And could be applied to these trains and cars proposed to be operated by the Portchester road? A. Yes.

Q. And with perfect safety? A. Yes sir; it would be very desirable.

Q. Can any emergency application of the brakes be made in the regular service of trains? A. The question is whether it should be made or not; it can be made, but it is a question if it can be used or not depends upon the conditions. In long freight trains and again in long passenger trains where the aggregate slack between the cars amounts to a good deal, an emergency application is very apt to be accompanied by considerable shock at the rear of the train. It is therefore very undesirable to use an emergency application upon very long trains. The conditions there are such that it is very apt to cause injury to the rolling stock. Upon short trains conditions are very different, and I have very frequently observed the effect of the application of the emergency brake at high speeds. The conditions there are such that there is no objection, especially at high speed. If the speed were very low, even upon a short train there would be no objections I should question the desirability of using the emergency brake in ordinary service, making station stops, but at high speeds there is no objection in my belief, and my belief is based upon my experience. There is no objection to the emergency application for all trains at high speed.

Q. When you say high speed, what speed would you regard high justifying the use in regular service when the train consist of two or three cars? A. Forty-five miles or above.

Q. I understand you then that if trains are run at the rate of speed as is proposed upon this Portchester road and consisting of one to three cars, there is no objection to the application of the emergency brake? A. I believe that it would be a very desirable thing to do, especially if it is desired to make a very fast schedule. I think it is not only desirable but very much so.

Q. Have you seen a schedule of the express train stops contemplated in the operation of the New York & Portchester Railroad, and if so, what do you find to be the average time and average distance in which a train could be stopped in the operation of this road, using a Westinghouse brake? A. The schedule which I have been given provides for eleven stops, one at 149th Street on a descending grade of 14.9 ft. to the mile, from a speed of 59.7 miles per hour. The second, at Bronx Park, an ascending grade of 9.1 ft. to a mile, at a speed of 62.7 miles; the third at B. P. and P. P. on an ascending grade of 27 ft. to the mile, at a speed of 60.4 miles. At Mt. Vernon on a descending grade of 38.5 per mile at a speed of 57.7 per mile. At Pelham at a speed of 50 miles 1.6. At New Rochelle on a descending grade of 59.9 ft. per mile and a speed of 50 miles per hour, and at Larchmont at 7.7 ft. per mile, 55 miles. Mamaroneck to Rye Neck 11.6 ft. on a descending grade at 55.4 miles. At Rye a grade of 1 ft. per mile at a speed of 51.2 miles and at Portchester 28.9 ft. descending, 52.2 miles. The distances in which it was expected that these stops may be made in the operation of this railroad are given an average of 1475 ft., that is computed on the stop at each one of these stations, and also I then computed the stops in the reverse direction and took the average. I found the average number of feet for the stops to be 1227 against 1475 which were estimated, and I found the average time to be 26½ seconds against the 35 seconds in the estimate. In the reverse direction I found the time about 26 seconds, and the average distance about 1206 ft. instead of 1227, so that it is more favorable in the return trip than in the trip given in the schedule. The average speed for the stops is 55.4 miles, so that the average time or the average distance—1475 ft.—which have been made the basis of this schedule, exceeds the average distance on the basis of stops that have been made under similar conditions with the quick-action brake and exceeds the average of those stops about 20 per cent. This I should think was an abundant allowance for difference in atmospheric rail conditions and that sort of thing, and these stops, made on the Pennsylvania road and other places where I have obtained data, which has enabled me to make these computations; the condition of the rail was good, that is to say, it was a good clear day. There was no moisture or frost on the rail, and of course those stops were under conditions where there is moisture on the rail or frost, in which case the stops would be longer than those made under favorable conditions. The 20 per cent allowance made in this case I should consider sufficient to cover such ordinary differences in the rail.

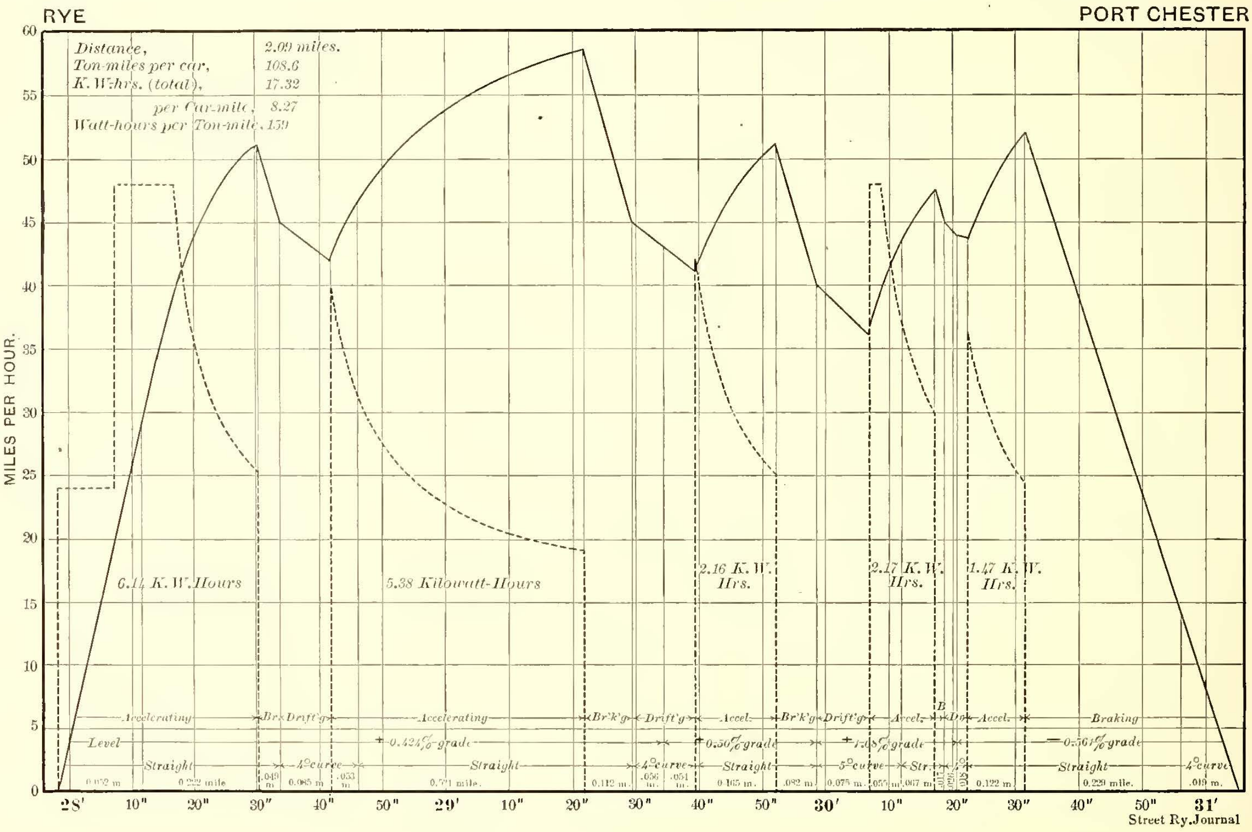


FIG. 12.—RUN SHEET FROM RYE TO PORT CHESTER

Q. This high-speed brake is upon the same principle that the emergency application is applied? A. The high-speed brake is the ordinary quick-action brake, with the addition of an automatic reducing valve by which you can apply a greater braking force than you can apply with the ordinary quick-action braking forces.

Q. How long has the high-speed brakes been in use? A. They have been in use on the fastest trains—the Empire State Express, the Congressional Limited, the Pennsylvania Limited and on the fast mail trains since 1894.

Q. Would it be fair to say that in the emergency application of the high-speed brake the train would run twice as far as in the case of the service application of that brake? A. It would have to be the other way. The service application would run further than the emergency application.

Q. The brake ordinarily in use on roads is the quick-action automatic brake? A. Yes; that is the one ordinarily used.

Q. You say it is a rare exception, taking into account all the railroads of this country where the high-speed brake is in use? A. So far it has only come into use on high-speed express trains.

Q. On heavy express trains? A. Not necessarily heavy. There are lots of heavy express trains that have not got it. It is a question of speed, but there is no reason why it should not be applicable to other kinds of service.

Q. Is the use of the high-speed brake in service application attended with more wear and tear upon trains than the quick-action automatic brake? A. No sir; not in service application.

Q. Is it attended with more wear and tear on the rail than the service application? A. No sir.

Q. Is it the design of the manufacturers of this brake that it should be used upon trains where frequent stops are made? A. When it was originally brought out it was not so designed, but the manufacturers have now come to the conclusion that the use of the high-speed brake should be extended to all passenger service.

Q. Do you know any train on which it is in practical and continuous use—where the stops are frequent? A. I do not know of any train now that makes a practice of using the high-speed brake, which is what you would call a local train or a train in which the stops are frequent.

Q. In respect to these experiments in Pennsylvania with high-speed brakes you stated, if I understood you correctly, that at 60 miles an hour, the train was 1111 ft. Now how would it be in a 45 mile rate of speed? A. I do not remember the figures at 45 miles, but it would be about the same proportion of the distance made by the quick-action brake; in other words, about 70 per cent of the figures I gave in regard to the quick-action brake at 45 miles an hour—686 ft.

Q. What percentage is that? A. About 72 per cent of the 652, that is, being reduced to a level.

Q. Were the wheels skidded on the Pennsylvania road? A. I don't think they skidded in any of the tests, either with a quick-action or with a high-speed brake. If they skidded in any test at all it would be only during the last 2 or 3 ft. of the stop where it was not of sufficient importance to observe, and it has been a notable fact that where this high-speed brake has been in use on railroads the freedom from real sliding has been unusually greater than with the ordinary quick-action brake.

Q. When you made those experiments on the Pennsylvania road, were the conditions practical; I mean was there an absence of dampness and frost, or were those experiments made under conditions where you have to make an allowance either for frost or moisture? A. I think I stated that the conditions were satisfactory. There was no dampness or frost upon the rails. The speed stops given are those which actually took place with no allowance or deduction for frost or moisture or any other hostile cause.

Redirect testimony.

Q. What variable conditions enter into the question of the distance in which a train may be stopped? A. The distance in which a train may be stopped depends upon the total weight of the train and its load upon the aggregate braking force; that is, the aggregate pressure of all the brakes used upon the wheels, upon the speed at which the train is running when the brakes are applied, and upon the grade. In addition, the length of time consumed in applying the brakes to the wheels must be taken into consideration from the time that the engineer or motorman moves the handle of his operating valve until the brakes are effectively applied to the wheels throughout the train. In case comparisons are being made between stops, it is also necessary to take into consideration the different lengths of time required to apply the brakes, and also the mean air pressure in the brake-cylinder throughout with each different kind of brake.

Q. Have you had experience with stops made under such different conditions as to the weight of train braking force, speeds and grades with different kinds of brakes and brake applications, so that, knowing the distances in which one kind of train stops under certain conditions, you can compute with fair accuracy the distance in which a different train can be stopped under substantially similar conditions? A. I have had large experience with train stopping under a large variety of conditions. Both as to length and weight of train, kind of brakes, speeds and grades. An analysis of these different stops has enabled me to make computations in which, knowing what distance a certain train stopped in with certain kind of brake application, under certain conditions, to compute the distance that another train of different weight would stop in on a different grade and at different speed; that is to say, the fact that certain experimental stops were made under one set of conditions and that the length of stop required for other conditions does not render the experimental stops applicable, or at least, the experimental stops can be very accurately modified to correspond with the other conditions, so that, if a very heavy, long train was used in making certain experimental stops, the corresponding stops for a light train or a short train, under substantially the same conditions, could be computed with very great accuracy. It is not necessary at all, in order to determine the distance in which a certain train could be stopped under certain conditions to have experimental information in regard to stops with trains of that particular make-up or length. The difference of that kind can be allowed for very accurately.

