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Changes of advertising copy should reach this office by 10 a. m. Monday preceding the date of publication, except the first issue of the month, for which changes of copy should be received two weeks prior to publication date. New advertisements for any issue will be accepted up to noon of Tuesday for the paper dated the following Saturday.

Of this issue of the Street Railway Journal 8000 copies are printed. Total circulation for 1905 to date, 319,750 copies, an average of 8204 copies per week.

The Philadelphia Convention

As this paper goes to press, four days of the Philadelphia convention have been completed, and the Accountants are holding their final sessions. In this issue we are presenting a complete report of the events of the first four days, together with an account of the proceedings and technical discussion at the meetings of the Mechanical & Electrical Association and of the American Street Railway Association up to Thursday noon, and all of the papers and reports presented at the meetings of those two bodies. In next week's issue a report will be given of the session of the parent association on Thursday afternoon, an account of the meetings of the Accountants' Association on Sept. 28, 29 and 30, a description of the exhibits at the convention and the Question-Box of the American Railway Mechanical & Electrical Association.

The results of the Philadelphia convention were so successful in every respect that we feel confident that every member will look back upon them with satisfaction. In the Mechanical convention, which was the first held, the papers and reports were more complete and extended than any which have ever been previously presented, and they reflect great credit upon the authors, as well as upon the association. The same remark is true of the discussion, which was taken up by the different members with an interest and zest which holds forth a great deal of promise for future meetings of this important body. The principal topics considered were those relating to power stations, track work and controlling apparatus. Our space in this issue makes it possible to comment editorially only on the track papers and on two of the power-station papers, but we expect in an early issue to discuss the facts which were brought out in other portions of the discussion.

The principal feature of the American Street Railway Convention was, of course, the adoption of the new constitution and by-laws by practically a unanimous vote. Previous to the convention, the executive committee considered very carefully all of the objections which had been offered to the proposed constitution. It was found upon examination that these criticisms did not relate to the main features of the proposed plan, but to minor details. A conference, at which all of the associations were represented, was held and a unanimous agreement was reached, and the approved constitution and by-laws, with the changes made since the publication of the constitution in our issue of Sept. 2, appear elsewhere in this issue. The unanimity with which the new constitution was generally received, and which was displayed on the final vote, must have been exceedingly gratifying to the officers and members of the executive committees of the various associations, who have given so much consideration and time to it during the last year.

The re-election of President Ely for a third term was a move which gave universal satisfaction. While all of the members realized that during the coming year this choice would mean that the present president must devote a great deal of time and consideration to the affairs of the association, and that during the past year he has already been required to make a great many sacrifices of both for the common good, it was the universal opinion that the new association should, if possible, have the benefit during the coming year of his broad experience and direction. To its president, more than to anyone else, the association owes the reform which has just been consummated in its organization, and no one is so fully acquainted with the requirements of the hour in this connection as President Ely. In the work of guiding the fortunes of the new associations during its trial period he will be associated with a particularly strong executive committee, and one which is in hearty sympathy with the new plan.

As already explained, we cannot attempt in this issue to discuss editorially more than a few of the papers and the other features of the convention. It is only proper to refer at this time, however, to the magnificent display of exhibits, which we hope to describe more fully in our next issue, to the admirable arrangements for both the meetings and the entertainments, which were also in charge of the Manufacturers' Association, and to the hospitality extended by the officers of the Philadelphia Rapid Transit Company, who were most assiduous in making the delegates feel at home, and in showing them the interesting features in connection with the Philadelphia Rapid Transit system.

The Report on Way Matters

The report of the committee on way matters before the American Railway Mechanical and Electrical Association this year is the first consideration that association has given to track subjects. It is the compilation of Fred G. Simmons, of Milwaukee, whose efforts to get way matters discussed more fully at national associations resulted in his appointment as chairman of a way committee for this year. The report consists of contributions from various sources on rail-joints, compiled and commented upon by Mr. Simmons. Four kinds of permanent joints receive extended attention by their most active advocates, viz., the cast-welded, the thermit-welded, the electrically-welded and the zinc or composite joint. Two points brought out by the discussion we wish to call special attention to. One of these is that the success of both bolted and permanent joints depends on the care used in their application. It can be stated with perfect confidence at this stage of the game that with any of the welded or permanent joints a track can be laid in pavement, on which the joints will be as good electrically and mechanically as the unbroken rail, and that they will so remain until the rail is worn out, if only the work is properly done in the first place. The evidence is not at hand to yet warrant a similar statement as to bolted joints in pavement where they cannot be got at for tightening of bolts, although on open track there is little doubt but that with proper care, both when the track is laid and subsequently, the life of the joint can be made to approach the life of the rail. Much better results than are common with bolted joints could be secured by following out the suggestions made in the report, namely, that the bolts be tightened, not only once when the track is new, but numerous times, so as to take up the looseness due to the wearing down of the rough surfaces between rails and joint-plates. It is the wearing down of these uneven surfaces that is almost entirely responsible for loose and battered joints. If the joint-plates and rail-ends made a perfect polished fit, one with the other over a large area, there would be no trouble in keeping a bolted joint tight. It is the roughness of rails and plates which makes a limited area of contact that is responsible for the trouble, because with a limited contact area the pressure is so great per square inch that steel cannot stand up under it without wearing down. The most successful types of bolted joints are those providing a large area of contact.

Returning to the welded types of joints, the compilation of costs for these various types made in the report is most interesting, and seems to leave cast-welding in the lead as far as actual cost is concerned. On the other hand, each of the other joints has certain special features which recommends it. All the processes of welding, except the thermit, require a formidable amount of apparatus, and this, rather than the cost of materials and labor, has prevented their more general adoption. The coming year will undoubtedly be a most important one so far as determining the relative value of the different joints is concerned, and at the next convention most valuable light should be available on this important subject.

Economical Power Distribution

It is a great pleasure to read two such practical and valuable papers as those by Messrs. Hile and Crecelius. The former, to summarize very briefly, is a study of how to keep out of power station difficulties, while the latter deals rather with getting out of them. The Boston Elevated system of power distribution is well known as a most effective one, judged by results, and it also stands quite alone in employing low-tension distribution from a group of allied stations instead of undertaking high-tension distribution from a huge central station. Judging from the results given by Mr. Hile, the Boston method is singularly effective. Perhaps the most striking feature of the case is the enormous load factor obtained at all the stations. The lowest figure of the lot is 63.2 per cent for the station as a whole, and 91.5 per cent for the machines in operation. Taking the whole group in fact, the lowest load factor for the machines is 81.7 per cent. Of course, the secret of this extraordinary result is the operation of the stations in parallel, making a network for the entire system, covering an area more than 10 miles in length and from 5 miles to 8 miles wide. Not only are the networks thoroughly interconnected, but the power stations themselves are linked by massive conductors, so that the whole group operates as a single plant.

The immediate result of this policy comes in the very high load factor and an exceptionally uniform distribution of the energy. Bearing in mind the load factors for the machines in use, one easily appreciates that batteries would here be of singularly small use. Also, it is fairly clear that generating sets of fearfully and wonderfully good efficiency when grossly underloaded have no earthly advantage in such a system. What is wanted here is high economy near full load, and to all appearance Mr. Hile has it. It is a very difficult matter to compare generating costs in stations under different managements, for station bookkeeping varies wonderfully in the manner of distributing the items, particularly those relating to maintenance and general expense. The Boston figures are, however, more than usually full, and the results as given may safely be taken as conservative. The mean cost per kw-hour for the whole system is 0.778 cent. This is much higher than figures often quoted, but fuel is relatively dear in Boston, costing for the term of years considered an average of about $3.57 per ton. Reducing the total cost to the basis of coal at, say, $2.50 per ton, the result is almost exactly 0.06 cent per kw-hour at the switchboard. How much allowance should be made for other items in comparison, it is hard to estimate, but it is sufficiently evident that there is precious little margin left for any power transmission scheme to travel upon. Of course, a complete low-tension distribution requires a very large amount of copper for high efficiency, but on the other hand, so long as d. c. railway motors are used, most of this copper can hardly be dispensed with. If the Boston system were organized on so-called "modern" methods it would probably have one central station and about the number of sub-stations at present operated as power stations. The saving in copper would be mostly confined to the special mains now connecting the stations, and if any central station in Boston could save enough over the present ones to pay for the loss in and upkeep of a high-tension system, we should like to see the plans for it.

The stations described in Mr. Crecelius' paper are in no such happy case as to load as the Boston stations. The factors knock around at 40 per cent to 50 per cent, and only is screwed up to 57 per cent when by interconnecting the stations it becomes possible to work the whole system from one station during part of the day. Part of this difference between the Boston and St. Louis figures can be explained, however, by the fact that Mr. Hile's figures are upon an 18-hour basis, while those of Mr. Crecelius are based upon 24-hour operation. The wholesome effect of even the slight increase of the power factor to 57 per cent, described by Mr. Crecelius and secured by interconnecting the stations, is well evidenced in the bettered costs of operation. From the magnitude of the gain it is altogether probable that if one could draw up a curve showing the improvement of costs with power factor, the knee of the curve would come not far from 50 per cent. Certainly gains hereabouts are worth making. But as the load on the plant becomes more favorable, and the load factor rises, a point is soon reached where a small gain is inconsequential. A system like that in St. Louis presents really very difficult problems for solution, and the one consoling feature of the case is the quickness of the response to remedial efforts. As Mr. Crecelius intimates, the use of batteries in this connection ought to be more carefully investigated than it yet has been. It is well known that in certain cases batteries have been extremely successful in steadying the output, but in other cases they have demonstrably proved a source of expense. Data on the subject are scarce, particularly maintenance data on the batteries themselves, and we hope that some one will take Mr. Crecelius' suggestion up and make a thorough study of the conditions of economy in the use of batteries.

The Gas Engine in Practice

The American Street Railway Association papers by Messrs. Bibbins and West and the resulting discussion will repay more than casual consideration. While the papers themselves may naturally be regarded as somewhat of the nature of special pleading, they are no more so than most other papers on prime movers, and there is no more reason to doubt the data presented than in the case, let us say, of a paper on steam turbines or quadruple expansion engines. As we have many times intimated, the gas engine is coming along rapidly. We are far from decrying the steam engine in its ordinary form—it is and probably will long remain the mainstay of power production. But the gas engine is here and is doing good work at a cost which, in many cases, compares well with other engine costs. This is not saying that a street railway load is the gas engine's long suit or that there will always be economy in using gas engines. The stock arguments against such engines are three: first, that they will not hold their speed well enough for irregular loads; second, that they are, when the producer plant is included, very expensive, so that the fixed charges eat up the possible profits; and third, that they entail an abnormally heavy cost for repairs. Let us take up these in the light of the present papers and see what weight is properly to be attached to them in the existing state of the art.

To begin with, a 4-cycle gas engine is, cylinder for cylinder, at a disadvantage compared with an ordinary steam engine. But, on the other hand, a two-cylinder, double-acting gas engine, such as is now produced for large work, will give the same regularity of impulse as a single-cylinder Corliss engine, while a four-cylinder gas engine will give a cycle like that of a compound steam engine. Thus similar regularity of effort merely means a duplication of cylinders, which appears in the capital and maintenance accounts, but gets there just the same. By the same token, the governing should be, and is, about the same in the two cases. As Mr. West also shows, the overload capacity of either machine depends on its rating, and any less overload capacity of the gas engine consequently appears in the costs to be discussed. It is a matter of record that gas engines can successfully drive alternators in parallel, which means that the governing is actually good. Their rotative speed is also fully up to that of Corliss engines of similar output, which means that in the two cases the generator design is about the same. Now as to cost, it is at the present moment true that a gas power plant is somewhat above a steam plant. This, however, affects the cost of the power produced only in so far as it raises the fixed charges. In the bids on an 8000-kw plant cited by Mr. Bibbins, the excess in cost between the favored gas plant and the favored steam plant was about 8 per cent, which would raise the fixed charge on the latter pro rata to partially offset the fuel economy, which was guaranteed at 1.61 lbs. coal per kw-hour, as estimated from the engine performance. This is not unapproachable by steam engines, but is far better than current steam practice.

Let us now touch upon the much-mooted question of repairs to gas engines. Two actual stations cited by Mr. Bibbins give pertinent data. One case, that of an 800-kw station at Bradford, Pa., operating on a station load factor of only 19.54 per cent, showed a total works cost per kw-hour of 0.825 cent, of which 0.01 cent was due to repairs on engines. This can hardly be rated as excessive. A second plant, belonging to the London Metropolitan Boroughs, on a load factor of 15.2 per cent, gave a total for repairs, including all, of 0.048 cent in a cost per kw-hour of 1.05 cents, the station capacity being 2000 kw. The average of eleven steam generating plants in the same district gave, with an average load factor of 17.25 per cent, a cost per kw-hour of 1.41 cents, of which repairs ran to 0.218 cent. Of course, such comparisons are a bit uncertain, but it is sufficiently clear that the gas engines were not the source of severe repair. The labor cost in these gas stations is relatively higher than in steam stations, the fuel cost being relatively so much reduced. These figures show at least that the gas engine is in the game, and when one considers that they were derived from small units operating at bad load factors, supposably disadvantageous for gas engines, the results are all the more striking. The long and short of it is that when one undertakes with a steam engine to go up against a thermal efficiency of 25 per cent or more, there must be very substantial gains in fixed charges and repairs to come out even. And as to plant efficiency, there is too much difference between less than 25,000 B. T. U. per kw-hour and 40,000 or more to be easily overcome. We believe that the next few years will see considerable gains in the efficiency of both kinds of engines. The gas engine has already proved a valuable stimulant in steam working. The fact that several American electric railway plants are being equipped with gas engines gives promise of livelier competition in the future.

PAPERS READ AT THE PHILADELPHIA CONVENTION OF THE AMERICAN RAILWAY MECHANICAL AND ELECTRICAL ASSOCIATION

THE POWER DISTRIBUTING SYSTEM OF THE BOSTON ELEVATED RAILWAY COMPANY

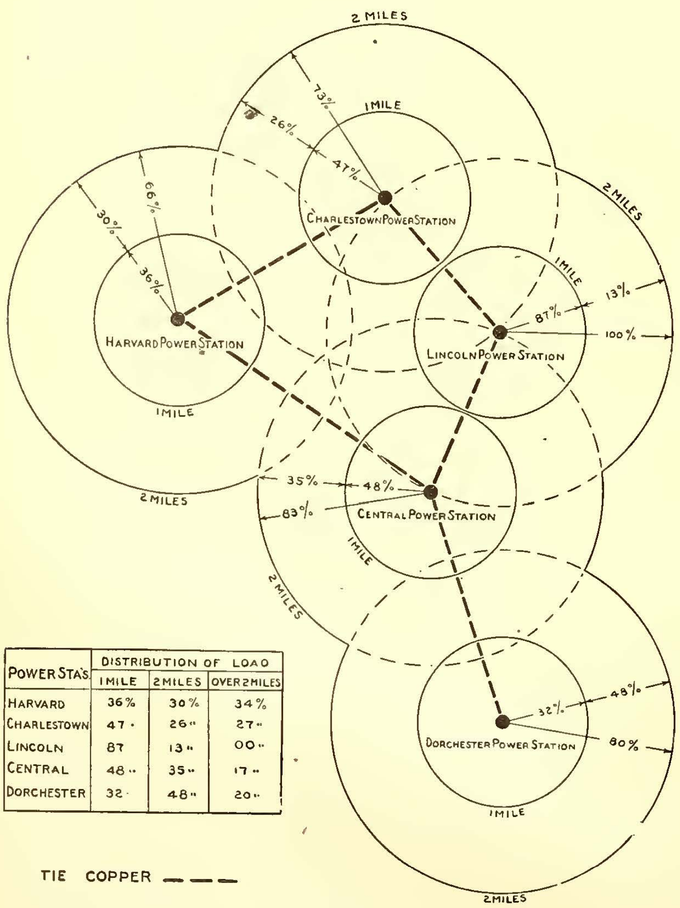
BY C. H. HILE,
Superintendent of Wires, Boston Elevated Railway Company

In considering an established power distribution system for the best understanding of its advantages and efficiency, it is essential that one has a knowledge of the conditions and disposition of the power plants in their relation to the territory served.

Among engineers entrusted with the laying out and designing of power plants and transmission systems there are two recognized tendencies in their treatment of such questions. The most prominent, perhaps, because the most radical of these two tendencies of late years, is for large central power stations, correspondingly large power units, and the alternating-current transmission system with sub-station conversions. The development in the science of engine and dynamo construction, in connection with the progress made in high-voltage transmission systems, has made such engineering ventures easily possible as well as practicable. The other tendency, while not necessarily opposite in method and effect, is more the result of a growth and development, based upon conditions as they have presented themselves to the engineer, covering years of progress and expansion of a single or a number of power systems.

BOSTON ELEVATED RY. CO.

PLAN SHOWING RELATIVE LOCATION OF FIVE PRINCIPAL STATIONS WITH DISTRIBUTION OF LOAD WITHIN 1 MILE AND 2 MILE RADII.
WINTER 1903-04



POWER STA'S	DISTRIBUTION OF LOAD		
	1 MILE	2 MILES	OVER 2 MILES
HARVARD	36%	30%	34%
CHARLESTOWN	47 "	26 "	27 "
LINCOLN	87	13 "	00 "
CENTRAL	48 "	35 "	17 "
DORCHESTER	32 "	48 "	20 "

FIG. 1.—DISTRIBUTION DIAGRAM

At present writing it cannot be said that the merits and advantages of either practice over the other have been conclusively proven. Each power and transmission problem has its individual conditions, and these in connection with the requirements of good engineering must determine the type and system of power plants and transmission systems.

It is the purpose of this paper to deal with an established system of separate power plants, with their interconnected power distributing systems, and to present facts, results and experiences which may be taken as fairly representative of such engineering practice. To illustrate the practice, its results and possibilities for the purpose of this discussion, only five of the eight stations on the system will be considered (the three stations not considered being of obsolete construction and operated only part of the time, or so situated as to have no bearing upon the main proposition).

The five power stations considered are fairly representative of the modern type of station, and include in their equipment direct-connected d. c. units, varying in size from 800-kw to 2700-kw rated capacity.

The diagrammatic sketch, Fig. 1, with the information contained therein, gives a very fair idea of the relative locations of the several stations with regard to each other, and to the territory each supplies with power.

TABLE I.—POWER-STATION DATA, BOSTON ELEVATED RAILWAY

POWER STATIONS	BOILERS						ENGINES				GENERATORS		
	No	TYPE	RATED H.P	METHOD OF FIRING	DRAFT	TYPE ECONOMIZER	No	TYPE	H.P	TYPE CONDENSERS	No	TYPE	CAPACITY KW
CENTRAL	24 8	WATER-TUBE "	250 500	HAND "	FORCED "	GREEN "	1 2 6	VERTICAL, CROSS COMPOUND CONDENSING HORIZONTAL " " " " TRIPLE EXPANSION "	4200 2000 1800	BUCKLEY SIPHON " " " "	1 2 6	MULTIPOLAR " "	2700 1500 1200
LINCOLN	8 4	WATER-TUBE "	450 475	MECHANICAL STOKERS "	NATURAL "	GREEN "	3	VERTICAL, CROSS COMPOUND CONDENSING	4200	JET	3	MULTIPOLAR	2700
CHARLESTOWN		WATER-TUBE				GREEN	1 2	VERTICAL, CROSS COMPOUND CONDENSING HORIZONTAL " " "	4200 1000	BUCKLEY SIPHON JET	1 2	MULTIPOLAR "	2700 800
HARVARD	6	WATER-TUBE	500	MECHANICAL STOKERS	NATURAL	GREEN	3	HORIZONTAL, CROSS COMPOUND CONDENSING	1800	JET	3	MULTIPOLAR	1200
DORCHESTER	2 2	WATER-TUBE "	500 500	HAND "	NATURAL FORCED	GREEN "	2	HORIZONTAL, CROSS COMPOUND CONDENSING	1500	JET	2	MULTIPOLAR	1000

The yearly output of the several stations under consideration during the year 1904 was as follows:

TABLE II.—YEARLY OUTPUT OF SEVERAL STATIONS IN BOSTON

	Kw-Hours
Central power station	51,146,535
Lincoln power station	31,978,676
Charlestown power station	17,449,963
Harvard power station	15,813,669
Dorchester power station	8,487,644
Total	124,876,492

In Fig. 1 is shown how the several stations are tied together and operated in parallel. The tie between stations is accomplished through feeder wires running into so-called feeder sections common to two or more stations. Sufficient copper is run from each station into the common feeder sections, so that in the emergency of a disabled machine, or an unusual load in any one of them, the others immediately respond by taking up more load from the tie feeder sections, either automatically or through an adjustment of the voltage in the stations affected. By thus operating the stations, heavy and extreme fluctuations of load are avoided, and, with the movement of maximum morning and evening loads from the outer to the inner feeder sections and from the inner to the outer feeder sections, the several stations are so located as to materially help each other when the need is most urgent.

While it is true that there is more copper required to thus distribute the power than if just a sufficient amount were strung to satisfactorily distribute the power output of each station individually, it is a fact that none of the copper is ever idle, and is always contributing to better conditions, both for the stations and for the operation of cars; and it is also believed that the extra expense occasioned by this additional copper is more than compensated for by the smaller surplus generating capacity required than is the case in the single generating station idea.

That which is equally interesting and best brings out the advantage of operating the several stations in parallel (thus practically getting the advantage of the high-load factor obtained in the single large central station) is the data given in Table III. These figures are presented as being fairly representative of the average load factor for machines in service throughout the 18 hours of day-service operation, and also shows the machine-load factor for the same period.

TABLE III.—GIVING THE APPROXIMATE LOAD FACTORS UNDER GIVEN CONDITIONS

Stations.	Load Factor for Station in Operation for 18 Hours. 6 A. M. to 12 P. M.	Load Factor for Machines in Operation During 18 Hours. 6 A. M. to 12 P. M.
	%	%
Central	.744	.817
Lincoln	.632	.915
Charlestown	.637	.929
Harvard	.807	.874
Dorchester	.881	.883

The graphic statement given in Fig. 2, and which represents average costs for the four years ending Sept. 30, 1904, is well worth careful consideration, and well illustrates the possibilities in small stations when operated in parallel with other stations. With regard to the costs per kilowatt-hour given in Fig. 2, consideration should

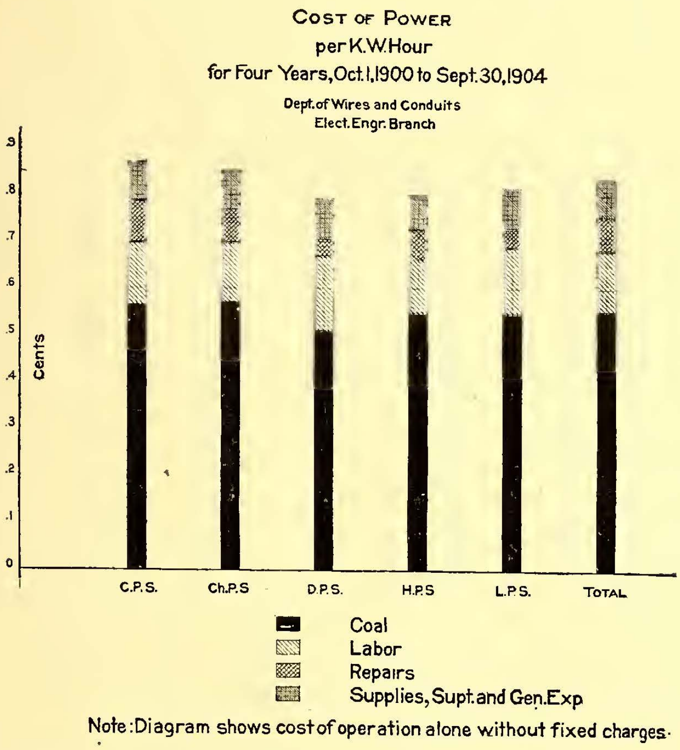


FIG. 2.—DIAGRAM SHOWING COST OF POWER IN BOSTON FOR FOUR YEARS

be given to the fact that the year 1903 is included in the four years taken. During this year, on account of the coal strike, the cost for coal was more than 35 per cent above that paid in normal periods.