Q. What is the difference between the conditions which obtained in the experiments upon the Pennsylvania road as to which you have testified, and those which are proposed upon the New York & Portchester railroad? A. The train conditions in the experiments upon the Pennsylvania road were these: There was a locomotive, a tender and six to eight-wheeled passenger cars, which weighed, I think, about 393,000 lbs.—the six. In that case, the braking power applied to the locomotive was less than that applied to the cars for two reasons. In the first place, there are practical reasons why it is considered less desirable to have a high-braking force upon the locomotive driving wheels than upon the car wheels. Moreover, the tender is always more or less loaded, and it is necessary to restrict the braking force upon the tender, so that the wheels shall not be caused to slide when the tender is empty; consequently, the aggregate braking force upon the Pennsylvania train was considerably less per ton-weight of train than would be the case if the train had been made up of cars alone, as will be the case, as I understand, on the New York & Portchester road. In other words, a smaller retarding force per ton-weight of train occurred upon the Pennsylvania train than would occur upon the express trains of the proposed road.

Q. Then, will the conditions on the proposed road be such that the distance in stopping their express trains will be longer or shorter than those upon the Pennsylvania road, in the experiments about which you have testified? A. The conditions will be such on the proposed road that the stops which they can make with their express trains are less, or will be less, than those which I have computed from the Pennsylvania train, because I have not made allowance for the difference in the ratio of braking force to the weight of train. The train on the Pennsylvania road was empty when stops were made. With the New York & Portchester trains the stops on them should be calculated for those trains when they were loaded to their fullest extent with passengers, but even making allowance for that loading, the ratio of the braking force to the loaded train was greater with the Portchester trains than was the ratio on the Pennsylvania trains, so that the figures that I have given are above, rather than below, the stops which can be made on the Portchester train. The stops that I have given are on the same side, and you can rely upon their being less than those I have given.

Q. I understood you to say yesterday that the average speed of the express stops on the schedule furnished you is 55.4 miles per hour, and that the average distance of those stops would be 1227 ft. under fair conditions of rail, with an emergency application of the ordinary quick-action brake. Can you give the corresponding distances with an emergency application of a high-speed brake, and with a service application of both the quick-action and the high-speed brakes? A. I have looked up this matter, and am prepared to give the lengths of stop with an emergency application of the high-speed brake, and also a service application of both the quick-action and the high-speed brakes. The distance which I gave yesterday for the average for all these stops, the average speed being 55.4 miles per hour, was 1227 ft. That was an emergency application of the quick-action brake. The distance with an emergency application of the high-speed brake would be 894 ft. The distance with a full-service application of the ordinary quick-action brake would be 1677 ft. The distance with a full-service application of the high-speed brake would be 1450 ft. I stated yesterday that my recollection, off-hand, was that a full-service application with the quick-action brake would exceed the stop in an emergency application about 60 per cent, and that the full-service application with a high-speed brake would exceed that of an emergency application with the same brake about 100 per cent. I had in mind stops with considerably longer trains. I find that the full-service stop with the quick-action brake is only about 40 per cent greater than emergency application upon this short train, and that the full-service application stop, with the high-speed brake, is only about 60 per cent greater than the emergency application.

Q. Would it be desirable from any point of view to use the service application of the ordinary quick-action brake in making these express stops with a single-car train? A. It certainly would not. On a single-car train there would be no necessity even of using the automatic brake. The street car (or straight air) brake would be entirely suitable in that case, where there is no connection between cars, and, therefore, no danger of the train parting where an automatic brake, of course, would be necessary. With the ordinary straight air brake on a single-car train, a stop could be made in 1227 ft., and there would be no throb about it; just the same distance that an emergency application with the quick-action brake would stop the train.. There could be no possible advantage in using a brake in which the time required for application of the brake-shoes is so great as that in full-service application of the automatic brake. The one reason why the full-service stop, with the quick-action brake, is so much greater than the emergency application, is the greatly increased length of time, the interval of time which elapses between the movement of the operating valve by the motorman, and the period at which the brakes are effectively applied to the wheels. In any case that should be avoided. There would absolutely be no necessity and no desirability in using a form of brake there which would require any such length of time, and any such long stop as would result from a full-service application of a quick-action brake.

Q. What are the operating conditions which are favorable to efficient rapid transit, suburban service, and what do you recommend in the way of brakes for such service? A. The service upon steam railroads—what is known as suburban service—has undergone considerable change within the last few years. It was formerly customary to use a little light engine, that had been outgrown for ordinary passenger service in this suburban service. The result was that the acceleration of suburban trains was very slow; they did not attain high speed, and the service was of a character that could not successfully compete with the trolley service that has sprung up in our largest cities, and with which the steam railroad has had to come into competition. It has, during the past few years, been customary to use a very much better class of locomotives, in order to increase the acceleration, and to better the service. I will simply say that the success of the rapid transit suburban service depends upon three things—first, upon attaining a high acceleration, to obtain which the railroads have gone to a considerable expense in getting large locomotives; second, to maintain a maximum speed as long as possible; and, third, to make the stop as quickly as possible. In order to do that, it is very essential that the best form of brake that can be secured should be used. There is no objection, so far as we have been able to ascertain, to using a brake which in this case would allow these stops to be made, on the average, in less than 1000 ft., and it would, therefore, seem to me that such a brake being available, there is a very large margin between the 1400 and some odd feet, which have been estimated as the average distance of stop, and that it is entirely practical to obtain it.

The Arbitration Case in London

(From Our Special Correspondent.)

The arbitration case between the Metropolitan District Railway Company and the Metropolitan Railway Company as to the best system of electric traction to be adopted on the Inner Circle controlled and operated by both companies, commenced this month in the Lord Chief Justice's Court at the Law Courts before the Hon. Alfred Lyttleton, K. C., M. P., as arbitrator, and assisted by Mr. H. F. Parshall, representing the district company, and Mr. Thomas Parker, representing the Metropolitan company, as arbitrators. The District Company had as counsel Mr. Fletcher Moulton, K. C., M. P., and Mr. J. W. Gordon; and Mr. C. A. Cripps, K. C., M. P.; Mr. Roger Wallace, K. C., and Mr. F. G. Thomas represented the Metropolitan Company. It is only possible in this letter to merely touch upon the speeches of the counsel and evidence brought forward by the experts on both sides, though a short account will be found in another column. Mr. Moulton opened the case for the District Company, and explained first the proportions in which the two companies were interested in the Inner Circle. He then went on to show how much experience America had had with electric traction lines as compared with England, and claimed that the direct-current system was universally used in that country. He then pointed out that as the systems became greater, high voltage and alternating currents were used for generating stations, the current being transformed to direct current at 500 volts for use on the cars. He then went on to state that the 3000 volts which Ganz & Company required for their system and which they proposed to use in the motors on the cars would be dangerous, and that there were no lines working to-day on the system proposed by Ganz & Company. He claimed that their system was also most complicated, and that the only railway which had ever been equipped with the Ganz system was still incomplete and had not been opened, and that the acceleration on the Ganz system was inadequate to allow cars to make the circuit of the Inner Circle in the time required. Mr. R. W. Perks, the chairman of the District Company, was the first witness, and he gave evidence as to the running rights for railways in the Inner Circle, and stated that 17 per cent of the 42,200,000 passengers were Inner Circle passengers, and stated also that there were 220 Inner Circle trains a day. He then went on to trace the history of the tenders, Messrs. Preece and Cardew's experiments, the investigation of the system of Ganz & Company by their engineers, their desire to accept the Ganz system, and the subsequent fears that it would be acceptable neither to the shareholders nor to the Board of Trade. Mr. Yerkes was the next witness, and he merely expressed his strong reluctance to recommend the expenditure of a million of money on a system which was, he claimed, only experimental, and has never been tried for an extended period.

Mr. E. W. Rice of the General Electric Company of Schenectady was then examined by Mr. Moulton, and he gave evidence as to the applicability of the system proposed by the British Thomson-Houston Company, Limited, in the Inner Circle, and strongly recommended a system similar to that which is now in operation on the Central London. He also went on to state that he had been experimenting with the system used by the Ganz Company for years, and had come to the conclusion that such a system was not reliable. On cross-examination Mr. Rice evidently objected to the cascade system, and did not believe that more than 5 per cent to 10 per cent of the stored energy in a moving train was returned to the line, and that he considered that this return was not worth the extra application involved. Many inventions of this nature had been experimented with in the States, and it had always been found that it involved complication and inefficiency in starting. Mr. James Swinburne, consulting electrical engineer, was next examined, and explained the working of the direct-current system and of the Ganz system, and claimed that the method of connecting the polyphase motors would not allow of such flexibility of speed or such great acceleration as in the direct current system. He also took exception to the water resistances to be used in the method of controlling, and then went on to point out the extreme complications which would arise in the overhead conductors carrying 3000 volts at junctions. Mr. Swinburne, when cross-examined by Mr. Cripps, would not admit that the contact rails near the running track on the direct system of 500 volts were more dangerous than the overhead wires that Ganz Company had of 3000 volts, and he did not believe that a person touching the rails would be killed. He also believed that the Ganz system could not get so great acceleration on the system proposed as by the direct system, and that it would be a great loss to run the alternating-current motors below their maximum speed. Mr. Cripps then cross-examined Mr. Swinburne as to the simplification of the system by omitting the rotary converters, and admitted, of course, that outside of the power house the Ganz system required no rotary machinery till the motors were reached. He would not admit, however, that the Ganz overhead devices for safety were good and sufficient, and he did not believe in liquid rheostats for traction purposes.

Mr. James Russell Chapman, Mr. Yerkes' chief electrical engineer, was the next witness, and stated that he had had an experience of twenty-seven years in railways in the United States. He maintained that a system similar to that proposed by the British Thomson-Houston Company would be eminently suitable for the equipment of the Inner Circle, but that the Ganz tender was not for a first-class equipment, and that if the equipment were proceeded with on their tender it would not yield sufficient power by about one-half. He did not think, for instance, that 1400 kw could be given from a boiler heating surface of 48,000 square feet. He objected to the condensers being run from each engine, and maintained that independent condensers were the only proper device in a modern traction plant. He objected also to the exciters being on the same shaft as the generator, and claimed that it was very poor practice as proposed by the Ganz system. He then went on to make a statement about his visit to Buda Pest and Sondrio, where he had inspected the experimental system of the Ganz system. His whole conclusion after investigation of this system was that the system was totally inadvisable for the Inner Circle. In criticising also the details of their device, some of which were in evidence, Mr. Chapman stated that they would not in any way perform the function of making their 3000-volt circuit safe. Mr. Chapman's testimony was most practical, and was listened to by the audience with marked interest. Mr. Chapman then gave practical testimony as to what the equipment should cost, as to the proper number of trains for the circle, and for the speed for them to run at, and stated that the trains in the Inner Circle would require to have an acceleration of 1½ ft. per second, and that his test of the Gans system would lead him to expect that no such acceleration could be arrived at.

Mr. Philip Dawson was the next witness. He stated that having built about a thousand miles of electric tramways and installed over 250,000 hp. for the purpose of electric traction, he was competent to judge as to what system should be used. He stated that he was also familiar with all the important three-phase traction systems which were worked, the Burgdorf-Thun Railway being the most important of these. Even in this line, however, the service was in no way to be compared with the frequent service which would be demanded on the Inner Circle. Mr. Dawson made a good witness, and gave his testimony fairly and squarely against the adoption of any 3000-volt polyphase system on the Inner Circle. On cross-examination he maintained that the direct-current system was more easily controlled than the alternating-current system, and more quickly. Mr. George Estall was the last witness for the direct-current system, and stated that he was resident engineer and locomotive superintendent to the District Railway. His testimony confined itself to showing sections of the tunnel, and he stated he believed that it would be impracticable to attach overhead wires or light conductors to the roof of the tunnel and yet leave sufficient room for the operation of the cars.

Mr. Cripps then opened the case for the Metropolitan Company, and pointed out at once that the Metropolitan Company was the predominant partner in the Inner Circle. In comparing the two systems Mr. Cripps maintained that the continuous-current system required additional factors, and that in that way the system cost considerably more, and that the Ganz system would effect saving in the sub-stations alone of just about £70,000. Mr. Cripps went on to draw attention to the fact that there was an element of risk in the using of continuous current in which the contact rails were laid on the surface where they could be touched, and contended that the 3000-volt system, with their overhead wires in an inaccessible place, was much safer. As regarded economy, he claimed that the Ganz system would show that they could save 13 per cent less leakage of energy in the alternating system than in the continuous current system. As compared with the Ganz system, the wear and tear of the continuous system in connection with the use of electric traction he estimated at an additional £4,500 in working cost per year. He then went on to defend the liquid rheostats, and maintained that it would be quite easy for their system to take care of triangular junctions.