It will be a long and difficult task to satisfactorily show in dollars and cents what advantage there may be and what saving is accomplished by having the several stations so nearly located to the load center of their districts, but in considering this fact as offset by the advantage there may be in the reduction in operating and maintenance expenses in the large central station, the costs given in the graphic statement afford interesting figures as a basis for comparison.

As a summarized statement, using the station outputs, cost for coal and power for the fiscal year ending Sept. 30, 1904, we have the following table:

TABLE IV.—SUMMARY OF POWER HOUSE DATA FOR YEAR ENDING SEPT. 30, 1904

Stations.	Rated Capacity in Kw.	Output in Kw. Hours, 1904.	Per Cent. of Load Within Miles.	Station Load Factor for 18 Hours.	Machine Load Factor for 18 Hours.	Cost of Coal per Ton at Station.	Cost of Power per Kw.Hr.at Sw.Board
			%	%	%		
Central	12,900	51,146,535	83	74.4	81.7	3.55	.00786+
Lincoln	8,100	31,978,676	100	63.2	91.5	3.50	.00760+
Charlestown	4,300	17,449.968	73	63.7	92.9	3.61	.00803+
Harvard	3,600	15,813,669	66	80.7	87.4	3.63	.00769+
Dorchester	2,000	8,487,644	80	88.1	88.3	3.73	.00759+
Average cost per kw. hour for all stations							.00778+

FEEDER SYSTEM

We may now take up the consideration of the power distributing system in its relation to the districts to which power is supplied from the several power stations just described.

Not taking into consideration the territory served beyond the limits of the railway company's tracks, there are approximately 72 square miles of populated territory included within the limits of twelve cities and towns served by the company's lines. This total territory is divided into sixty-four feeder sections. The smallest feeder section has 1.6 miles of single track. The largest feeder section includes 16.2 miles of single track.

The most heavily loaded section during the hour of greatest travel in the winter months requires, approximately, 2300 amps., which are supplied through five feeders aggregating 4,000,000 circ. mils of copper.

The smallest section with regard to power required during the hour of heaviest travel takes during the winter months approximately 55 amps., supplied through 1,000,000 circ. mils of copper. This large amount of copper capacity is required, since unusual loads may be thrown upon this section, due to temporary changing of routes in case blockades occur on certain streets.

In addition to the subdivision of the territory served by feeder sections there is still further division made by keeping the elevated division feeder system separate from the surface line sections, and the subway and tunnel sections independent of both the elevated and the surface feeder sections.

The general scheme of the distribution system is largely the result of growth with its accompanying experience, and may be said to be a compromise between two extremes of feeder layouts. While it would seem to be an ideal system from the operating point of view to have the feeder sections so disposed and limited that each might be supplied with power through a single feeder, thus giving the most complete control of the feeder system at the switchboard and securing the least disturbance to the general system in case of trouble on any part of a single feeder or its section, it is not believed that these advantages are sufficient to compensate for the extra copper required, and loss of the more efficient use of the copper installed. The other extreme, which is seldom resorted to, is where all feeders supply power to one large common section, which may embrace an entire system. While this scheme has the advantage of securing the most efficient use of the least possible amount of copper, it practically takes all control of the feeder system out of the hands of the operator at the station, and in case of trouble on any part of the system or upon a feeder, the entire feeder system may be seriously affected.

With us the size of the feeder section is determined by the location of the line to be supplied with power, its relation to connecting or cross lines, how heavy the traffic may be, the importance of quick control of any section in case of fire, and the number and size of feeders which the load conditions would seem to justify in running in parallel for the best operation at the switchboard.

By the use of section insulators in the trolley wires in connection with legs leading from the trolley wires to a switch in a box on the pole opposite from where the section insulators are installed, any two sections or number of sections may be tied together and run as one large section. In addition to this means of tying the feeder sections together, at suitable or advantageous locations in the feeder system, switches in pole boxes are installed so that any desired number of feeders may be tied together or thrown from one section to another.

With respect to the "L" division, subway, tunnel and surface feeders, emergency switchboxes, or switching stations, are located at the most advantageous points, so that the feeders of one division can be connected in with those of another, or so that feeders of one division can be disconnected from their regular section and utilized in another. For the manipulation of the feeder system outside the power stations in cases of emergencies, tests, or repairs, 964 section insulators and 1540 switches are maintained as important features in the feeder system. By the foregoing arrangements any feeder wire or group of feeder wires if disabled may be quickly disconnected from the system and the service still be maintained by the use of feeders from other sections, or by tying sections together.

Considering the distribution system with reference to its physical construction the following amounts, sizes, kinds of material and types of construction enter into its make-up. The standard sizes of conductors used are 500,000 circ. mil, 1,000,000 circ. mil. and 2,000,000 circ. mil overhead wires or underground cables.

About ten years ago, for the purpose of keeping down the number of kinds and sizes of wires to be carried in stock, 500,000 circ. mil was adopted as the standard size for both overhead and underground conductors. Later, as the feeder sections increased in the amount of power required, transmission distances grew, and when general feeder wire adjustments became necessary on account of new power plants being added to the system, it was found desirable to include the 1,000,000 circ. mil conductor as a standard. With the construction and installation for the elevated division to meet the heavy current demands for this new kind of service, 2,000,000 circ. mil was determined upon as a suitable and standard sized conductor.

On Oct. 1, 1904, there were 424.078 miles of trolley wire and 16.015 miles of third rail being served by the following amount of copper conductor:

Total miles of overhead conductor	545.469
Total miles of conductor in conduits or buried	255.743
Total miles of conductor in submarine cables	5.254
Total miles of conductor, not including trolley wire	806.466
Approximate weight of copper in conductor	7,101,542 lbs.
Amount in weight of copper for each kilowatt capacity at stations	195 lbs.

UNDERGROUND CONDUITS AND CABLES

About 32 per cent of the power distributing system is carried underground, all feeder cables and a large portion of the return copper being carried in conduits, and the balance of the return wires buried directly in trenches or just outside the conduits.

The following shows the total amount of underground conduit in service in 1904:

	Miles
Total length of conduit	28.386
Duct length in conduit (cement-lined iron pipe)	76.341
Duct length in conduit (vitrified-clay pipe)	195.360
Duct length in conduit (wrought-iron pipe)	9.106
Total number of manholes	683

The underground conduit system was begun in 1894, and has been added to each year in varying amounts.

Practically the whole of the conduit system has been built by contract under the direction and supervision of the railway company's engineers. It may not be foreign to the purpose of this paper to briefly outline some of our practice and experience with underground conduits.

In the matter of construction our experience has shown that the less a conduit deviates in depth from 3 ft. between the top covering and the surface of the street the more satisfactory will be the conditions for the conduit system. The deeper a conduit is constructed in the street or highway the more likely it is to become a subsurface drain for the surrounding soil, the deeper and more expensive becomes the manhole construction, and the more difficult is the drainage. As more or less water will seek a drainage way in most street subsoils, it is an advantage in all cases where it is practicable to construct a conduit so that in cross section its height is greater than its width, thus having the fewer ducts on the bottom layer, and therefore the fewer wet ducts in the conduit, since any water leaking into a conduit will invariably get to the bottom ducts in any vitrified clay pipe conduit.

Experience has shown that it is desirable to drain manholes wherever practicable, as it is not possible, within reasonable cost of construction, to build them water-tight, nor is it believed practicable to maintain water-tight frames and covers to prevent surface water from getting into the manholes. Where conduits are built in streets containing gas mains and service pipes, it is believed that all danger from gas explosions can be avoided by maintaining perforated covers on the manholes. In so maintaining the covers the necessity as well as the advantage of having the manholes drained is obvious.

In laying out a system of conduits for street railway service, large trunk lines with one set of manholes should be avoided. Any large and important traffic section should be so supplied with power that a burnout or the disabling of any one section of conduit would not seriously interfere with or suspend car service. Cable burnouts or break-downs are due to various causes, and in spite of all precautions will sometimes occur, and in such instances either in the conduits or in the manholes one or more adjoining cables may be injured by the escaping current. It is therefore deemed to be good engineering to divide up trunk line conduits into two or more distinct lines, separated at least by 6 ins. of concrete and having separate systems of manholes.

It is important throughout any conduit system to isolate, so far as practicable, each cable conductor, both for its safety and for the safety of other conductors in case a burnout occurs. For street railway service, where cables are always required to carry their full current capacity, and when it is considered that single conductors as large as 2,000,000 circ. mil may be carrying 1600 to 1800 amperes, the chances for serious damage in case of a break-down in the insulation may be readily appreciated. In view of these considerations it is believed that single duct or pipe sections, built in the conduit, with all joints carefully sealed with cement mortar and well staggered in relation to joints in other ducts, will be found to give the most satisfactory conduit.

For the construction of manholes in city streets where water and gas pipes and other underground constructions are plentiful, it is believed that the use of good sewer brick will give the best satisfaction, since it will be found that the shapes of the manholes will be constantly varying on account of the limiting spaces and obstructions in the street.

An 8-in. wall is considered sufficiently strong for all sizes of manholes up to 6 ft. x 6 ft. x 8 ft.

For ordinary feeder cable transmission, manholes built with brick recesses or with cast iron or other type of hanger will give good satisfaction.

Where conduits and manholes are to be used for carrying high tension cables, it is believed that the importance of each conducting cable is such as to justify taking extra precautions in both conduit and manhole construction in order to secure complete isolation and safety from outside sources of injury.

CABLES

Taking into consideration the fact that our experience with underground cables has extended over a period of nearly eleven years, Table V is interesting as an indication of what may be expected in the life of lead-covered conductors. The installation and maintenance of underground cables is much more expensive than is the case with overhead lines, and the chances for trouble to the transmission system, in our experience, are greatly increased. Faults will develop in the cable from defects in the insulation, injury to the lead covering in handling it in the ducts, or from picks or bars when digging is being done in the streets, and in case of burnouts due to a break-down in the insulation of one cable every cable in the conduit may be more or less injured.

Ever since the underground cables were installed, a regular system of testing for trouble has been maintained. Depending upon the importance of the cables, size of conduit and the condition of insulation, tests are made on every cable varying in frequency from twice a week to once a month.. The insulation resistance test is used in keeping tab on the condition of the cable for the work it has to perform. While this method is somewhat expensive, in our experience it has proven fairly effective, and our records show that nearly 90 per cent of the defects which develop in cables are found by the tests and removed before a break-down and burnout in the insulation occurs.

For convenience and safety in the installation and maintenance of underground cables the following methods and practices have been found to give good results:

Preparatory to the installation of the cables, careful and accurate plans are gotten up showing the size of the conduit, duct, distance between manholes, size and shape of manholes and the relative locations of the conduits entering the manholes. Each manhole is designated by number and each duct entering and leaving a manhole is numbered.

Each individual cable is assigned its proper location in the conduit system, from the switchboard at the station to its terminal where it feeds into the overhead wires, and is diagrammatically shown and located in plan, by its own number and the number of the duct it occupies throughout the conduit system.

The cable lengths are required to be furnished by the manufacturer in proper lengths, according to lists furnished by the railway, each reel being marked with length numbers, number of feet in each length and the section of conduit indicated by the number of the manholes between which the lengths are to be installed. The pulling-in gang is supplied with the diagrammatic plans of the conduit, and also lists giving reel numbers, length numbers, number of feet in each length and the location of each length in the conduit system.

By such precautions there is secured the least amount of waste in cable, in labor of handling and the avoidance of trouble in jointing, testing and the making up of the cable records for future use.

When installed and jointed up ready for service, every cable is stamped with its number in each manhole throughout its length.

It is important that each cable be as fully individualized as possible from the switchboard to its street terminal, so as to give the least possible chance for a mistake occurring in case of handling it as a feeder, testing it, or making repairs.

The following figures are believed to represent a fair average cost per foot for complete installation ready for service:

	Cents per Foot
500,000 circ. mil conductor; average weight per foot, 6.6 lbs. Cost of installing	2
1,000,000 circ. mil conductor; average weight per foot, 7 lbs. Cost of installing	2.5
2,000,000 circ. mil conductor; average weight per foot, 11.5 lbs. Cost of installing	3.25

The cost of maintenance per foot per year, which includes testing, inspection, repairs and changes, will amount to from 1 cent to 1¼ cents.

To date there is little conclusive evidence upon which to base a prediction regarding the life of an underground cable. With proper usage and care the life of a first-class cable would seem to be limited only by the period during which the lead covering remained intact. Under fair conduit conditions and with proper care and usage, I cannot see why an average life of from twenty-five to thirty years should not be experienced.

With regard to the question of type or kind of insulated cable which may be expected to give the best satisfaction, I would say that while our experience has included fibre, rubber and paper-insulated cables, covering a period of nearly eleven years, to date there has not developed sufficient conclusive information to allow of a statement which would show how much better one type of cable is than another.

In a few instances in recent years, consideration has been given to the possibility of using in underground conduits, rubber-insulated, heavily-braided and waterproofed cables without lead covering. As yet the experience with this type of cable has not extended over a sufficient period to prove its advantage over the lead-covered type, but if the manufacturer can cover the insulation with a waterproof braiding and compound having good lasting qualities, there is much to commend such a type of cable over the lead-covered type. The chance of break-down in the insulation would certainly be reduced to a minimum. If a burnout or break-down in the insulation should occur, the chances of the trouble spreading would be very small. The testing which is so important and desirable in the maintenance of lead-covered cables could practically be dispensed with.

In conclusion and in general, since the function of any power-distributing system is to supply adequate power whenever and wherever needed for the continuous and uninterrupted service as scheduled, the engineer has performed only a part of his duty when he has determined the amount and general layout of the copper required for carrying power for street car traffic in thickly populated sections, such as we have in Boston and vicinity. In the event of fire, streets are blocked, cars must be sent over roundabout routes, all power in wires within the sphere of the fire-fighting force must be quickly cut off, and at the same time the least disturbance to the general traffic be secured. The blockade of any track may occur, due to various causes. In such event cars must be diverted to other streets, and the feeder system must meet this new condition at any time and with practically no delay to the service. Burnouts on underground cables or the breaking down of overhead wires are occurrences which must be met, and the inconvenience which such interruptions may cause to traffic must be reduced to the smallest practicable degree. A good working system for power distribution must, therefore, be studied and perfected with the view of securing the least interruption to service within reasonable provision and cost, and having laid out and constructed such a system, its best use and successful operation is no small part of the consideration which must be given to secure desired results.

The construction and maintenance of the distributing system of the railway company is carried on through the department of wires and conduits, organized under a superintendant. The operation or use of the system is directly in charge of an official with the title of superintendent of power distribution. The switchboard operators are directly responsible to this official for the distribution of the power delivered at the switchboard and the best use of the system of feeders with their connections. Complete plans of the distribution system, showing details of every feeder, with their switches and connections, are kept at every station for the use of the operators.

Seven emergency crews are maintained, conveniently located in the several districts into which the territory served by the railway company is divided. These crews respond to all trouble calls and to all fire calls which may affect the lines and property of the railway company. These crews and also the entire organization of the department of wires and conduits are at the call of the power station operators at all times in case of trouble, or if the need arises for changes in the feeder system outside the stations.

In review of the power distribution system herein treated, considering it as a whole, the cardinal features distinguishing its construction, maintenance and operation are:

1. The construction and operation of several power stations conveniently located with respect to the territory served.

2. The operation of all stations in parallel, their bus-bars being tied together through feeder conductors which supply power to feeder sections common to two or more stations.

3. The great flexibility of the power distributing systems which enables the operators to quickly meet all possible contingencies either in power stations or in elevated, subway, tunnel or surface feeder sections.

4. The organization for the operation and maintenance of the distributing system.

5. The systematic testing, inspection and care of all underground cables and structures.

TABLE V.—SHOWING QUANTITIES OF CABLE IN CONDUITS EACH YEAR FOR A PERIOD OF TEN YEARS, AND THE AMOUNTS OF CABLE REMOVED EACH YEAR ON ACCOUNT OF DEFECTS DISCOVERED BY TESTING, AND ON ACCOUNT OF BURN-OUTS:

Year.	Total Amount in all Conduits.	Total Amount Removed Acct. Repairs.	Per Cent of Total Removed.	Total Amount Removed Account Burn-outs Due to Breakdown of Insulation.	Per cent of Total Removed.
1895	135,593′	2,969′	2.19	......	....
1896	224,404′	1,009′	.45	700′	.31
1897	339,245′	1,290′	.38	3.765′	1.11
1898	431,733′	1,671′	.39	......	....
1899	480,111′	2,587′	.54	16,708′	3.48
1900	599,229′	3,402′	.57	1,742′	.29
1901	657,979′	9,712′	1.48	1,815′	.27
1902	687,932′	6,770′	1.00	2,847′	.41
1903	698,361′	4,699′	.67	1,747′	.25
1904	777,406′	5,759′	.74	6,878′	.88
	......	3,868′	.841	36,202′	.70

AVERAGE PER CENT PER YEAR FOR TEN YEARS

Account repairs .... 0.841—Average feet per year, 3,986.8
Account burn-outs .... 0.7 —Average feet per year, 3,620.2

Total average 1.541

THE POWER STATION LOAD FACTOR AS A FACTOR IN THE COST OF OPERATION

BY LAWRENCE P. CRECELIUS,
Chief Electrician United Railways Company, of St. Louis, Mo.

The question of keeping proper load charts of the power station loads has already been given much attention, and its value has long been recognized. The irregularities of the power station load diagram of a railway system depend entirely upon the nature of the travel on that system.

In urban railway systems the load curve is double peaked, having the characteristic morning and evening peaks of city travel when the people go to and from work. The breadth, magnitude and duration of these peaks depend, of course, upon local conditions, such as the size and layout of a town, and upon its sociology. In a manufacturing center the peaks are often remarkably symmetrical, and are little affected by climatic conditions, as the people usually go to work at about the same time in the morning and leave to go home at nearly the same time in the evening. In the larger cities, where it becomes necessary to transport a mixed community consisting of factory employees, merchants, clerks, shoppers, theater-goers, etc., the peaks lose their symmetry and the morning peak becomes lower and not so sharp as the evening peak. This is accounted for by the fact that in these cities the morning travel generally extends over a period from 6 a. m. to 11 a. m., while in the evening the homeward-bound passengers leave the business districts at about the same hour. Here also the condition of the weather and the season of the year become governing factors in the shaping of load curves.

Any method that will tend to smooth up the load curve is indeed worthy of consideration, as an increase in the load factor means a corresponding decrease in the cost of power per car-mile. This becomes very apparent when we compare the amount of station apparatus which is required to carry the peaks with that which is required to carry the average, and the manifest inefficiency of this arrangement when the load factor is small. The load factor is the ratio between the average load and the maximum, and, therefore, represents the ratio between the amount of station apparatus required for the average and that required to carry the peaks. Further, since the morning and evening peaks are both 3 and 4 hours respectively in duration, we find that from 45 per cent to 60 per cent of the station apparatus of a system is idle for 17 hours or more.

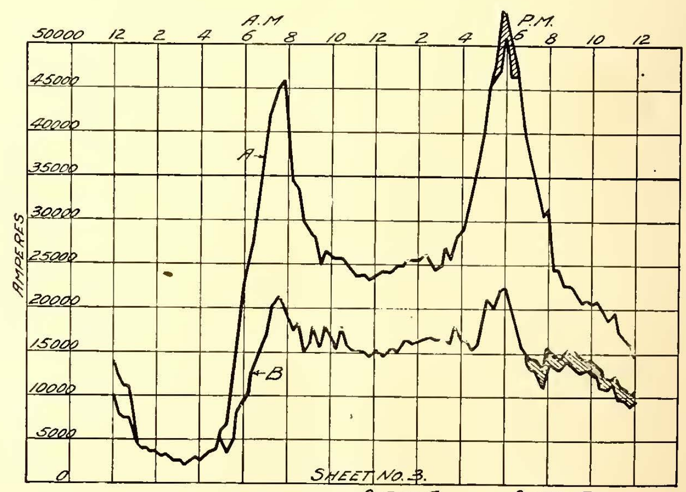
Since there are so many causes, depending upon local conditions, which become governing factors in the shaping of a power station load diagram, and therefore determine the load factor of a system, it would be very presumptuous on my part to attempt to describe to you a certain fixed method by which the load factor of a system might be brought up and the advantages derived thereby. Each and every system has its own peculiarities, which have to be met, and which prohibit the application of a general method, hence they must necessarily be dealt with separately. I shall, therefore, confine myself to outlining a method employed by the United Railways Company, of St. Louis, in increasing the load factors of the main power stations, and showing how the load factor in this case plays a prominent part in the cost of power per car-mile.

A good many of the larger railway systems are the result of consolidations of the different independent companies in a locality, each having its own power stations, some of which it becomes necessary (for various reasons) to continue in service. In the majority of cases, this seldom constitutes the most economical arrangement of power stations for the consolidation. The power station layout of the United Railways Company, of St. Louis, is of this order. It would be a real treat, indeed, to have charge of a layout where the necessary central station or stations are located at a point where both fuel and water can be conveniently handled, together with enough sub-stations sensibly located, containing storage batteries, to cap off the peaks, etc., as in that event it would be possible to generate power at the lowest price without any apparent effort on the part of the power superintendent.

The United Railways system, of St. Louis, has in operation four power stations at the time of writing. Two of the larger stations, one of 13,950-kw and one of 7000-kw capacity, are kept in operation continuously, and constitute the main central stations. The two smaller stations are operated on swing watches on week days, that is, operated during the peak hours only. But bus wires have been run from the larger stations to both of the smaller ones and are there connected through circuit breakers and double-throw switches to either one of the two feeder busses, with which the smaller stations have been supplied. The installation of double-throw switches on both the feeders and bus wires in these stations makes it possible to operate them on one bus to which any number of feeder sections can be connected, and at the same time to operate the bus wires independently of the station on the other bus to which the rest of the feeder sections can be connected. During the rush hours the bus wires are connected to the same bus on which the stations are operated, thereby becoming equalizer wires. The amount of copper in the bus wires is just sufficient to carry the load of the smaller stations during the lighter part of the day, allowing a reasonable drop in potential.

	CURVE A.	CURVE B.
OPERATION. COST PER K.W. HOUR	$.00712	$.00621
MAINTAINENCE. COST PER K.W. HOUR	.000955	.00089
TOTAL COST PER K.W. HOUR	.008075	.00710
K.W. HOURS PER CAR MILE	3.2599	
COST PER CAR MILE	2.632	
LOAD FACTOR	46.78%	48.64%

FIG. 1

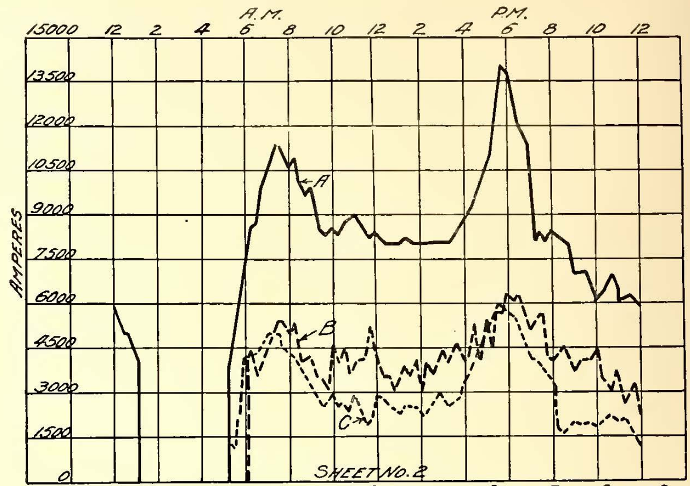


	CURVE A.	CURVE B.
OPERATION. COST PER K.W. HOUR	$.006325	$.00528
MAINTAINENCE. COST PER K.W. HOUR	.001175	.000729
TOTAL COST PER K.W. HOUR	.0075	.006009
K.W. HOURS PER CAR MILE	3.261	
COST PER CAR MILE	2.445 IN CENTS.	
LOAD FACTOR	43.4%	52.1%

FIG. 3

The resulting economy of operation in this case more than justifies the expenditure of a good many dollars and cents in the bus wires, and also the resulting increase in the cost per kilowatt-hour of the power generated under this arrangement in the smaller stations, as may be seen by referring to the load curves.