Mr. Otto Titus Blathy, manager of the electric works of Ganz & Company, Buda-Pest, was the first witness, and was examined by Mr. Cripps. He stated shortly that it was at the beginning of 1885 that his firm introduced the alternating system of distribution, and that they had been experimenting and perfecting it ever since, until their experimental line at Buda-Pest was put in operation in December, 1899, and had been kept in operation for two or three hours every day for the last two or three months. The pressure of this experimental line was 3000 volts. Mr. Blathy went on to give statistics of certain railways which were run on the alternating-current system in various parts of the Continent. For the Inner Circle they propose to use a high-tension three-phase current in the generating station of about 10,000 volts to 11,000 volts at 25 periods; that this current would be transmitted to sub-stations, where, by means of static transformers, it would be transformed down to a tension of 3000 volts. A great point was made of the fact that no attendants would be required at these sub-stations, there being no rotary converters there. The 3000-volts current will be carried on two overhead conductors, and the current collected by two pairs of controllers with rollers on them. There will be two groups of motors on each motor car, and the control will be effected by liquid rheostats operated by compressed air the same as that used for the Westinghouse brake. In starting the polyphase motor, he stated the current would operate first on one motor at half speed, the secondary motors were then brought into use, and they were enabled to get double power as though they used a single motor. To bring the train to stop, the cascade connection would be put in, when current would be given back to the line. In further examination, Mr. Blathy stated that in the case of the Ganz motors that up to half speed the acceleration was 2.6 ft. per second per second, and in the second half 1.44 ft. per second per second. According to the proposals of Messrs. Ganz, they would require an energy of 71 watt-hours per ton mile to get round the Inner Circle in 50 minutes, with twenty-seven stops of 20 seconds each.

Mr. Gisbert Kapp, M.I.C.E., M.I.E.E., was next called, and also gave evidence in favor of the alternating-current system. Mr. Kapp is well known in England as well as on the Continent, and he stated that he had a great amount of practical experience in advising and inspecting systems using the three-phase current. His evidence was all of a nature confirming all that Mr. Blathy had said and speaking very favorably of the three-phase system in that it would be perfectly suitable for use in the Inner Circle. He gave evidence also that the cascade brake was under perfect control, and also gave evidence to the effect that on the Valtelina Line he had observed acceleration of 1½ ft. per second per second. Mr. Kapp also gave evidence regarding the practice of coupling exciters direct to the main dynamo, maintaining that it was good practice, and spoke as to the excellent results of the use of liquid rheostats, though he admitted that they had never been used for railway work. Mr. Fletcher Moulton, in his cross-examination, brought out the fact that Mr. Kapp has never been in charge of an electric railway, and that his knowledge was more theoretical than practical. He also stated in his cross-examination that the cascade connection was an invention which did for the alternating current what the series parallel control did for the continuous current. Mr. Blathy was recalled at this time, and stated that at triangular junctions a special signal would have to be given to the driver at a certain point so that at that point he would reverse his motor connections. In doing so he would switch off all the motors behind his car, and they would have to run into the next station with reduced power. In the event of the driver running past the point a mechanical shock would be given to the passengers, but only equivalent to a negative acceleration of ½ ft. per second per second. Mr. Moulton, in his cross-examination, went thoroughly into the details of the motors, liquid rheostats, air cocks controlling the rheostats, and a vast amount of details intending to show the unreliability of their system of control. Mr. C. Kalman de Kando, vice-manager of Messrs. Ganz & Company, then gave evidence practically in confirmation of Mr. Blathy's evidence. On cross-examination he stated that while he knew that Mr. Rice was of opinion that it was not good practice to run polyphase motors in cascade, that his own experience showed that it was an excellent system. He admitted that the system of multiple-unit control proposed by Messrs. Ganz had never yet been subjected to extensive experimental or to practical working.

Professor G. A. Ewing, F.R.S., was then called, and on examination was of opinion that the necessity for rotary converters in the direct-current system was prejudicial to the interests of the railway, and he also considered that the limit of voltage in the direct-current system was a detriment in equipping a railroad, especially one which would have outside connections. He maintained that the direct-current system could not be used with a higher voltage than 500, and that when the railways started to increase from the Inner Circle and operate on the suburban lines it would be an extreme detriment to use voltage so low. He then went into the loss by drop of voltage on the feeders and rail conductors on the direct-current system, and compared it with the very small loss which would follow the introduction of a high-tension system. He admitted that the continuous-current motor had a small advantage so far as acceleration was concerned, though the cascade system as proposed by the Ganz Company was an ingenious and effective invention. He considered that the 3000-volt working in the tunnels would be quite safe with the precautions proposed by Messrs. Ganz, that the liquid rheostats were an excellent resistance, and that he fully believed and could prove by experience that the alternating motors could readily achieve an acceleration of 1.6 ft. per second per second. On cross-examination, the witness admitted that some of the points brought up in his evidence were simply matters of opinion and not based on practical experience. Mr. Gordon endeavored at some length to get Prof. Ewing to admit that the same acceleration was an important factor in comparing the two systems, but he did not succeed in getting the witness to admit that. He maintained that it was not necessary to a fair comparison that the acceleration should be the same in both cases.

Major Cardew was the next witness brought forward by Mr. Cripps in the interests of the Metropolitan Railway, and stated that he had been much engaged in inspections of electric railways while acting in the capacity of electrical adviser to the Board of Trade a few years ago, and that he was familiar with the systems of the City & South London, the Liverpool Overhead, the City & Waterloo, and the Central London Railway, and he considered that the third-rail system could be economically applied to long lines having a large traffic. He claimed that there was a loss of 10 per cent in the continuous-current system conductors, while on the polyphase conductors the loss was under 4 per cent. He stated that a few years ago he would not have advocated the polyphase system, but he claimed that Ganz had worked out tremendous improvements in the last few years, and now he considered that the polyphase system was absolutely the best system to use on the underground railway, and that the proposed multiple-unit system of control of the polyphase system was a perfect system, and that the use of liquid rheostats was quite safe. He believed also that the engineering ability of Ganz & Company would easily overcome any difficulty with conductors at triangular junctions. Major Cardew rather damaged his case, however, by stating that he hoped that the Ganz system would be admitted, and thought that the Board of Trade should allow them to experiment on the system. The arbitrator then asked him several questions about the time necessary for such experiments, and Major Cardew wound up his evidence by saying that the best system should prevail, and that Messrs. Ganz should have fair play. On cross-examination by Mr. Moulton, Major Cardew went into statistics on the power house, and later stated that he considered that the equipment of the Inner Circle could not be made without considerable experimental changes from any engineering plans that could now be provided.

Mr. E. Talbot was then put on the stand, and gave evidence very shortly as to the use of overhead wires in Leeds, and that he had had no trouble with them breaking. It perhaps ought to be stated here that Mr. Moulton's witnesses had all spoken as to the damage which would accrue to overhead wires if fastened rigidly in the tunnel, and claimed that all modern practice of suspending trolley wires was by flexible suspension. Mr. Talbot's evidence was to refute this, and he stated that he had had no trouble with conductors which he had put up rigidly in Leeds as long ago as 1897. He also gave evidence as to the clearance between the armature-field magnets in the G. E. 58 motors which were used in Leeds. Mr. Moulton's witnesses had made a special point that for practical service the alternating motors, with a small clearance of about one-twelfth inch, would not work successfully for any great length of time, as the wearing down in the bearings by use would necessarily soon bring the armature into frictional contact with the field poles.

Prof. Sylvanus P. Thompson was then put on the witness stand as the last witness for the Metropolitan Railway, and proved to be a very good witness. He stated that the rival systems were the same until the sub-stations were reached, and that he distinctly thought that the rotary converters in the direct-current system were a detriment, involving extra cost and extra energy loss as a piece of apparatus. He calculated that with seven or eight sub-stations in the direct system there would be an average loss of 8 per cent on the conductors, with a maximum loss of 12 per cent or 13 per cent. This calculation was based on forty trains with a consumption of energy of 7800 kw. It would also lose from 7 per cent to 8 per cent in the converters and from ½ per cent to 1 per cent on the commutators of the motors. He made the total loss about 16 per cent, and, allowing 3 per cent for the loss on the Ganz system, it left a net of 13 per cent in favor of the Ganz. He also claimed that the polyphase motors had advantages, being lighter; that they would work with a smaller clearance; that, having no commutators, they required less attention, and they were more simply controlled. He considered the cascade coupling an advance on the series parallel control. He was averse to overhead wires in general, but on certain electric railways they were the only method possible. He stated most emphatically that he considered the exciters on the shaft of each generator was the best practice, and quoted the exciter of the City & London Electric Lighting Station for example. Mr. Parshall here corrected Prof. Thompson, and asked him if he did not know that it was the coupling of the exciters to one bus-bar which caused all the trouble in that station, and that now separate steam driven exciters were used. On cross-examination by Mr. Moulton, a rather amusing incident took place as Mr. Moulton read a long paragraph from Prof. Thompson's book on "Polyphase Electric Currents and Alternate-Current Motors" of the edition dated 1900, where it states in effect that the very system proposed by the District Railway of polyphase stations, rotary converters and direct-current system on the motors was the best system to use for electric railways. Prof. Thompson got out of it by stating that it was his opinion when the book was written, and at that time he believed that it was the best practice.

This concluded the evidence for both companies, evidence which has taken two weeks to put in, the Hon. Alfred Lyttleton and his associates, Mr. Parker and Mr. Parshall, having sat for eleven days on an average of six hours a day. It might be stated in word that Mr. Moulton's efforts were entirely to show that the direct system was one that had been tried for years, and that it was eminently successful, and he claimed that there was no dispute as to that point, whereas the polyphase system as applied to electric railways was an experiment, that no lines of any magnitude were practically worked by it, and that the District Railway was the last place in the world where an experimental line of this magnitude should be tried. Mr. Cripps advocated the polyphase system, and tried to show that it was a distinct advance in the art, and that if they were not to use polyphase system it would be like stifling progress, and he claimed in his closing speech which followed immediately on Prof. Thompson's concluding evidence that all the essentials required had been proven to be satisfactory on the Swiss and Italian lines, and that the remaining details could be easily solved in the present stage of electrical knowledge. He claimed a large saving in the initial cost and a large saving in the operation, and that it was absurd to suppose that the conductors could not be insulated with safety, and that the acceleration of the polyphase system had been proven to be as good, if not better, than that of the direct-current system. He considered his case amply proven as regards cost, safety and proficiency, and he awaited the arbitrators' decision with confidence.

Mr. Moulton, in summing up his case in favor of the direct-current system, reiterated, of course, a good deal of what I have said above; that he really felt it difficult to treat the case seriously, and that it seemed absolutely absurd that any fair-minded man would recommend a system which was absolutely untried and was practically in its experimental stage. He dwelt on the fact of how much money had been spent in the development of the direct-current system; how it commenced very small some fifteen years ago with small motors; how it had gradually increased; how it had gained the confidence of engineers and of the financial public, and how it had gradually developed into a system which was now confidently installed wherever occasion necessitated. How there are practically about 20,000 miles operated in the United States on the direct-current system, and maintained that before anything could be done with the polyphase system the advocates of it ought to follow something of the same history, commencing by exclusively installing small roads, and gradually growing up to a position in which they could solve a problem like that of the Inner Circle. He maintained that it was practically an impossibility for such a system to be put on the Inner Circle at present, and did not believe for a moment but that the arbitrators would look at the case in the same way. It was like sending a boy to do a man's work.

It is reasonable to suppose that both companies would like a decision as soon as possible, as they are now anxious to get the road electrified.

Mr. Alfred Lyttleton, the umpire, however, explains that it is provided that not only he, but the tribunal as a whole—including the two arbitrators, Mr. Parshall and Mr. Parker—shall report to the Board of Trade. The task before them is a difficult one, and after they have completed it the Board of Trade will itself have to come to the final determination as to whether the direct-current system, as favored by the District Railway, or the Ganz system, put forward by the Metropolitan, shall be selected.