In the accompanying load diagrams on Fig. 1 are shown two curves. The upper curve represents the total load of all the power stations for a period of 24 hours. The second curve represents the load on



	CURVE A.	CURVE B.	CURVE C.
OPERATION. COST PER K.W. HOUR.	$.00618	$.0100	$.01219
MAINTAINENCE. COST PER K.W. HOUR.	.00094	.0012	.00101
TOTAL COST PER K.W. HOUR	.00712	.0112	.0132
LOAD FACTOR	50.3%	50.0%	41.6%

FIG. 2

the 13,950-kw station before the installation of the bus wires. Under the curves are shown the cost of operation and maintenance per kilowatt-hour, the cost per car-mile, the kilowatt-hours per car-mile and the load factor. Fig. 2 represents the performances of the other stations on the same day. Figs. 3 and 4 are carried out on the same order, and represent the output of each of the stations under the new arrangement, after the installation of the bus wires. The summary of the above is as follows: By plotting a curve which is the sum of the load of both the main stations, we can arrive at a curve, the load factor of which is nearly the correct factor to work by, as obviously the effect of the load factors of the smaller stations will have little bearing upon the total cost of operation as compared with that of the larger stations. Nevertheless the shutting down of these stations during the lighter part of the day, thus operating them at an absolute disregard toward economy, does influence the load factor of the main station curves very materially, and ultimately effects a saving. This is clearly shown by the curves in Fig. 5. This curve sheet gives the sum curves of the two main stations when working under both conditions. Curve

"A" represents the load of the main stations for the same day on which all four stations were in operation all day. Curve "B" represents the load of the same stations when taking the load of the smaller stations during the lighter part of the day. Thus it is found that in bringing up the load factor of the sum curves of the main stations from 50.23 per cent, in the first case, to 57.7 per cent in the second, that a saving of .000575 of a cent per kilowatt-hour has been made on the total power cost. And on a basis of 310,000-kw hours per day, which is about the average output of the stations of this system during the summer months, this would represent a saving of $178.00 per day when operating under these conditions. All of the above figures, giving the cost of operation and maintenance per kilowatt-hour, were taken from a report received monthly

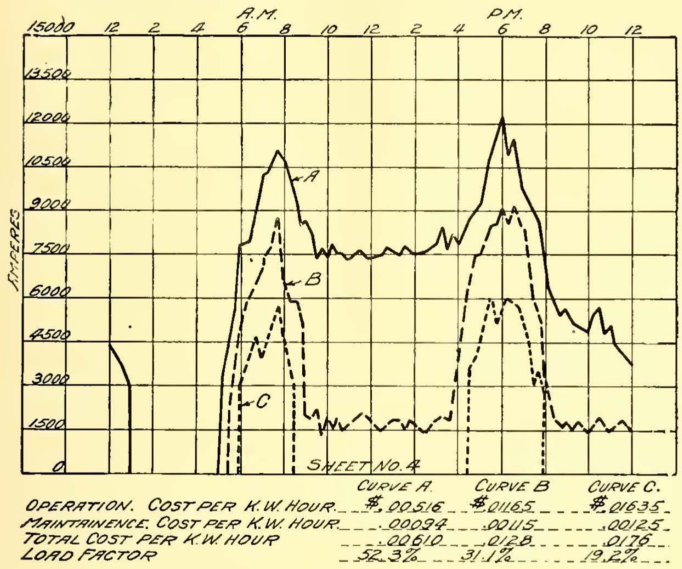


FIG. 4

from the auditing department, while the curves were plotted from readings taken daily. It is, therefore, possible that the cost of power per kilowatt-hour for the specific days shown on the curve sheets may have been a trifle more or less than given.

The curve sheets show the use of a storage battery to level the evening peak. The charge and discharge of the battery are shown

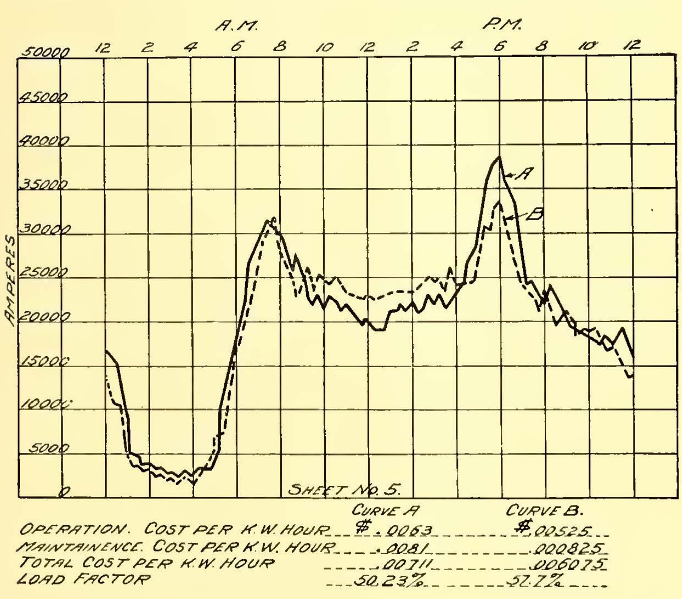


FIG. 5

by shaded areas above and below the load line. It has been found that since the installation of the battery, which is located in the business district of the city where the traffic is very congested, the service has been increased to a marked degree during the rush hours. A large reduction in the amount of copper required to handle the sections located in this district from the four stations has also been effected. This, and the fact that a battery can always be called upon in cases of emergency to take hold of the load point to the advantages to be derived in using storage batteries to smooth up the load curve when conditions warrant their use.

There is still a tendency among power men to regard batteries with suspicion and distrust, owing partly to the enormous cost of a complete battery installation, and partly to the rapid depreciation of a battery when overloaded. Nevertheless, the use of storage batteries abroad, with their attendant economical results by leveling load curves, has gradually led to the adoption of them here, until now we find that in every modern installation they form an integral part of the power equipment.

It is not my intention to take up the effects of storage batteries on power-station load diagrams in detail in this paper, as the same is getting rather lengthy. But from the resulting economy, as pointed out above by the crude and uneconomical arrangement of operating power stations in swing watches to bring up the load factor, it would seem that the question of employing batteries for that purpose should be given some attention and might be made the subject of a paper which would prove of considerable value to the members of the association.

PAPERS PREPARED BY THE COMMITTEE ON CONTROLLING APPARATUS

ASSEMBLED BY J. S. DOYLE,
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MULTIPLE UNIT SYSTEMS OF TRAIN CONTROL

BY HUGH HAZELTON,
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Electric motor power found its first application on single motor cars, and when its use was extended to train operation the single motor idea was for a time retained. Placing all the electrical apparatus on one car has the obvious advantage of simplicity and lowest first cost, and the use of a single motor car system was the natural and only feasible thing to do in the early development of the art. The first application of electricity to train operation was made at the World's Fair, Chicago, in 1893. The trains were made up of one motor car and three trailers. This installation was followed in 1895 by that of the Metropolitan West Side Elevated Railway, in Chicago, where similar equipment was used. The experience of these two roads demonstrated that electric traction was fully as reliable as steam, and more economical for this class of service. A single motor car pulling trains of several cars has, however, many of the limitations of the steam locomotive, and some of the pioneers in the art saw that important improvements could be made with electric traction, if the motors were placed on each car in the train and a suitable method devised for their simultaneous operation from the forward car. By such an arrangement the weight of the motive power equipment is distributed, and there is effective for traction as great a percentage of the total train weight as desired. The demand for more rapid acceleration and increased speed had forced steam roads to build successively heavier locomotives, which in turn required stronger bridges, heavier rails and better roadbed.

With an electric locomotive or a single motor car the problem of providing the necessary weight for traction is the same as with a steam locomotive, and an equipment designed for a specific service has the same limitations when increased service is desired. Frank J. Sprague was the first to point out the advantage made possible by equipping each car with its own motors and providing for their simultaneous control, and in 1885 he made the first concrete suggestion of such a "multiple unit system," with special application to the Manhattan Elevated Railway, in New York. The advantages enumerated by Mr. Sprague were as follows:

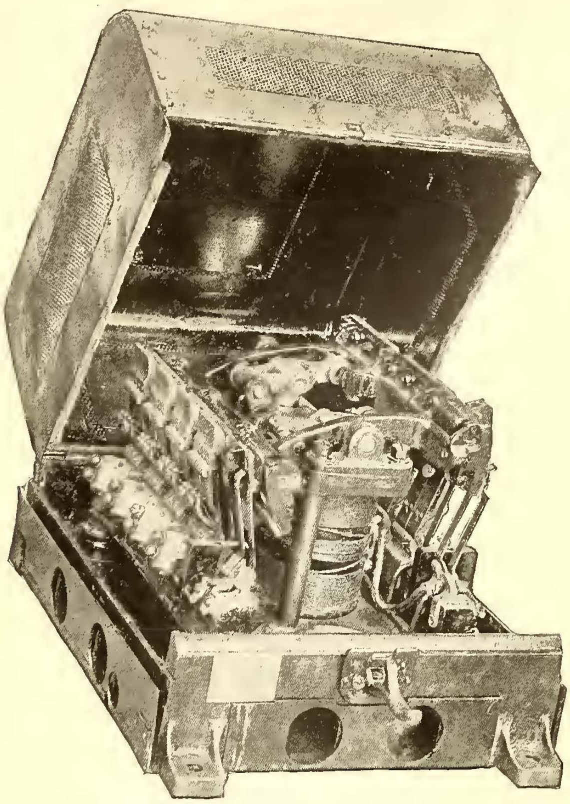
(1) The number of cars in the train may be increased at will, thus increasing the carrying capacity of the road.

(2) The speed of the trains may be increased, thus improving the service and also increasing the carrying capacity.

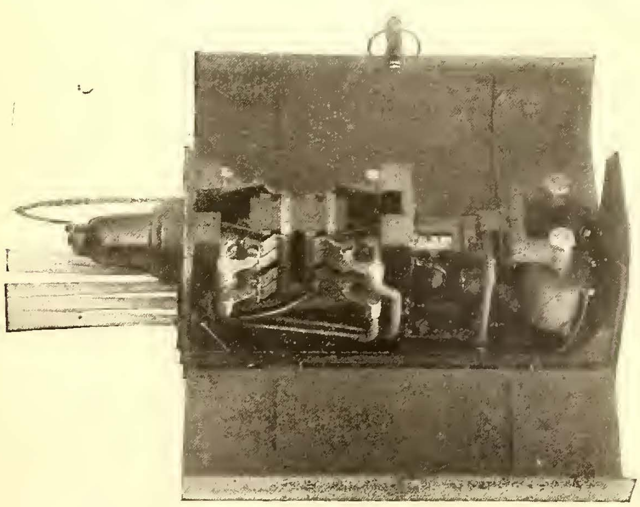
(3) Long trains may be run at the same speed as single motor cars and with equal facility.

These claims are now fully established, and all of the elevated and subway lines in this country and Europe, which have been installed within the past five years, have adopted some type of multiple unit control, and the earlier roads which adopted the single motor cars are already replacing them by multiple unit equipments.

Although multiple unit control apparatus found its first application on elevated railways for passenger service, it is now coming into use on interurban roads, and it may be of interest to consider its claims in this more extended field. The necessity for rapid acceleration on interurban roads is not as great as on elevated or subway roads, where the station distances are shorter, and the traffic demands on many interurban road may be supplied at first by single motor cars, but as the traffic increases it may become desirable to run trains of two or more cars. Unusual local conditions, such as fairs and ball games, also frequently make it desirable to run a number of cars together in a train. If the motive power equipment is designed for propelling a single car, the addition of trailer cars is sometimes impossible, if the road has steep grades, and it is always unsatisfactory, for it results in overloaded motors, reduced speed and unreliable service. If the cars have been equipped with multiple control apparatus it is possible to couple together as many cars as desired without increasing the load on the motors, or reducing the schedule, and the train of cars has the same ability to climb grades or start on a slippery rail as a single car. By adopting multiple control apparatus, therefore, no limitations are imposed which may restrict future increase of service.



SPRAGUE-GENERAL ELECTRIC REVERSER D. B. 26

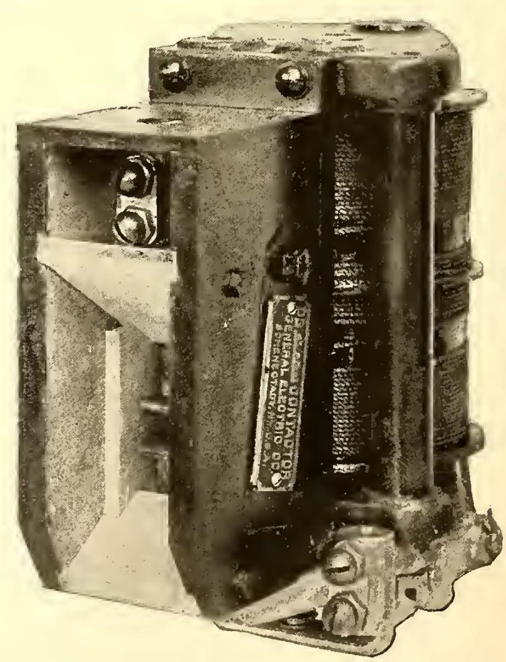


WESTINGHOUSE REVERSER, SWITCH TYPE 176C

The first operative system of multiple control was installed on the South Side Elevated Railway, in Chicago, and put into operation in 1898. The Boston Elevated Railway also adopted the Sprague control, of a somewhat modified type, and began the operation of its cars in 1901. The General Electric Company and the Westinghouse Electric & Manufacturing Company also developed multiple control apparatus, and sample equipments of the three types were put into competitive operation on the Boston Elevated and on the Brooklyn Elevated Railway.

In the original Sprague system a drum-controller placed on each motor car was operated by a pilot motor so attached as to give a step by step motion to the drum. A current-limiting relay was provided on each car to regulate the speed at which the drum controller was advanced through the resistance positions. The current operating the pilot motors on the several motor cars throughout the train was supplied through a control cable in circuit with the master controller, which was turned on or off by the motorman. The early form of Westinghouse control made use of a drum controller operated by an air cylinder with a ratchet arrangement. The air cylinder was provided with electrically-operated valves, and these valves were simultaneously operated throughout the train by control wires in the circuit from the master controller. A current limit relay on the forward cars provided automatic acceleration. In the original type of General Electric control a radical departure from the drum type of controller was made by substituting independent electrically-operated switches or "contactors;" each contactor consisting of a main switch with blow-out coil and a solenoid, wound for line potential at 600 volts. Similar contactors on the motor cars in the train are simultaneously operated by the control cable in circuit with the master controller. By the successive operation of the different contactors the resistance units are cut out until the motors are in full series; then the multiple connection is made and the resistance units again cut out until the motors are in full multiple. The original type of General Electric Control was adopted for the 800 motor cars of the Manhattan Elevated Railway, in New York, and put into operation in 1902. The control equipment supplied on this road does not include the current limiting relay, which accomplishes automatic acceleration, but this feature was included on the 430 motor cars of the Interborough Rapid Transit Subway, which were put into operation in New York in 1904.

There are at present on the market two types of multiple-control apparatus, known respectively as the Sprague-General Electric Control and the Westinghouse Electric Pneumatic Control. By the combination of the Sprague and General Electric Companies, the best features of the apparatus of both systems are brought together.



SPRAGUE-GENERAL ELECTRIC CONTRACTOR D. B.-41-A1

The "contactors" of the General Electric Company have proved greatly superior to the drum type of controller, and the Sprague-General Electric system now has the General Electric type of contactor switch and receiver, and the Sprague current limit relay and master controller.

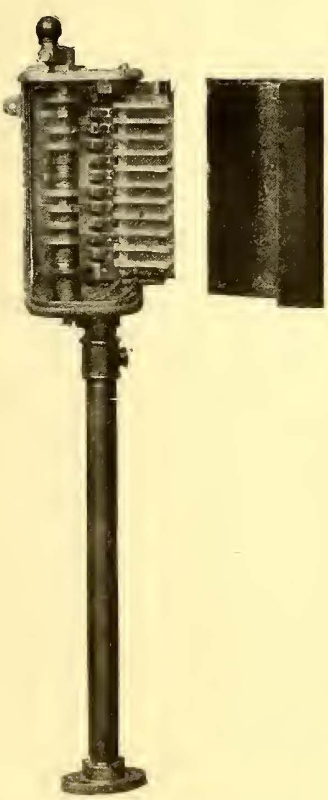
The Westinghouse Company has also adopted in its present electro-pneumatic control a "unit switch," or contactor, in place of the original drum controller, and this switch is operated by means of an air cylinder with electrically-controlled valves. It is worthy of note that while the design of the mechanism has been radically changed and materially improved, the fundamental principles of operation, defined by Mr. Sprague and incorporated in his original apparatus, have finally been adopted almost unchanged by all manufacturers of control apparatus to-day. As a practical uniformity of results is obtained by the control apparatus of both systems now on the market, some attention will be given to the advantages common to both, and a comparison of the more important features of difference in the design of the apparatus supplied by each company.

CONTACTORS

In both systems independent switches, or contactors, are now used for closing and opening the main motor circuits. With these independent switches large current values may be handled with greater safety and certainty than was possible with the drum type of controller, for a wider air-gap and stronger magnetic blow-out is provided, and the contacts of the independent switches open more quickly than was possible with the revolving drum controller.

In the General Electric contactor the contact fingers are closed and opened by a solenoid wound for line potential, which is operative between the limits of 300 and 750 volts. The advantages claimed for this design are simplicity and low cost of maintenance, by reason of the small number of working parts.

The Westinghouse contactor consists of a similar switch and blow-out coil, but an air cylinder is provided for opening and closing the contact fingers of the switch, and electro-pneumatic valves for controlling the admission of air to the cylinder. The valve magnets are energized by current at 14 volts potential, supplied by a duplicate equipment of storage batteries. In the present design the Westinghouse contactor provides a wider air-gap between the contact fingers when open, and greater pressure to the contacts when they are closed, than in the General Electric design. The amount of air-gap and pressure necessary for satisfactory operation is, however, capable of definite determination, and with either solenoid or air cylinder operation, results equally satisfactory may be secured. The rapidity of closing the contacts is less with air operation, and the wear resulting from the hammer blow correspondingly less. While the use of 14 volts potential for the operating circuits makes it necessary to install and maintain duplicate storage batteries on each motor car, there are compensating advantages, for the operation of the contactors is made independent of line voltage and of interruptions of current on the forward car. Another advantage of the independent operating circuit is the possibility of stopping the train, even in the unusual event of simultaneous failure of brakes and power supply, by reversing the master controller handle to multiple so that the motors are made to act as generators.

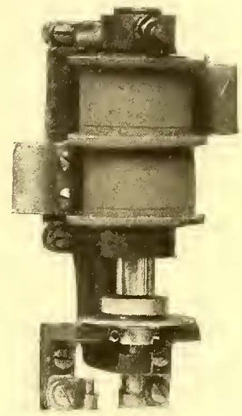


SPRAGUE-GENERAL ELECTRIC MASTER CONTROLLER

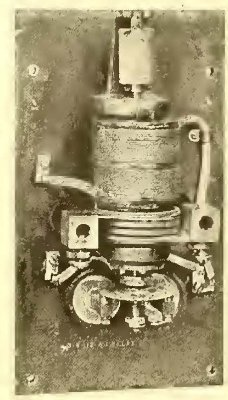
WESTINGHOUSE NO. 12 MASTER CONTROLLER

CURRENT-LIMITING RELAY

The current-limiting relay, common to both systems, consists of a solenoid placed on each motor car through which the current of one motor passes. The armature of this solenoid is attached to a contact disc which opens and closes the operating circuit for the main contactors. The operation of the current-limiting relay may be described as follows: In starting the train the motorman usually turns his master controller to the full multiple position. The current is first completed to the contactors that connect the motors in series with all resistance in circuit. This connection is maintained, and the armature of the current-limiting relay is drawn up until the counter e. m. f., due to the increasing speed of the motor armatures, causes the current in the motor circuit to drop to a value which no longer holds up the armature of the current-limiting relay. This armature then drops and makes connection to the operating circuit of the next resistance unit. The contactors are thus interrupted in their progression at each successive step, so that a nearly constant amount of current is allowed to the motors during the period of acceleration until the motors are in full multiple without resistance. The current-limiting relay is now recognized as an important, if not a necessary, feature of multiple control systems, and its use provides operating advantages which are not obtained in any system of hand control. With the hand controller the motorman starts his car as quickly or as slowly as his judgment or caprice may dictate, and the slipping of the driving wheels is the only limitation to the amount of current imposed upon the motors in starting. For heavy electric service it is specially desirable that the current used in starting trains shall be kept within certain well defined limits. Consideration of speed requirements and economical use of power, fix the minimum rate of acceleration and the corresponding minimum starting current, while the maximum allowable acceleration and starting current is defined by the following considerations:



WESTINGHOUSE CURRENT-LIMITING RELAY



SPRAGUE-GENERAL ELECTRIC CURRENT-LIMITING RELAY

(1) Excessive starting current results in violently fluctuating loads at the power house, and in order to meet these demands, the power equipment must be increased in output and the line equipment in carrying capacity. On interurban roads, where the number of trains on the line is small, the fluctuations due to heavy starting currents is especially objectionable.

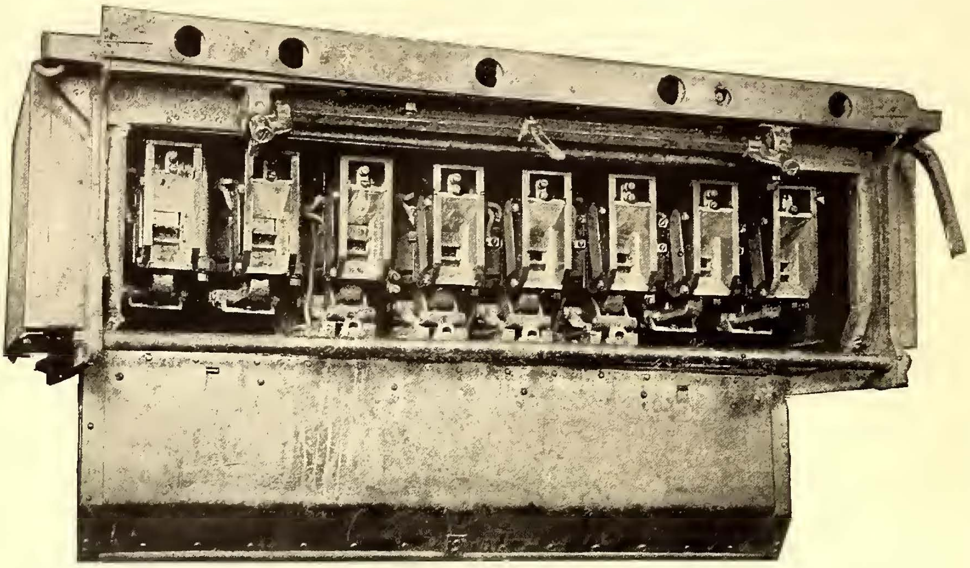
(2) Excessive current applied to the motors results in destructive mechanical strains which materially increase the maintenance charges on gears, pinions, armature shafts and bearings. On an elevated road which has recently discarded hand control for multiple control with automatic current input, the number of motors laid up in the shop for repairs is now only four, where formerly it was fourteen. With the current limit relay on each motor car, each motor does its share of the work, irrespective of possible differences in wheel diameter or variation in the electrical characteristics of the different motors.

MASTER CONTROLLER

The provision made in the master controller, of both systems of control, for opening the main circuit and applying the air brakes whenever the motorman releases the controller handle, is considered a valuable safety feature, and its application is so simple as to well warrant its use. The master controller on both systems is very small and compact, as it handles only the small currents of the operating wires. In the Sprague-General Electric system the control circuits require not over 2½ amps. at 600 volts, with two 125-hp motors, and in the Westinghouse system not over 10 amps. at 14 volts for a ten-car train.