Locating Faults in Underground Distribution Systems*

BY HENRY G. STOTT

With the rapid and extensive growth of underground-cable systems for the distribution of electricity for light and power purposes a problem of great practical importance has arisen—namely, to find a method of quickly and accurately locating a fault or ground in any part of the system.

With small conductors, such as those used for telegraph cable, the ordinary Blavier and loop tests with galvanometer, Wheatstone bridge and battery suffice; but the percentage of error in locating a fault varies directly with the cross section of the conductor or inversely as the resistance. Anyone familiar with the most refined methods of battery test will admit that the loop test is the best of all, as it eliminates the worst variable—namely, the fault resistance. Even under the best conditions the loop test has an element of uncertainty in the variation of the zero on the galvanometer due to earth currents getting into the cable through the fault. In a city, the source of this error becomes of greater importance than in submarine cables, owing to the leakage of street-railroad currents through the earth from the rails. As a matter of fact, it is frequently impossible to use a sensitive galvanometer on any test involving the use of the earth as a part of the circuit.

Loop tests carried out with the comparatively large current of ten amperes, using millivoltmeters instead of reflecting galvanometers in the hope that the stray currents would thus become such a small percentage of the test current that the errors due to the presence of the former would be practically eliminated, also failed entirely, and the conclusion was reluctantly reached that the galvanometer and battery must be abandoned whenever the resistance to be determined was less than .25 ohm.

The distance between manholes is evidently the practical degree of accuracy essential to any successful method. This will average about 350 ft. Assuming that .25 ohm is the limit of accuracy obtainable under these conditions, in the loop test this means that the method is not applicable to any conductor larger than No. 9 B. & S. gage, and therefore of no practical value for lighting and power purposes.

Resistance measurements having been eliminated as a possible means of solution, there remain three others, which may be called:

(*a*) "The cut-and-try method."

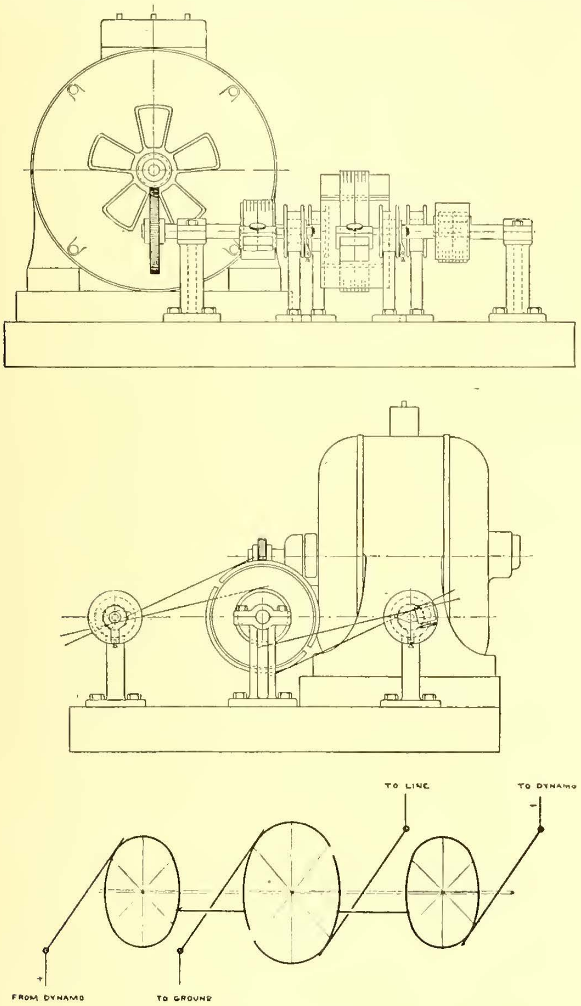
(*b*) "The smoke method."

*A paper read before the American Institute of Electrical Engineers, Nov. 22, 1901.

(*c*) "The compass method."

(*a*) The "cut-and-try method" is too well known and too bad to merit much description, as it simply means cutting the cable into as many sections as necessary until the fault is finally located in a length between manholes. This is a slow, expensive and unscientific method, and should only be used as a last resort. A three-conductor high-tension cable joint costs from five to ten dollars, and a jointer and helper cannot make more than two per day, so that if the cable is five or six miles long it may easily take four or five days to get the cable in service after removal of a fault.

(*b*) The "smoke method" is also crude, and simply consists of putting a current of sufficient magnitude into the cable through the fault, to cause the insulation to burn and give out volumes of



FORM OF REVERSER USED FOR DETECTING FEEDER GROUNDS

smoke, by means of which the location of the burnt section may be discovered upon opening up the manholes.

The method is more rapid in yielding results than (*a*), as no unnecessary cuts are made in the cable, but it may give rise to serious trouble in other cables, especially if the fault be in or near a manhole, as the flames may burn not only a great length of the cable itself, but also other cables, or cause explosions due to the ignition of the gases ever present in all city conduits.

(*c*) The "compass method" is, in the writer's opinion, the only practical and safe means of quickly and accurately locating a ground in cables larger than No. 9 B. & S. gage. This method consists, briefly, in sending a constant continuous current of about 10 amperes into the cable through the ground, the current first passing into an automatic reverser, which reverses the direction of the current flow every ten seconds. A manhole is then opened near the center of the cable length and a pocket compass laid on the lead sheathing of the faulty cable and observed for say half a minute. If the ground is further from the source of reversed current, the compass needle will swing around approximately 180 degrees upon every reversal at the end of each ten seconds' interval. The manhole is immediately closed and another opened, say a mile further away from the source of test current, and if no motion of the compass needle occurs, then the fault has been passed, and another manhole is opened between the two first positions, and so on until the fault is finally located in a section between two manholes.

It will be observed that by this method (1st) the cable is not cut, thus causing no delay or expense in rejointing; (2) the number of manholes opened is a minimum, and the time spent in each is only about one minute; (3d) the amount of current used is so small that no arcing or burning occurs and no explosions.

The figure shows one form of reverser used by the Manhattan Railway Company, consisting of a ¼-hp three-phase induction motor, geared to a two-part commutator, which revolves in oil in order to insure the quick reversal of current without danger of arcing across between segments. An ordinary constant continuous current arc-light machine is the most convenient source of current for this test, as it will supply a constant current throughout a wide range of voltage, thus automatically adjusting itself to the varying fault resistance. Should an arc-light machine not be at hand, 500-volt current can be used through a resistance and reverser.

Before putting on the reversed current it is advisable to break down the fault resistance by the application of a high-potential testing transformer to the cable for a few seconds.

This method of test is especially useful in any network of cables, such as 2200-volt single, two or three-phase mains and feeders, as the test current can be run on the network, without shutting down the supply service or interfering with it in any way, by simply sending the 10-ampere reversed current through a reactive coil (or the primary of a transformer) before entering the grounded main. This is merely done to protect the arc-light generator in case another ground should develop and thus cause a short-circuit on the alternating-current generator. This method of testing live circuits is only applicable, of course, to those supplying alternating current and having no permanent ground attached.

After using this method of locating faults for four years, the writer cannot recall any case, in which the method was properly applied, that required more than three hours to locate a fault in cables having a length of from four to six miles. The whole secret of this rapidity lies in the fact that the first test at the center of the line eliminates one-half of the cable from the question. To find a fault in a duct between manholes in a similar length of cable, by any other method known to the writer, may easily take two days, and as many more may be required to repair the cuts.

The writer trusts that the above notes may be of some practical value to the profession, and that the method recommended will be found as certain and satisfactory by those who have not as yet used it as by those who have.

The American Exhibition in London

From May to September of next year, the Crystal Palace, near London, England, is to be the scene of a collection of exclusively American exhibits. For fifty years this immense hall has attracted multitudes from the heart of the city to view the results of progress in the sciences and arts, but the exhibition planned for 1902 is one of the most novel in its scope that has been so far contemplated. Coming as it does on the year of the coronation of King Edward, it will not only have the customary summer population of the English metropolis to draw upon, but will be held at a time when the largest number of British, colonial and foreign visitors ever before accommodated will be in the capital. As the opportunity to inspect the latest development of American manufactures will undoubtedly be grasped by the majority of these strangers, the directors of the enterprise are well satisfied that no more fitting time or place for a world-wide exploitation of their products could be conceived of by manufacturers on this side of the water. It is reported that requests already received for permission to exhibit from prominent American concerns considerably exceed the available space. As the scope of the exhibition is so unusually extensive, it is desired to secure applications for space from representatives of all the varied interests concerned before proceeding to final allotments, so as to assure a truly representative exhibition of American apparatus, processes and systems and to fill the immense building, which can accommodate easily 100,000 persons under one roof, with an exhibition which will surpass in quality as well as quantity anything previously attempted in Great Britain.

It is proposed to build before the opening next spring a cable railway to the exhibition grounds from the railroad station, which is at a considerably lower level than the Crystal Palace. The distance is 300 yards and the gradient is about 8 per cent. It has been further determined to run a service of automobiles, each vehicle having a capacity for ten passengers, around the grounds, which are generally admitted to be the most beautiful ornamental grounds in Europe, extending over 200 acres, and including the most extensive series of sporting grounds in the United Kingdom, for cricket, football, baseball, cycle and motor racing, tennis, swimming and other athletic sports. Only a very small portion of the visitors to the Crystal Palace at present visit these grounds, because of lack of transportation. It was at first suggested that an electric traction system should be laid, but as the road which would constitute the main route, about one and a half miles in length, would have to be laid with rails, and certain prominent interests in the Crystal Palace Company were loath to have it cut up, it has therefore been decided to utilize automobiles.

The American Advisory Committee includes Colonel Millard Hunsiker, for many years European representative of the Carnegie Steel Company; J. W. Downer, British representative of the National Tube Company; Thos. J. Farrell, London manager of the American Steel & Wire Company; Clark Harrison, British representative of the United States Cast Iron Pipe Company; J. G. White, president of J. G. White & Company; R. W. Blackwell, of Robert W. Blackwell & Company, Limited; Charles Churchill, of Charles Churchill & Co., Limited; Thomas L. Field, president of the Anglo-Saxon Shipping Company; Frank E. Bliss, of the Anglo-American Oil Company. The British Advisory Committee comprises the Lord Mayor of London, the Duke of Sutherland, Sir Dudley Baines Forwood, of the shipping house of Forwood Brothers & Company, and Sir Douglas Fox, formerly president of the British Institution of Civil Engineers.

The American exhibition has for its commissioner in the United States Alfred H. Post, of Alfred H. Post & Company, Produce Exchange, New York City. Mr. Post's company is the official forwarding agent in this country, and all particulars relating to applications for space or other exhibition matters may be addressed to him. In this connection it is further expected that a commercial bureau will be established under the direction of a committee of representative American and British firms, the object of this bureau being to supply exhibitors with all necessary information regarding channels of trade and the placing of goods upon the markets of Great Britain, the Colonies and the Continent.

Meeting of the Engine Builders' Association

The third meeting of the Engine Builders' Association of the United States, which was held at Sherry's, New York City, Dec. 2, was conspicuous for the meritorious character of the papers read. The meeting was opened by a short address of welcome from Vice-President W. M. Taylor, of the Chandler & Taylor Company, Indianapolis, at the close of which Prof. R. C. Carpenter, of Sibley College, Cornell University, read a paper on "The Evolution of the Shaft Governor." This paper was an extremely interesting historical presentation of the development of this type of governor.

The discussion following the reading of the paper was almost wholly in the direction of engine regulation for the parallel operation of alternating-current generators. Mr. Rites said that while satisfactory results could not be obtained with an ordinary Corliss type of governor regulating closer than about 4 per cent, the shaft type of governor made it feasible to bring the regulation within 1 per cent without incurring hunting. Samuel G. Neiler said that his experience had been that less than 4 per cent regulation was inadvisable where alternators were direct connected to engines, and pointed out that very close regulation involved an extremely sensitive governor, which led to excessive variations in angular velocity, and this was the chief trouble in parallel work.