LINE RELAY

In both systems a potential or line relay is provided which opens the main circuit whenever the supply of current from the line is interrupted. When the current is again restored to the line the contactors are closed through successive resistance steps before returning to their former positions. This device obviates the shock which would otherwise occur in passing over road crossings or turnouts where the continuity of the third rail is broken.



GROUP OF SPRAGUE-GENERAL ELECTRIC CONTACTORS IN CASE WITH COVER OPEN

BUS LINE

In connection with multiple systems of control, it is often advisable to install a bus line cable throughout the train connecting the several contact shoes, so that in case the shoes of one car are not in contact with the third rail, the motors of this car may receive current through the bus line from the other cars. The bus line greatly facilitates operation where it is necessary to interrupt the continuity of the third rail at street crossings or yards, and at such points a continuous supply of current for motors and for car lighting is thereby maintained. The bus line also serves to eliminate motor flash-overs, which sometimes occur when the cars are running at high speed, and the supply of current is suddenly interrupted and restored, as is the case when the contact shoes on one car momentarily lose contact by striking a high joint or an approach incline. In the case of snow or sleet on the third rail, the bus line serves to distribute current to all cars in the train from any car which may secure contact with the third rail.

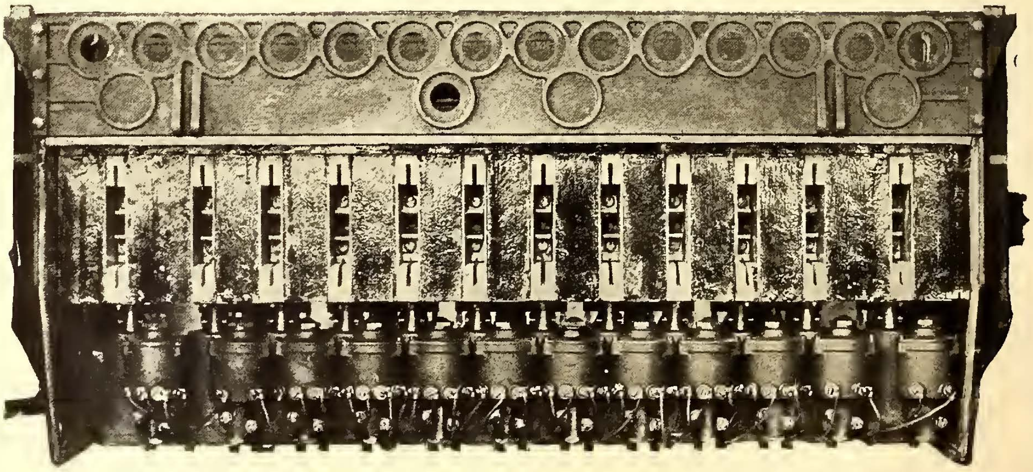
CIRCUIT BREAKERS AND FUSES

For the protection of circuits against excessive current, circuit breakers and fuses are used in connection with multiple control apparatus. Fuses are usually placed in the circuit from each contact shoe, and a common form of shoe fuse consists of two copper wires, about No. 9 B. & S., connected in multiple with suitable terminals and placed on the wood beam that supports the contact shoe. Some of the large roads are using enclosed fuses of 400 amps continuous-carrying capacity in place of the copper wire fuses. For protecting the main motor circuit some roads are using fuses and some circuit breakers. The type of fuse most widely used for the purpose consists of a copper ribbon 10 mils in thickness and 1¼ ins. wide, placed in a fireproof box with magnetic blowout. A hole ½ in. in diameter is made at the center of the ribbon, so that the fuse will begin to melt at the center. A copper ribbon of this size will carry 400 amps. continuously. For larger capacity the number of copper ribbons is increased. These fuses will open an overload or short-circuit with entire safety, and the cost of renewals is small. They do not open a short-circuit with as little noise and flash as the enclosed type of fuse, however. When a circuit breaker is placed in the main motor circuit it is arranged with a tripping device, placed in the motorman's cab, and in some cases the circuit breaker may be reset from the cab also. There is some doubt about the advisability of resetting the circuit breaker until an examination of the cause of its opening is made, and the trouble remedied.

In equipping cars with multiple control the practice of placing all the apparatus under the car has now become standard. The main motor circuits are all kept below the car, and the wiring is done in iron conduit pipes, and the bottom of the car is thoroughly protected by fireproof material. These precautions have greatly reduced the risk of fire, and on one of the elevated roads in Chicago, which has recently replaced its original hand control by multiple control apparatus, the underwriters have voluntarily reduced the fire insurance rate. The reduced fire risk is also given as the controlling reason for the installation of multiple control apparatus on single-motor cars on one of the street railway lines recently opened in Boston.

Before leaving the subject of multiple control, a word should be said concerning the reliability of the apparatus in service—for this is the final measure of merit.

During the first years of its introduction, the most serious obstacle against the adoption of multiple control was the apparent complication of the system, which suggested a doubt as to whether it could ever be operated with as few failures as the simpler apparatus of hand control. The experimental stage is now past, however, and in the more modern types of multiple control it is safe to say that the apparatus is fully as reliable in operation as hand control, and it has the ability of handling much larger current values. On the Manhattan Elevated Railway, in New York, where there are over 800 motor cars in daily service, the number of delays to service chargeable to failure of control apparatus averages only about five per month. It is the practice to inspect the control apparatus on this road once every three days, and except for occasional cleaning, little work is necessary.

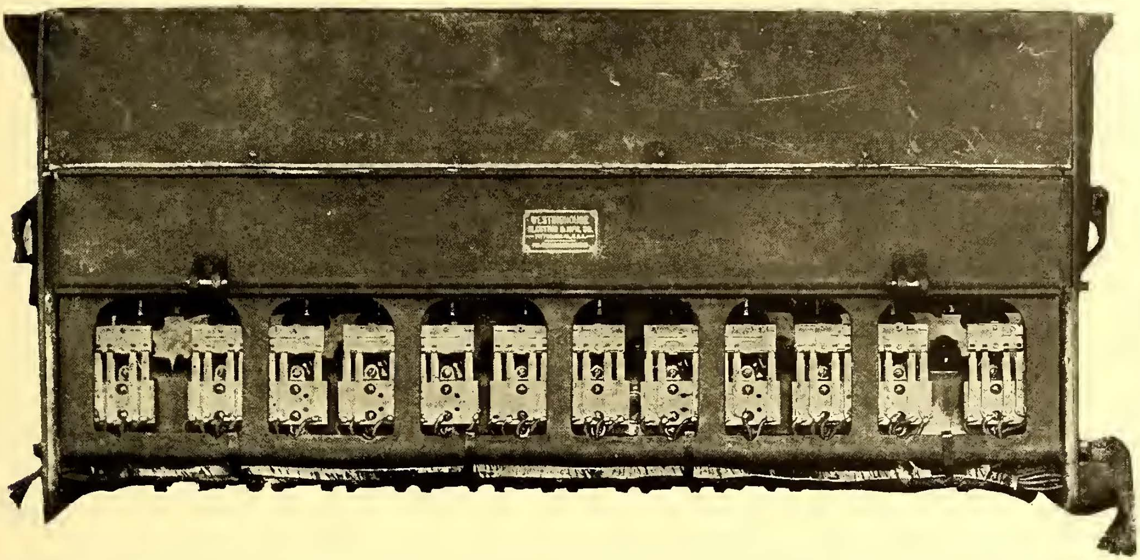


WESTINGHOUSE UNIT SWITCH GROUP TYPE 253, REAR VIEW, COVER REMOVED

In conclusion, the writer would express the hope that this paper may serve to emphasize the merits of the multiple control system for many interurban and street railway lines where the limitations of hand control have stood in the way of the best service and most complete development of the property. The ability to run cars in trains of any desired length, without reduction in speed, and without overloading the motors; the advantage of limiting the current during acceleration to a predetermined value, and the decreased fire risk by placing the control apparatus under the car, are features of the multiple control system which warrant the attention of all progressive railway men.

THE SERIES-PARALLEL RAILWAY CONTROLLER

BY W. A. PEARSON
Electrical Engineer, New York City Railway Company



WESTINGHOUSE UNIT SWITCH GROUP, TYPE 253, FRONT VIEW, COVER REMOVED. (SEE PAGE 568)

When the first electric railways were put into operation one small motor was considered sufficient to propel a car. On some of these early equipments in which shunt motors were used, the brushes were designed to be moved around the commutator for the purpose of reversing the direction of rotation, it being considered impossible to provide the same neutral commutating points for both directions. In developing the series motor it was found that common neutral points for both directions of rotation could be produced, permitting the use of a double pole, double-throw switch for reversing the connections of the armature leads.

The simplest way to start and control the speed of the single motor was to use a dead resistance in series with it. This method, which was adopted, has been successfully used for single motor equipments since the earliest days of the art. To meet the increased requirements of heavier cars and higher speeds, a second motor was added to the equipment. As the rheostatic control had proved sufficiently satisfactory for one motor equipment, it was also considered suitable for two motors permanently connected in parallel. Consequently a heavier rheostat was used with two motors connected in this manner.

At first a reversing switch similar to that used for a single motor was employed, the armature leads from the two motors being connected in parallel. This connection was soon found to be impracticable owing to the unbalancing of the load on the two motors, and necessitated the use of separate reversing switches.

In order to obtain an efficient running speed at somewhat less than the full speed of the motor, several methods of varying the field strength were tried with different degrees of success. Some motors were provided with field taps, or "loops," the full field being intended for use in starting and in ascending heavy grades. The field strength was weakened by cutting out a portion of the winding by means of the tap, thereby allowing more current to pass through the armature, increasing accordingly the speed of the motor. Another method consisted in connecting sections of the field coils, first in series and then in parallel, to produce different field strengths. These two methods were used for a few years, and finally abandoned owing to troubles resulting from the burning out of field coils. In the next field variation method that was used, a resistance was placed in shunt around the fields of each motor, thereby accomplishing the same result, but in a somewhat different manner. This also led to complications, as motors were operated under such varying conditions. In some cases the full field point was used excessively by the motorman, the coils becoming overheated, and in other cases the shunt point was used too much on heavy grades, resulting in armature and commutator troubles. Field variation for obtaining speed control was abandoned by the manufacturers of railway motors about nine years ago, and since that time but two speeds have been provided without series resistance in controllers supplied with two-motor equipments.

About fourteen years ago the attention and energies of manufacturers of railway apparatus were applied to the development of a control for two motors, which, when starting or running slowly, would waste less power than the rheostat and would permit running efficiently at half speed. The method which seemed to promise the best result was to start the motors in series, and after they had reached their full speed for this position, reconnect them in parallel. Many different experimental controllers were constructed in the attempt to produce a satisfactory piece of apparatus. Nearly all original electrical apparatus was crude as viewed from our present standpoint, to which view these early series-parallel controllers formed no exception.

One of the forms was fan-shaped with a stationary slate board to which were secured the motor, resistance and other contacts, with a movable arm, pivoted at its lower end, and adapted to move from side to side of the slate board, thereby making the necessary circuit combinations. This form was defective for two reasons. The circuits made were not suitable for giving proper speed variations, and no adequate means were provided for breaking the arcs formed at the contacts. Several different manufacturers attempted to design controllers of this shape, both for single motors and two motors, but without success.

A more successful series-parallel controller was brought out in 1892, which was located beneath the car and operated by means of rods and bevel gears from either platform. This controller was used in conjunction with the same reverse switch as was used with the rheostatic control. It was expected to fill the great want, but after several hundred had been put into service it was found that improvements were necessary. The starting of the car with this form of controller was jerky, as an insufficient number of points had been provided, while the impossibility of properly installing the controller under the car, so that lost motion in the gears would not be excessive, produced serious burning at the contacts. This controller contained a magnetic blow-out for disrupting arcs, which was very much superior to anything made previously and which served its purpose in proving the value of the magnetic blow-out. It was also the first controller which shunted one motor in passing from series to parallel.