The next paper read was one by H. M. Norris, on "The Premium Plan of Labor Remuneration." Mr. Norris advocated the application of a bonus system to manufacturing companies. The plan consists, roughly, of paying employees the usual day wages and an additional premium for all time saved in the performance of a given operation over the time that the factory records have shown such an operation previously required; the rate at which he proposed to compensate the workman for saving in time was one-half of his wage rate. For example, if a workman saved two hours on a given piece of work, he was credited with two hours' time at one-half of his day-rate of wages. Mr. Norris cited several cases in which large reductions in the cost of given pieces of machinery had been effected by this scheme. The paper was discussed at considerable length by T. C. Wood, of the Ball & Wood Company, New York; W. M. Taylor, S. N. Bagg, of the Watertown Steam Engine Company, Watertown, N. Y.; John Dick, of the Phœnix Iron Works, and M. N. Maclaren, of the Ball & Wood Works at Elizabethport, N. J.

Following the discussion Mr. Maclaren read an interesting paper on "Shop Administration," in which he pointed out the advantage of laying out a factory plant in such a manner that future growth would not divide the plant up into several distinct shops nor change the course followed through the shops by work in process of manufacture. This paper was discussed briefly by Messrs. Dick, Gates and Taylor.

George T. Reiss, of the Niles Tool Works, Hamilton, Ohio, then read a paper on "Machine Shop Tools for Engine Builders," in which he described a number of special tools designed for the purpose of economizing both time and the labor of handling large pieces of work. The paper was illustrated by a large number of photographs and half-tone engravings. There was not a great deal of discussion of the paper presented by Mr. Reiss, for the reason that all of the delegates concurred heartily in all recommendations contained therein. The question of using grinding machines for finishing shafts was discussed to some extent by Messrs. Dick, Taylor and Wood, Mr. Reiss explaining that the best method of using a grinding machine was to reduce the amount of work done by it as far as possible, that is, to rough-turn the shaft down to within, say, 1-64 of an inch of the finished size and then grind it true.

A sound paper, full of common sense, entitled "From the Consulting Engineer's Standpoint," read by Mr. Neiler, was the closing paper of the session. Mr. Neiler briefly defined the function of the consulting engineer in this country, and pointed out the excellent work that had been accomplished by the American Society of Mechanical Engineers and the American Institute of Electrical Engineers in perfecting standards of manufacture and standardizing methods of testing. He argued that a consulting engineer should not attempt to design apparatus, but should specify machinery that could be furnished by manufacturers without undue hardship. He also pointed out that, in order to obtain the best results, manufacturers should supply, with their bids to consulting engineers, complete data regarding their engines, so that intelligent selection can be made. He criticised the practice many manufacturers follow of doing preliminary consulting engineering work for prospective purchasers without charge. Such work, he pointed out, very rarely pays, and usually has to be done over again by the manufacturer who succeeds in landing the order in such cases where an order is actually obtained by anyone. In the most of such cases, however, he said, a large amount of engineering data was given to persons who had no idea of buying the machinery concerning which they asked for information. Mr. Neiler mentioned the offer which had been made by the authorities of the coming exposition at St. Louis, to have elaborate tests made of engines exhibited there, and expressed the opinion that engine builders should take advantage of this opportunity. In the discussion which followed, Mr. Dick said that the Chicago Exposition officials had made very specious promises as to the tests that were going to be carried on, and induced a large number of engine builders to go to great expense for exhibits, but that no tests were made of which anybody had ever heard.

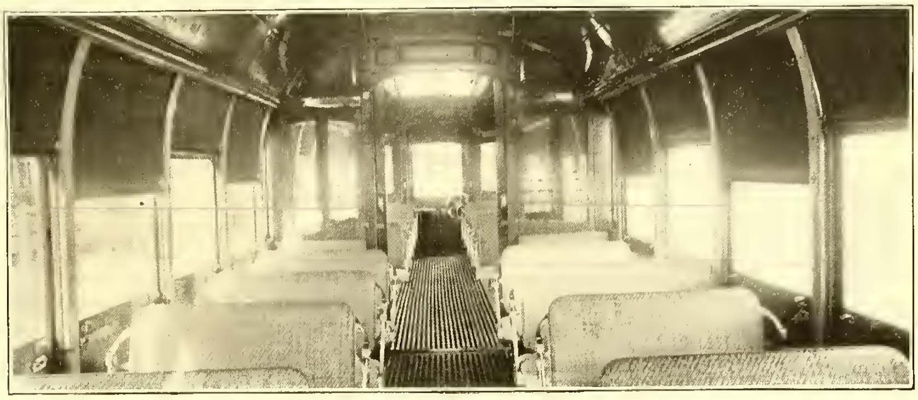
With reference to the specifications of consulting engineers, Mr Dick said that it seemed to him unreasonable for an engineer to require that an engine bought for operation at 100 lbs. pressure should be made able to stand 150 lbs. pressure, and Mr. Neiler explained that it was his practice not to make any such stipulation, except in cases where it was the intention to ultimately raise the pressure in order run the engine condensing. Mr. Wood said that a feature of consulting engineers' specifications that had always seemed unfair to him was the stipulation of a bond. He thought that the manufacturer took sufficient risk in building an engine and delivering it without having a bond from the purchaser for the settlement of the account. Mr. Neiler said that he never exacted bonds from engine builders, except where the engine was for a municipality or some State institution, in which case a bond was legally compulsory. After a unanimous and enthusiastic vote of thanks to the authors of the five papers, on motion of Mr. Gates, the session adjourned.

The Storage Battery and Electric Railways

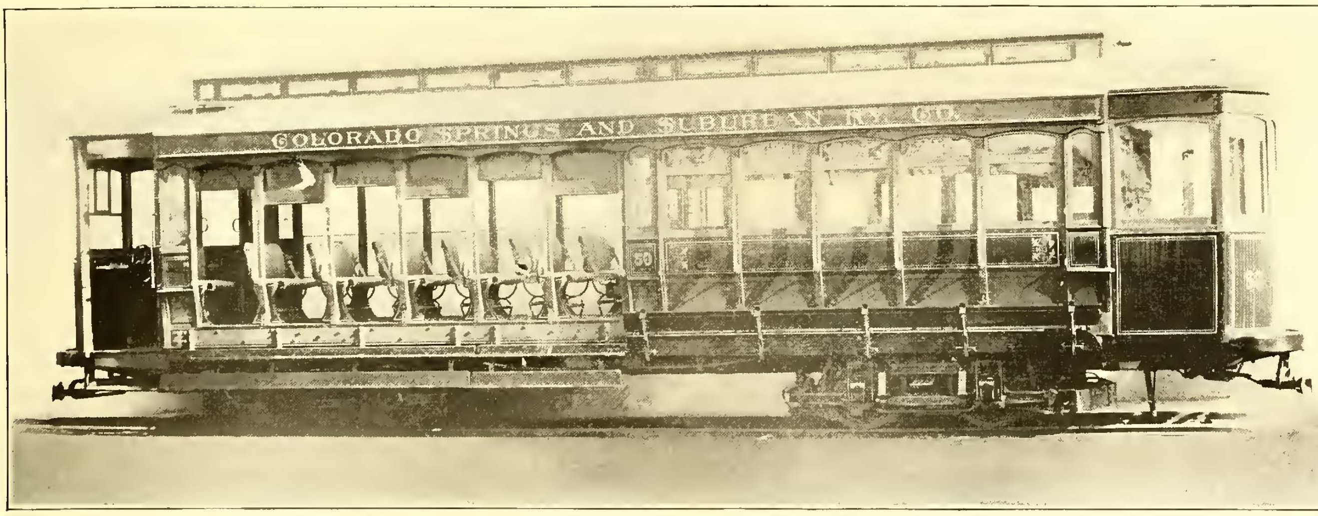
The Electric Storage Battery Company, of Philadelphia, has installed 158 batteries of "Chloride Accumulators" in street railway service for the purpose of regulation, carrying the peak during heavy traffic and for use in emergencies. These batteries, representing over 103,000 kw-hours of output, are installed in power houses, sub-stations and rotary-transformer stations, and cover every application of storage batteries in the operation of street railways. Among recent installations may be mentioned those for the Detroit United Railway, consisting of 250 cells of type 53-G; the Chicago City Railway, 250 cells of 39-G; the Southern Ohio Traction Company, 290 cells of 11-F, and the Fairmount & Clarksburg Railway, 250 cells of 11-E.

A Novel Convertible Car

The cars illustrated in the accompanying engravings have just been shipped by the J. G. Brill Company to the Colorado Springs & Suburban Railway Company. They are especially interesting because they combine a number of new and ingenious features. The car bodies are of the Brill convertible type, and are 31 ft. 8 ins. in length. The width at the sills is 6 ft. 7 ins. The first and most striking feature is the fact that the cars are divided into two compartments with sliding doors between then, one end having five posts and the other four. The division of a car of this type is a novelty. When the car is used in summer it presents the curious feature of an open car with a partition in the center. In the winter one of the compartments is used for smokers. The cars are mounted on 27-F trucks, furnished with G. E.-67 motors, and V-shaped pilots are placed on each truck. In order to give easy access to these cars an unusual feature is introduced. The steps are double, bringing the lower one within easy reach of the ground, but in order to get them out of the way when the car is closed, the double step is made to fold, as is shown at the right-hand side of the engraving of the outside of the car. Owing to the great length, these steps are cut into three sections. The placing of a partition in the center is taken advantage of to introduce a solid panel similar to those which are always placed at the ends of a convertible car. The wheels are 33 ins. in diameter with 2½-in. tread and ¾-in. flanges. The seats are of the reversible back pattern, covered with spring cane, the arrangement of the car giving four seats with stationary backs. The cars have Brill's patented angle iron bumpers, ash grip-handles in malleable iron sockets, and they are also fitted with Brill entrance guards between the posts. There are two Dedenda gongs to each car. The brake furnished is the Sterling, but it will be noted that in order to save space a vertical hand wheel is used. Christensen air brakes are also installed. The inside of the vestibule is paneled in oak, in fact the whole inside, including the ceiling, is given in natural finish. These vestibules are fitted with removable doors, making a complete enclosure for the winter season. Eight heaters are placed in each car with the necessary controlling devices. The cars are wired for eight lights inside, staggered on the lower advertising molding, four on each side of the car, with a single light in each roof-sign and an electric arc headlight arranged so that the front and rear platform light burn at the same time. Push buttons are placed flush on each post, connected with a bell on each platform. One feature characteristic of steam railroad practice is introduced in the shape of a tool box underneath the car floor. It is 2 ft. 6 ins. long by 12 ins. by 16 ins. In view of the fact that these cars are likely to reach steam road practice in the matter of speed with the accompanying possibility of derailment, a tool box is not such an unnecessary part of the equipment. It is expected that the steps at the vestibule only will be used about nine months in the year, during which time the other long side ones will be removed. One peculiar feature of this order was that the cars were knocked down and boxed for shipment, while the trucks were shipped whole with motors mounted upon them. The service for which these cars are intended is not an altogether easy one, presenting many sharp curves. That of shortest radius is but 34 ft., making it necessary for the trucks to take a very sharp angle with the body in rounding it.



INTERIOR OF CONVERTIBLE CAR WITH PARTITION



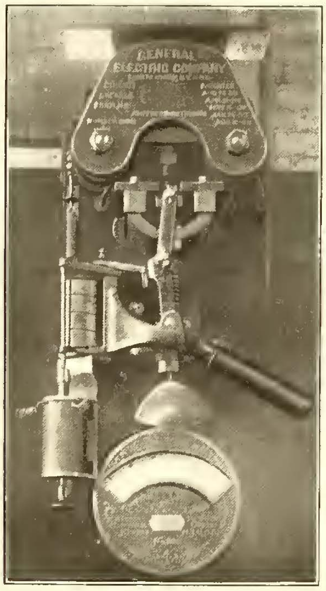
NOVEL CONVERTIBLE CAR PARTLY OPEN

A New Duplicating Apparatus

The use of an efficient duplicator is as necessary in the offices of street railway companies as elsewhere. The systematization of clerical work has been reduced to a fine art by up-to-date managers in this as in other industries, and any improvement in labor-saving devices is immediately investigated. The Felix F. Daus Duplicator Company, of New York, has recently perfected a novel machine of this kind which will make from 100 to 150 distinct copies of an original writing, and has named it the "Tip Top" Duplicator. The operation is performed without the use of stencils or rollers and is claimed to be the cleanest and most reliable yet obtained. The apparatus consists of a neat box containing a copying pad the surface of which is a section of a long strip of prepared paper. This "negative" paper is rolled on cylinders at each end of the pad so as to be readily changed, and, as an impression will entirely disappear in a few days, it may be used over and over again. The motion of the cylinders containing the material is automatic, so that the operation of changing the face of the pad is easily performed, no matter in what direction it is desired to move the band of copying paper. By the use of specially-treated typewriter ribbon duplicates of work done by the machine can also be made. As most of the reports, notices, statements, etc., which it would be of convenience to a railroad company to have copied, are now typewritten, this is an important feature.

An Automatic Circuit Breaker Trip

One of the most disastrous accidents to a dynamo in a railway power plant is the shutting down of the engine without first cutting out the generator from the circuit. This, of course, seldom happens intentionally, as an engineer who would close his throttle before opening his switches would probably be requested to seek other employment, but where automatic engine stops are installed there is more danger from this source. The accompanying engraving shows an attachment which can be placed on the circuit breaker to entirely obviate the liability of thus short-circuiting the generator. It is known as the Reliance Circuit-Breaker Tripper, and is made by the Reliance Manufacturing Company,, of Brockton Mass., which also manufactures the Valentine automatic block signals and other efficient accident-preventing devices.



CIRCUIT BREAKER TRIP

The illustration shows the general arrangement of the tripper. All that is necessary, to attach it to a G. E. K.-type circuit breaker, is to take off the nut from the lower end of the existing tripping-magnet bar, slip on the device and replace the nut. One wire is then run to a suitable contact, through which the circuit is closed the instant the automatic engine stop is brought into play, or if desired, the tripper can be operated by a contact placed on the governor, or on the stem of the throttle valve. Station current is used to operate the apparatus. Switches can be located at any desired point to operate the tripper by hand. The tripper can be attached to any kind or type of circuit breaker. It is also used successfully on several large roads as a booster protector.

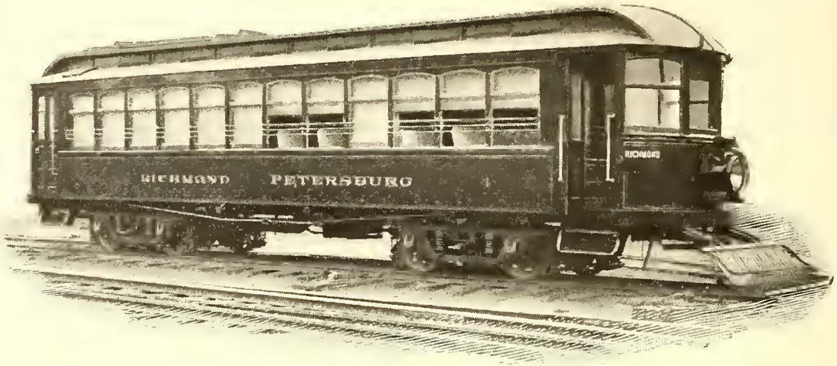
New Cars for Richmond, Va.

The accompanying illustrations show views of a handsome car recently shipped by the Jackson & Sharp Works of the American Car & Foundry Company, at Wilmington, Del. This car is one of an order placed by the Cleveland Construction Company, of Akron, Ohio, for equipping its new road between Richmond and Petersburg, Va. The order includes five other passenger cars like the one herewith illustrated, two combination passenger and baggage cars, and a work car, all equipped with trucks of the M. C. B. pattern.

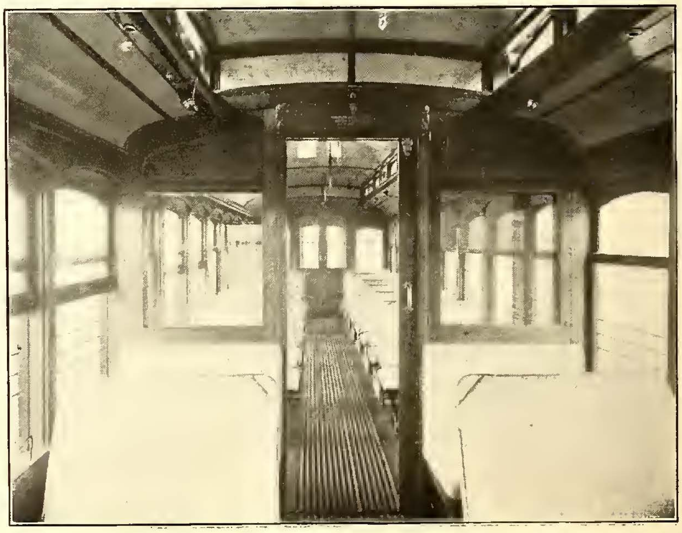
As will be seen from the engravings, these cars contain some interesting and novel features. The ends are of peculiar construction, the view of the exterior showing the front. It is intended to run the car only in one direction all the time, and loops are provided in Richmond and Petersburg for this purpose. Entrances are provided on both sides of the rear vestibule, but at the front end only one opening is left, that on the right-hand side. The cars have twelve windows on each side. They are 34 ft. 4 ins. long in frame, with 4-ft. 7-in. platforms at each end, making the length over vestibules 43 ft. 6 ins., and over bumpers 44 ft. 7 ins. They are 8 ft. 3 ins. wide over sills, and 8 ft. 4 ins. over siding, which gives a 33-in. seat each side, and a 22½-in. aisle. The underframes are especially strong. The two outside sills are of yellow pine 4½ ins. x 7½ ins., and plated with ½ in. x 7½-in. steel plates, with an additional sill of 2½ ins. x 5¼ ins. bolted through the iron plates and outside sill. The two center sills are 4 ins. x 5¾ ins. yellow pine, running from bumper to bumper, and plated on each side with 5-in. x ½-in. steel plates. Two tie-rods of ⅞-in. round iron are placed on the inside of these center sills, and go from bumper to bumper, running over the bolster and directly under the car floor, which is double, building felt being placed between the two floors. The platforms are supported with two 4-in. x 5-in. T-irons in addition to the center sills. On account of this construction, the platform floor is level with the car floor, thus making it necessary to use double steps, which are of the Stanwood type.

The vestibules are fitted with doors as well as gates, and either can be used. The doors are placed out flush with the side of the car, and the steps are covered with trap doors, the same as in steam railroad equipment. The cars are provided with upper and lower sash, fitted with polished plate glass. The top sash are fixed permanently, while the lower sash are made to raise, the same as in steam cars. Although these cars are somewhat lower than the standard cars on account of overhead bridges at Richmond, yet the sash raises 22 ins., which gives a very good opening.

The interior is finished in quartered oak in a neat design, with carvings and fluted pilasters between each window. The car is divided between the fourth and fifth window by a cross bulkhead, giving a large and roomy smoking compartment, seating sixteen persons. The seating capacity in the passenger room is thirty-two, making forty-eight in all. The seats are of the Wheeler Walkover pattern, made by the Heywood Brothers and Wakefield Company, fitted with bronze grab handles on the corners. Under every other seat is placed an electric heater, supplied by the Consolidated Car Heating Company, thus insuring a well heated car even in the coldest weather. The cars are also provided with Providence fenders, made by the Consolidated Car Fender Company, registers with rod-ringing device, trolley catchers and Christensen air brakes. The trucks are of the steam railway pattern, as will be noticed from the engravings, and they were also made, as stated above, by the American Car & Foundry Company, at its Jackson & Sharp Works. Four 30-hp Westinghouse motors are used, one on each axle, which are 4½ ins. diameter.



HANDSOME LONG CAR FOR RICHMOND, VA.



INTERIOR OF RICHMOND CAR

The combination cars are of the same general style as the passenger cars, with the space which is used for smokers made into a baggage compartment. The work car is 30 ft. in frame, 40 ft. over all, and is fitted with M. C. B. couplers and mounted on extra heavy trucks of the same make as the passenger car trucks. These cars are fitted with four 50-hp Westinghouse motors, Christensen air brakes, etc. The entire equipment of rolling stock represents the most up-to-date practice, and is probably the finest yet shipped to this portion of the South.

A New Fender in Toronto

The accompanying illustrations show two views of the "Twentieth Century Fender," as applied to the cars of the Toronto Railway Company, Toronto, Ont. After a thorough trial, this company has recently contracted with the manufacturer, W. T. Watson, of New York, for the equipment of its entire system with the "Twentieth Century Fender." This fender was described some months ago in these columns, and it will be remembered that it contains many points of usefulness as a life saver and is claimed to possess great durability. Its peculiar construction renders it particularly easy to take to pieces, and the perfect interchangeability of its parts provides for its economical repair in case of damage, although the resiliency of its spring construction and its flexibility prevent it from being seriously injured when coming in contact with obstructions on the track or in collision with vehicles. The fender is easily detachable and its fastenings to the car simple. One of the ingenious features of the device is an attachment by which the fender can be run at any predetermined height from the roadbed. This enables the fender to be lowered within half

TWO VIEWS OF THE FENDER

an inch of the track when passing through congested districts and relieves the motorman of much responsibility; while upon the resumption of high speed, as the car approaches the suburbs, the fender can be raised to its normal height by a foot device without delay or the motorman leaving his position.

An Efficient System of Railway Generators

The Bullock Electric Manufacturing Company, of Cincinnati, Ohio, is making a line of railway generators that contains many features of excellence. The accompanying engravings show a 1000-kw complete machine, and a 200-kw armature. The frames of the generators are divided horizontally, and are elliptical in section, with pole seats projecting sufficiently to allow of machining to provide for a perfect magnetic point between yoke and pole. The pole pieces are made from thin annealed sheet steel having high magnetic permeability. The form of punching somewhat resembles a letter "T," having one-half of the upper line cut away. They are assembled with each alternate sheet turned so that the formation of the pole is a perfect "T," but owing to its peculiar formation, the pole is slotted to a depth of about ½ inch across its entire face. The effect of this is a more perfect distribution of magnetism in the air-gap, resulting in a fixed point of commutation and sparkless operation at all loads.

The shunt and series coils are separately wound. The former is in each case wound upon a built spool of press and fuller boards. After winding, the exterior of the spool and coil is covered over with cotton tape and finished by an exterior winding of "Sampson" cord which is varnished with shellac, thus giving a handsome appearance. The series coil is of copper strip insulated with cotton and similarly treated. By winding the coils separately, better radiation is secured, and the ample carrying capacity and good ventilation guarantee a low-running temperature under constant load.

The armature coils are all bar-wound. Copper strip is forced into a cast-iron mold of the proper form for the coil, the coil

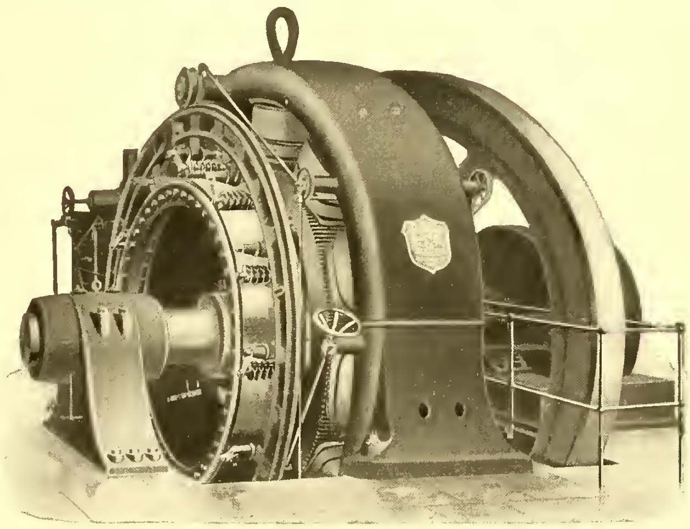


FIG. 1.—1000-KW ENGINE-TYPE RAILWAY GENERATOR

consisting of two or more convolutions, according to requirements. After being thus formed each convolution of the coil is wrapped throughout with cotton tape, and the several convolutions are then grouped and the ends or exterior portions are again wrapped with tape, forming the unit winding. After being thus far completed, the coils are dipped in insulating varnish and placed in the drying oven. When the drying process is complete the active portion of the coil, or that part imbedded in the armature core, is covered with several thicknesses of red-rope paper, "Empire" paper, India mica, and an outside covering of "Fish" paper, each layer being treated with shellac. The coil is then put into a steam-heated press and assumes a rectangular form of the exact dimensions of the core slot. It remains in the press under heat until all surplus insulating varnish and shellac has been driven out, and while still under pressure the coil is cooled. Fig. 2 shows a partly-wound coil of a 200-kw belt-driven generator.

The commutator bars are standardized, thus facilitating repairs when necessary. The mica used is of a special quality, and in service wears uniformly with the copper and adds materially to

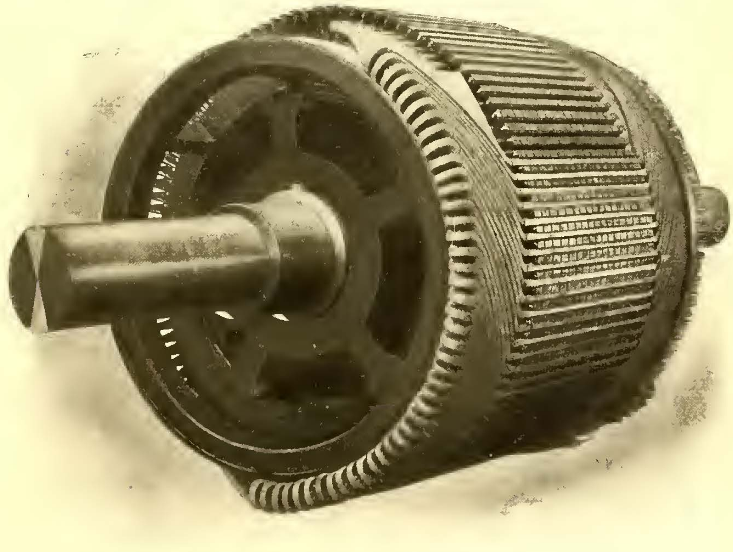


FIG. 2—PARTLY WOUND ARMATURE OF 200-KW GENERATOR

the life of the same. The bars are well insulated from the shell. Ample brush service has been provided to care for current to be carried and brush friction without undue heating.

The armature core is built from laminations of thin sheet steel mounted upon a spider of cast iron. The ends of the arms are of a dovetail formation, carefully machined for an exact fit, and engage slots on the inner periphery of the core. The slots for the windings have parallel sides with grooves near the top into which the coil-retaining wedges are driven. These wedges obviate the use of band wires, and protect the coil from mechanical injury. Thus should a bearing run hot and melt out, the windings would not be injured by contact with the poles. No band wires are used.

The brush holder is very simple in design, and of the reaction type. A dovetail groove is cut in its face, in which a projecting screw head from the brush engages. This prevents the brush from jarring out or swinging away from the holder when the tension finger is raised. Carbon brushes of rectangular section and beveled ends for tangential contact are used. Flexible leads connect the brushes with the holder, furnishing a direct path for the current.

A heavy cast-iron ring is mounted upon three trunnions supported by the yoke. Internally-projecting arms carry the brush studs. Brush studs of like polarity are connected to copper cross connectors, mounted between the yoke and brush ring. These connectors are wound with "Sampson" cord and connected by leads to the terminal board. On engine-type machines of 200 kilowatts and above there is a brush-shifting mechanism for shifting the brushes latterly. This movement is similar to the end play in belted machines, and obviates any tendency of the brushes to groove or cut the commutator.

The design of these machines permits a large air-gap. Operation, however, is not seriously interfered with, even with quite a large displacement of the armature, and no material change in the magnetic pull on the armature occurs with such displacement. The generators will run perfectly in multiple with other similar machines. They are so designed that they will take their proportion of the load under all variations. Great care is taken to have the mechanical and electrical balance of the machines perfect. The standard for insulation is based upon the specifications adopted by the American Institute of Electrical Engineers. Besides making the above-described generators, the Bullock Company is prepared to furnish all accessories for the complete installation of power plants, including switchboards, boosters, etc., and the same care in design and manufacture marks all of its apparatus.

New Publications

Shop and Road Testing of Dynamos and Motors. By Eugene C. Parham, M. E., and John C. Shedd, Ph.D. 641 pages. Illustrated. Price, $2.50. Published by the *Electrical World and Engineer,* New York, 1901.

This is the second edition of a book which met with considerable success in its original form. As is customary with books for which a demand for a second edition is created, the present volume has been considerably enlarged, and such typographical errors as were present in the first edition have been carefully eliminated. Considerable space is given to the elementary principles of electricity as related to the dynamo and testing instruments, but a large amount of valuable and practical information is found in the remaining chapters. Chapters 15 and 16, on street railway equipment tests, which appear for the first time in this edition, form a valuable supplement to the original book. An amount of useful tabulated data precedes the well-arranged index, and the general mechanical features of the volume are of a high order.

Poor's Manual of Railroads. 1840 pages. 24 maps. Price $10. Published by H. V. and H. W. Poor, New York, 1901.

Poor's Manual is too well known among financiers and railway officials to need a detailed review of its aims and applications. The volume for this year contains the usual amount of important data and statistical information, which has made the work a valuable book of reference and one which ranks among the highest authorities on railroad matters. The statements presented in the present number of the Manual are arranged in four sections. The first (pages 1 to 861) comprises the statements of all the steam railroads in the United States and Canada and the chief ones in Mexico; the second (pages 863 to 1083) comprises the statements of all the street railway and traction companies in the United States; the third (pages 1084 to 1177) contains statements of the leading industrial corporations and organizations auxiliary to the railway interests, and the fourth (pages 1179 to 1320) contains statements showing the finances and resources of the United States, the several States separately, and the chief counties, cities and towns of the country. Information received too late to be inserted in its logical position in the text is included in an extensive department set aside under the heading "Postscript and Addenda," which brings the matter strictly up to date.

Moody's Manual of Corporation Securities. 1522 pages. Price, $7.50. Published by John Moody & Company, New York, 1901.

This is the second annual number of the reference book, which received so cordial a reception last year. A compilation in a convenient form of the various facts and figures of interest to the financial world is always greeted with a greater degree of criticism than is ordinarily accorded to publications, but this volume seems to have stood the test, and appears in a greatly improved form some two months earlier than the 1900 issue. The book is divided into thirteen sections. The first gives the names of the members of the stock exchanges in the principal cities, financial institutions, American and foreign government securities, and other financial statistics. The second section is devoted to financial statistics of electric railway, gas and electric light companies. The third section contains statistics in regard to industrial companies, the fourth to manufacturing companies, etc. A great deal of the matter published in the book cannot be found elsewhere, and consequently is of great value.

Compressed Air, Its production, Uses and Applications. By Gardiner D. Hiscox, M. E. 822 pages. Illustrated. Price, cloth, $5; half morocco, $6.50. Published by Norman W. Henley & Company, New York, 1901.

The author of this book is well known in technical literature from the many useful volumes which have appeared under his name, but in "Compressed Air" he has surpassed, if possible, his previous efforts in making a thoroughly complete and up-to-date collection of the various devices and machines relating to his subject. As in his former works, he has produced a book which is more of a compilation of previously published matter than one which contains many new ideas, but through the co-operation of many authorities in both the purely scientific and manufacturing side of the business, he has obtained access to a larger variety of material than has ever before been attempted in dealing with the subject of pneumatics. Although the title is "Compressed Air," the principles of liquid air, vacuums, windmills, kites, etc., are also treated, and the theory and application of thermo-dynamics are explained at considerable length. The main feature of the book is the applications of compressed air as a motive power in the operation of stationary and portable tools and machinery and the propulsion of vehicles. Altogether the book will prove very useful to the worker, and with its forty air tables and 545 illustrations, makes a most comprehensive manual for both study and reference.

Electrical Engineer's Pocket Book. By Horatio A. Foster. 995 pages. Illustrated. Price $5. Published by D. Van Nostrand Company, New York, 1901.

While most of the other branches of engineering have been thoroughly covered by various hand books, that devoted to all applications of electricity has never before been treated in its entirety between two covers. This pocket book is the first to attempt, in a satisfactory form and in a degree of completeness at all commensurate with the subject, the compilation of the tables, facts, figures and methods directly related to electrical engineering. The practical man who realizes the usefulness of a practical book will find much of value in its pages, and the author has succeeded in producing a work that appeals as strongly to the man of moderate education as to the expert engineer. In its preparation the co-operation and assistance was obtained of many authorities in the profession, and a large number of the more important sections were revised by men of high reputation. The main object in a volume of this kind is not so much to create anything new as to place before the reader in the most concise form all the information he is likely to require. The vast amount of technical literature that has been published on electricity renders it harder to obtain the most satisfactory reference to any one division, so that for this reason alone an up-to-date hand book on the subject has, for some time, been needed. In the 125 pages devoted to street railways but little which relates to the electrical features of the line and rolling stock escapes mention, portions being treated in great detail, as in the description of the multiple-unit system of train control, by Frank J. Sprague, reprinted from the Street Railway Journal. It would be unreasonable to expect the first edition of a book largely made up of tables, formulæ and abstracted data to appear flawless in regard to typographical or other errors, but such as have slipped in are, in most cases, of a purely mechanical and not misleading nature. The author and publishers are to be complimented on the arrangement and general make-up of the book and the excellence of its index, upon which its utility is so largely dependent.

NEWS OF THE WEEK

To Tax Rhode Island Companies

There has been introduced in the General Assembly of Rhode Island an act to provide for levying a tax upon the street railways of that State. The new measure provides that every street railway company shall make and file with the general treasurer, at the time of making payment of the State tax provided, a certificate, signed and sworn to by its treasurer or other officer designated by its board of directors, setting forth the gross earnings of the company and the amount of any dividend paid by it during the year ending on the 30th day of June next preceding the date of such payment, and showing the manner in which the tax paid at the time is computed. If any company shall neglect to make or file the certificate required, it is to become liable to a fine of $25 for each day after the allotted period.

Only One New York-Brooklyn Tunnel

The applications of the New York & Brooklyn Union Transportation Company and the New York, Brooklyn & Jersey City Rapid Transit Company to construct and operate railroads through proposed tunnels under the East River from Manhattan to Brooklyn, New York City, have been denied by the Railroad Commissioners of New York. The reason assigned for denying the applications is that the construction of a tunnel other than that to be built by the city would seriously interfere with the latter project. The New York-Brooklyn tunnel to be built by the city, as previously announced, will simply be a continuation of the present tunnel now under construction in New York. The tunnel, from South Ferry to Joralemon Street, Brooklyn, or the part under the river, will be, roughly, 4000 ft. long. A series of about forty "wash borings" have already been made to determine the character of the soft material on bottom and the depth at which bed rock is reached. These are to be supplemented by seven equidistant borings into the bed rock itself. These will be alternately slightly to the north and to the south of the route, so that they will not penetrate the rock that is to be its roof. Thus far, beginning at the Brooklyn side, the first four have been completed. The fifth has twice been begun and twice interrupted by accident.

The Franchise Tax Question

Street railway men throughout the entire country are certainly greatly interested in the outcome of the franchise questions that are now agitating Illinois, Ohio, New York and New Jersey. In the latter States it will probably be some time before anything of more than passing interest occurs, but in the cases of Illinois and Ohio there have just been handed down two very important rulings. The franchise tax case in Illinois has absorbed most of the attention recently, because of the multiplicity of moves and counter moves made by the litigants, culminating, Nov. 19, in the dissolution of the temporary injunction which had been secured by the Chicago Union Traction Company and the Consolidated Traction Company, of Chicago, to restrain the State Board of Equalization from assesssing the capital stock of the companies. Interest in the Ohio situation is stimulated because of the prominent part played by Mayor Tom L. Johnson, of Cleveland, the former street railway magnate, and the decision of the Supreme Court of Ohio last week to grant Mayor Johnson leave to file a petition asking the court to determine the powers of the State Board of Equalization is important. The plan of Mr. Johnson, like that in the Illinois case, is to have the State Board of Equalization reassess the properties of the railway companies on the basis of the market value of their securities. The final decision of the court in regard to the exact powers of the State Board is awaited with much interest. A further hearing on the franchise litigation in New York is to be held Dec. 6, and it has been further decided that the closing arguments be made by the attorneys for the State and for the corporations on Jan. 2 and 3. In the New Jersey tax case the Court of Errors and Appeals, at Trenton, is now hearing argument on the appeal taken by the North Jersey Street Railway Company, of Jersey City, from the decision of the Supreme Court, concerning the assessment made for taxes of 1900 against the company by the tax board of the city of Newark. The city appealed to the Supreme Court, and that body rendered judgment in favor of Newark, upholding that city's contention that rights of way in public thoroughfares were easements, and as such constituted real property and were taxable as such. Newark assessed the corporation's property in that city at $3,100,000, and this the State Board of Taxation subsequently reduced to $2,264,000. The final decision, which it is expected will be rendered in a month, is anxiously awaited.

"Hold Ups" Not Tolerated

The Everett-Moore syndicate is nothing if not independent in handling villages and towns which attempt to play "a hold-up game" when franchises or rights of way are being secured. The town of Geneva recently demanded exorbitant terms for a franchise through the main street, with the result that the extension of the Cleveland, Painesville & Eastern Railway is now being built half a mile south of the business portion of the town. It is believed that while this move will detract but little from the business of the road, it will force the citizens of the unreasonable town to walk a good distance when they might have had the cars pass their doors. The same tactics are being carried on by the citizens of Massillon. For several months past the syndicate has been endeavoring to secure right of way over either one of the main streets for its proposed direct line from Akron to Massillon. Repeated attempts to secure fair terms have failed, and there is now little chance that the direct Akron-Massillon line will be built. The work which has been done on the line will be stopped, and the road deviated to Turkeyfoot Lake, a fine summer resort. In all probability the deal for the purchase of the Canton-Massillon Railway will be completed within a few days, and citizens of Massillon who desire to go to Akron or Cleveland will be forced to travel by way of Canton. Many are the suburban railway projects that have been abandoned because one or two towns along the route of the line positively refuse to grant concessions that permit their acceptance by the company building the line.

The Scranton Strike

Strenuous efforts are now being made by a committee of citizens of Scranton, Pa., to bring about a settlement of the strike, and the general belief is that a settlement shortly will be effected. The committee, headed by a prominent lawyer, has had several conferences with General Manager Silliman, of the Scranton Railway Company, and the strikers' executive board. The one question that cannot be settled without liberal concession, however, is that regarding the retention in the service of the company of the many men who have been secured from outside sources to take the place of the strikers. Mr. Silliman stoutly maintains that he cannot discharge the men who were secured to take the places of the strikers. The strikers also wish to have the union recognized, but the company will probably not concede this point. The men will, however, be taken back as individuals. The strike was declared Oct. 1, and has been far more disastrous than the short strike of last December, business being completely demoralized and the city being in a general state of chaos. The situation, as far as the business interests of the city are concerned, is desperate. The stores are stocked with Christmas goods which cannot be sold, and many of the mercantile establishments are practically deserted at a season when they should be thronged with customers. Goods which ordinarily would be reposing on shelves are placed out on the sidewalk in order to attract the attention of the public. One of the jewelers has stopped his street clock, and over it he has placed the legend, "Union clock; will not run until the strike is settled." The company is operating its cars regularly, but very few passengers are carried. Scranton, in the heart of the coal regions, is "unionized," there being no less than 100,000 union workingmen in the vicinity of the city. The strikers have inaugurated a hack service, which is liberally patronized. The strike, as previously stated, resulted from the discharge early last September of two conductors—one for failing to collect and register all the fares on his car, the other for issuing more transfers than he had passengers on his car. The company, in the hope of avoiding a strike, agreed to submit to a prominent bishop the question of re-instatement of the discharged employees, but the offer of mediation was refused. The strike would be broken at once if the people were to patronize the cars, but personal convictions are laid aside because of the fear of the labor unions, which have threatened a boycott.

To Relieve the Crush at the Brooklyn Bridge

Chief Engineer C. C. Martin's report on the plans to relieve the congestion of passenger traffic at the Manhattan terminal of the Brooklyn Bridge has just been handed to Bridge Commissioner Shea, who has approved it and will submit it for further action at the next meeting of the Board of Estimate and Apportionment.

Engineer Martin condemns the proposal of the board of expert engineers to build a crosstown elevated road along Park Row, crossing Broadway, running down Vesey Street and thence to the Pennsylvania Railroad. Touching on this feature, the report, which estimates the total cost of the improvemnet at $2,862,300, he says:

You will note that the Board says, with regard to this plan:

We regard the Vesey Street line as very important, and it is strongly recommended, but it is independent of the Centre Street line, and its omission would not affect the other improvements recommended.

I would recommend that the Vesey Street line be omitted. If it were constructed and trains were run on a headway that would be at all satisfactory on that line and on the Centre Street line at the same time there would be a series of grade crossings with loaded trains where the two lines came together, which in my judgment could not be permitted if the safety of passengers were to be considered.

If the Centre Street and Vesey Street lines were built the connections at the Bridge terminals would be so complicated that it would be impossible to retain the present tail switching tracks, and this I consider vitally important. It is proposed to run through trains on forty-five seconds' headway; I do not think this is practicable or possible, and hence I desire to retain the tail switching system, so that if at any time through trains cannot be run on the specified headway they can be supplemented by local Bridge trains, as is now done during the evening rush, and in case of an entire blockade of through trains on the elevated roads connecting with the Bridge, the entire traffic could be taken care of by local Bridge trains.

The report favors a system of elevated railroads designed eventually to form an endless track over which trains will circle across all of the new bridges now proposed south of Delancey Street. The principle is the one suggested by the board of expert engineers appointed under the laws of this year, to look into the problem how to relieve the evil, and it is practically to distribute the taking-on places of the passengers over a wide area rather than to permit them to jam and crowd in a single spot, as is now the case at the bridge entrance.

Commenting on the recommendation of the board of experts and the system of elevated roads, the chief engineer says:

In this recommendation of the Board I concur. There is no possible temporary arrangement that has yet been suggested that will relieve the congestion at the New York terminal, and relief can be had only by the completion of the other bridges and the execution of the plans approved above (the elevated road plans).

Subject to the sanction of the Board of Estimate and Apportionment, the following are the new lines of elevated railroads that will be built at an early date:

An elevated structure from the Park Row end of the bridge to run up Centre Street, up Marion Street to Spring Street, through Spring Street to Delancey Street, and to the Manhattan end of the new East River Bridge, which already spans the stream. As soon as the new bridge at the foot of Canal Street has been completed it is further recommended that a branch be built running from a station on Canal Street of the proposed new road, down Canal Street to connect with Bridge No. 3, not yet begun.

On Centre Street, just north of Worth Street, it is recommended that a commodious new station for the taking on of passengers be built, and also that here be installed sidings and switches for tail-switching and returning trains.

As recommended by Mr. Martin, the new road will run through Grand Street up and beyond the Second Avenue trains, so that connection could be made by stations with both the Second and Third Avenue Elevated Railroads. Commenting on this arrangement, the report says:

As soon as that portion of the proposed elevated road is built from the existing Bridge terminal, through Centre Street and through Grand Street, up to and beyond the Second Avenue Elevated Railroad (on Allen Street) an immediate relief to the congestion at the Manhattan terminal of the Bridge Railway will be obtained, because passengers on their way to the present Bridge by way of the Second and Third Avenue elevated railways will transfer at the Grand Street stations to trains that will approach the Bridge on the Centre Street extension of he Bridge Railway.

Again, the proposed stations at Worth, Canal and Grand Streets will be used by the people who come from points west of Centre Street and north of Duane Street, who now go to the present Bridge terminal. Those stations will be nearer to them than the Bridge station, and by taking at that point the cars that will pass over the Bridge they would avoid the crush at the Bridge entrance.

Another alteration recommended in the report is to convert the present gallery floor into a trolley terminal, each track to be connected with a separate stairway, thus preventing the present necessity of crossing tracks at the risk of life and limb.

Further recommendations are that a commodious entrance stairway be built at Rose Street to accommodate a small army of passengers working in that vicinity. Also, the present stairway leading from William Street to the first floor of the terminal is to be widened, its present capacity being inadequate. The proposal that a curb be built separating the roadway from the trolley track the entire length of the bridge, in order to give the trolley cars a clear track, Mr. Martin does not favor. It would practically destroy the value of the roadway, he says, inasmuch as no vehicle could pass another and any sort of a serious accident to any wagon or carriage would block the entire traffic.

The report of the expert engineers was published in full in the STREET RAILWAY JOURNAL some weeks ago.

PERSONAL MENTION

MR. NELSON GRAYBURN, formerly of Montreal, and more recently of Paris, France, has been appointed general manager of the electric street railway system of Alexandria, Egypt.

MR. C. M. CUBBISON, assistant superintendent of the Indiana Railway Company, of South Bend, Ind., has resigned from the company. Mr. Cubbison will enjoy a short vacation, but has matured no definite plans for the future.

MR. GEORGE H. WALBRIDGE, vice-president of J. G. White & Company, has returned from a trip to Porto Rico, where he has been inspecting the electrical equipment of the San Juan Electric Tramways, in which his firm is interested. Mr. Walbridge, while in Porto Rico, made quite a tour of the island.

MR. W. W. BORMAN, of Robert W. Blackwell & Company, sailed for London on Nov. 30, and will in the future be connected with the London office of Robert W. Blackwell & Company. The New York office of this well-known firm will be in charge of Mr. S. Seymour Follwell, who has been connected for some time with the office in that city.

COL. JOHN N. PARTRIDGE, formerly president of the Brooklyn City & Newtown Railroad, of Brooklyn, N. Y., which is now merged with the Coney Island & Brooklyn Railroad, has been selected by Mayor-elect Low as Police Commissioner of New York. Col. Partridge served for more than three years in the Union Army during the civil war, rising from first lieutenant to captain in a regiment of Massachusetts volunteers. A few years later he became lieutenant of a company in the Twenty-third (Brooklyn) Regiment of the National Guard of New York State, and was promoted by successive steps to the colonelcy. His military training has made him "a master of men," for while in every position he has held he maintained a high standard of efficiency, he, by his deliberate and careful judgment, steadfastness of will and equitable treatment of those with whom he was associated, won the respect and regard of all.

MR. ARTHUR W. SOPER, president of the Pintsch Compressing Company, Safety Car Heating & Lighting Company, and a prominent figure in many corporations, clubs and other organizations, is dead. Mr. Soper had suffered from a complication of stomach troubles, which took an acute turn on Nov. 27, and he died on Sunday, Dec. 1. Mr. Soper was born in Rome, N. Y., July 16, 1838, being the eldest son of Albert and Esther Soper. He was educated in the Rome Academy. When seventeen years old he entered his father's lumber business, but in 1858 left his father to enter the freight offices of the Rome, Watertown & Ogdensburg Railroad. His advancement was rapid, and in 1871 he left the assistant superintendency of the Rome, Watertown & Ogdensburg Railroad to accept a similar position with the St. Louis, Iron Mountain & Southern Railroad. Within a year after accepting this position he became superintendent, and later general superintendent, and then general manager. In conjunction with George M. Pullman, Sidney Dillon and others, Mr. Soper organized the Pintsch Compressing Company and the Safety Car Heating & Lighting Company.

CONSTRUCTION NOTES

SAN FRANCISCO, CAL.—The Market Street Railway Company has commenced the work of reconstructing and equipping with electricity that portion of its Sacramento Street cable line west of Central Avenue.

OAKLAND, CAL.—The Oakland Transit Company is taking active steps toward rebuilding and doubling the capacity of its Elmhurst electric power station, which was wrecked recently by a boiler explosion. One boiler, which was uninjured, and a portion of the generating machinery, will soon be in operation again. Current for the lines that were supplied from the power station is at present being secured from the Bay Counties Power Company.