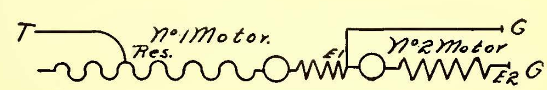


FIG. 1

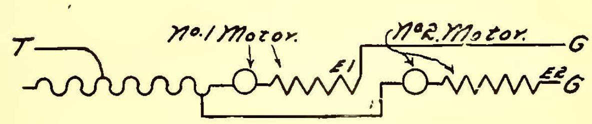


FIG. 2

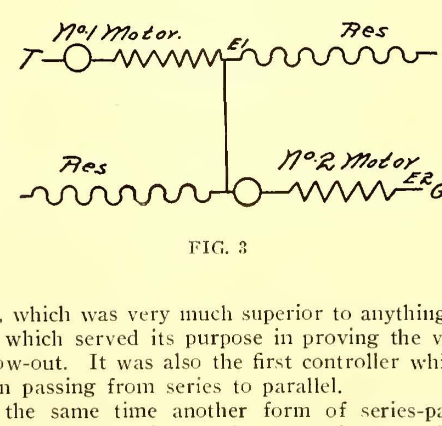


FIG. 3

At about the same time another form of series-parallel controller was brought out by another manufacturer, in which a cylinder was used in conjunction with stationary contacts, or fingers, for producing the different resistance and motor combinations. As it was installed on the car platform it did not require operating mechanisms and was in consequence simpler in construction and not liable to the troubles due to lost motions in transmitting the turning effort from the operating handle. This controller also met with partial success, although the arcing at contacts was considerable, which, in the absence of a magnetic blowout, caused the principal trouble. These two forms of controllers clearly demonstrated the practicability of series-parallel control, and demonstrated that the magnetic blowout to take care of arcing, and the cylinder for compactness and simplicity, were necessities in the design of a controller for operating two motors of the capacity about 30-hp, then used.

The final outcome of the series-parallel controller for street car service was the present well-known K-type, which has been practically standard for about twelve years. This controller owes its success very largely to the form of magnetic blowout employed for extinguishing the arcs formed in opening the circuits and the method of making the transmission from series to parallel. Other forms of magnetic blowouts differing in detail have since been designed which have operated satisfactorily, but the form used in

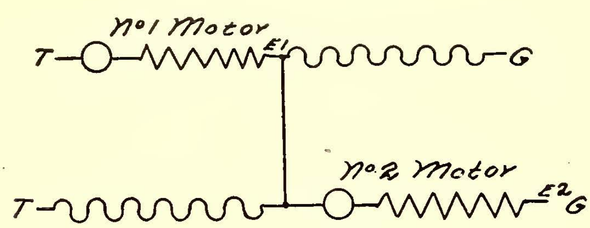


FIG. 4

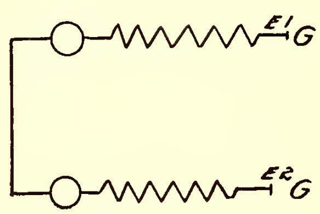


FIG. 5

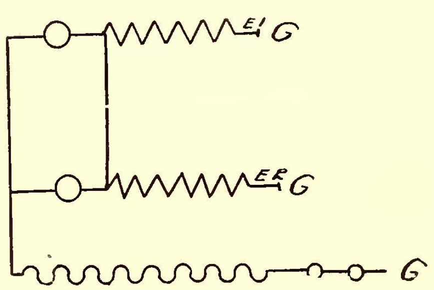


FIG. 6

the K-type of controllers was the first to be made commercially successful.

In this type of controller, after the motors have reached the full series position, a portion of the starting resistance is quickly reinserted in the circuit and a shunt is put around the No. 2 motor by connecting E-1 to ground, thereby eliminating that motor from the circuit, as shown in Fig. 1. Immediately after this circuit has been established the connection between No. 1 and No. 2 motors is broken, and the positive lead to armature of No. 2 motor is connected to the rheostat, while the line current then passes to No. 2 motor, and the motors are in parallel, as shown in Fig. 2.

In the L type of series-parallel controllers, instead of maintaining the current through one motor during the transition, the circuits of both motors are broken. This method of passing from series to parallel was adopted in railway controllers for motors of a total of over 250 hp. It was found that the arcing in the controller when using the K-type of connections was too great to permit their use in large controllers.

In the development of multiple-unit control it was found that a better method of making the change from series to parallel, which had been proposed before the first K-type of controller was made, was possible with separately actuated switches or contactors. This is what is known as the "bridge method," and consists in keeping the current on both motors during the transition. Each motor is provided with a separate resistance, and when full series has been reached the connections are as shown in Fig. 3. When passing from series to parallel the first transition step is with resistance for No. 1 motor connected to the ground, and resistance for No. 2 motor connected to trolley, as shown in Fig. 4. It will be seen that this last step has put the two motors in multiple with an equalizing connection between E-1 and the positive side of the armature of No. 2 motor. This equalizer is next open circuited, and the motors are in the first parallel position. This method of making the series to parallel change permits a somewhat smoother acceleration than with the K-type of connections, but it is not essential for light equipments where great smoothness is not such an important consideration, as on heavy cars operating with multiple-unit control.

Several attempts have been made to produce a control which would be still more economical in use of power than the series-parallel method now in use. One of these, on which a considerable amount of ingenuity has been expended by different inventors without producing satisfactory results, consisted in providing a "counter electromotive force generator" in series with the motors, so that they should not require any resistance to consume energy in starting. This scheme proved complicated and expensive, and in actual service the proportionate time consumed in operating motors at below half speed, or between half and full speed, was so inconsiderable that there was no saving in power of consequence. Another method, somewhat attractive to those unacqainted with the excessive complications involved, consisted in the use of shunt field motors with control connections arranged for generating current and returning it to the line when stopping the car or descending grades. A number of patents have been taken out for different means of accomplishing this result, and various attempts have been made to produce a satisfactory motor and control. It is very attractive in theory to be able to make the motors on a car generate useful current, but there are a number of obstacles which have thus far prevented practical realization. The motor must be provided with a shunt field with apparatus for varying its strength, dependent upon the speed while braking, and apparatus must also be provided for giving practically a straight series field for starting. In addition, it is necessary to connect the armatures in parallel and series relation for braking, according to the speed of the car. When the armatures are in series, and the field strength is at a maximum, the minimum car speed at which current at line potential may be generated is obtained. It is obvious that when the car is moving at a speed less than this critical speed, the motors will be taking current from the line instead of furnishing it.

On a K-10 controller, or similar two-motor equipment, it is a well-known fact that in an emergency the car may be stopped when the trolley is off, or main fuse blown, by throwing the reversing handle to its backward position and turning the controlling handle around to multiple. The connections made are such that the two motors are really connected in series, as shown in Fig. 5, but in such a manner that the voltages of the two armatures oppose each other. If these voltages were exactly the same there would be no flow of current, and consequently no braking. As a matter of fact no two motors are identical, and the slight difference in initial voltage gives one motor predominance over the other and determines the direction of the flow of current, one being obliged to reverse its polarity. This can be readily accomplished, as the changing motor is operating as a series generator. If the car is moving at any more than a very moderate speed the current generated by the two motors will almost instantly reach an amount sufficient to slip the wheels. As the momentum of the car tends to throw more than the normal weight upon the front wheels, and relieve the rear wheels of a corresponding weight, it is to be expected that the rear wheels should slip first. The instant the wheels slip the motor on the same axle naturally ceases to generate current, but as current from the other motor is flowing through it, it is rotated in the reverse direction as a motor. It is well for motormen to know that an effective braking can be accomplished in an emergency by this method.

On four-motor equipments where two motors are permanently connected in multiple, it is only necessary to throw the reverse handle to cause the motors to generate, as the circuits are already made, and it is only necessary to reverse the relation of armature and fields. With a four-motor equipment, care should be taken that the car is brought to rest before the reversing handle is returned to its forward position, otherwise the contacts are liable to be burned. A recent controller, known as the K-28, has been provided with extra air space in the vicinity of the reversing contacts, while barriers are located between them, so that the chance of injuring the reversing switch when "bucking" the motors has been removed

When motors have been used with electric brakes the controller made connections somewhat different from the foregoing, as it was necessary to vary the quantity of current taken and divide the load equally. Fig. 6 shows the connections.

Electric brakes have not proved very satisfactory, principally for the reason that their action was too irregular, and they could not always be depended upon. In order to generate current satisfactorily it was essential that the commutator should be in good condition. A comparatively slight increase in the resistance of the circuit, caused by a dirty commutator or loose connection, would prevent a motor from building up at a certain speed. Due to this irregular action in the motor it was sometimes difficult to make a smooth stop with electric brakes. It was also found that the high voltage and additional duty imposed upon the motor was productive of commutator trouble and overheating.

The duty required of a street car controller has gradually increased. Instead of two 30-hp motors as formerly, four larger motors are now controlled in the same space. Voltages have been increased and the capacity of the line also raised, so that when an extraordinary arc occurs in a controller from any cause the damage is greater than formerly. For this reason it is especially necessary to keep fingers properly adjusted, segments renewed and connections tightened to avoid troubles on the road.

There is a growing tendency to place controlling apparatus for large and medium size motors under the car. It removes the heavy capacity parts from the platforms and not only leaves a greater passenger space but also eliminates all possibility of danger from controller "blow ups."

PAPERS PREPARED BY THE COMMITTEE ON TRACK

ASSEMBLED BY FRED G. SIMMONS,
Superintendent of Construction and Maintenance of Way, the Milwaukee Electric Railway & Light Company

THE TREATMENT OF RAIL-JOINTS

BY FRED G. SIMMONS

The treatment of rail-joints is undoubtedly one of the most important matters concerning both construction and maintenance which obtrudes itself upon the consideration of the "way" engineer, and its more or less successful solution interests in an almost if not quite equal degree the superintendent of transportation and superintendent of rolling stock, who are responsible for the cars operating over the joints; and the power house man and electrician, whose current efficiency depends largely upon their condition. Allowing the unquestioned interest of the financial and managerial representatives, we find the subject to be one in which practically the entire staff is vitally concerned. It is, therefore, impressed upon us that a fairly successful method of treatment constitutes information which it becomes the duty of this association to place before the electric railway world.

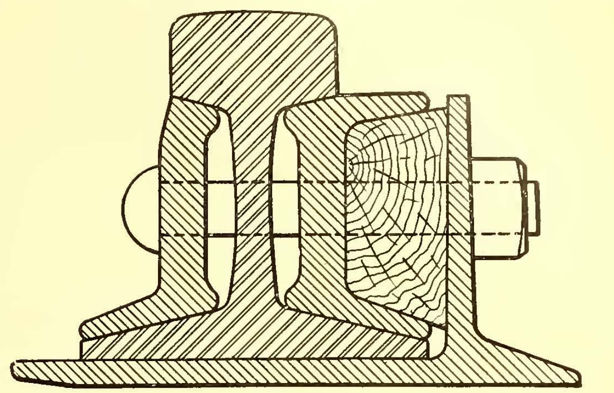
It would probably be a hopeless task to ask any body of men to establish a standard or uniform method of treating the rail-joints, as several methods may approximate in point of efficiency and the local conditions influence each particular individual in forming a preference for his own method, provided that method has rendered a fair degree of satisfaction in the past. The idea of the writer, however, in taking up this broad subject has been to set before the electric railway interests as nearly as possible exact data as to the most successful methods now employed in bringing about the maximum of efficiency in the treatment of rail-joints with regard to both electrical conductivity and surface and alignment.

It is undoubtedly a fact that many roads, particularly the smaller ones, are continuing to use some inferior and inefficient type of joint, solely because they have been unable to obtain comprehensive information as to some more reliable and more satisfactory type. The failure of one person or system to obtain proper results has often unjustly condemned some type of joint in the minds of many persons, when the reason for such failure may have been, absolutely, a lack of proper knowledge and proper workmanship in the application thereof.

The present most accepted methods are divided into two exact types: (First) the mechanical joint, bolted, riveted or wedged, and connected by means of a metal bond for the passage of electricity with the least possible resistance. (Second) The various kinds of welded joints (thermit, zinc, electrical or cast). The first type applies more particularly to interurban or exposed track, the second type to urban or buried track.

In Milwaukee the Weber joint has been in use nearly eight years, the first joints applied have been entirely undisturbed up to the present time, no work has been done on them, and not one low or battered joint has developed. With constant use on a double track for a period approaching eight years the writer considers this a first-class showing. The joints are used on a 56 lb. section of ordinary T-rail, and the summer traffic particularly is very heavy. Accompanying engravings show the latest improved type of both the Weber and the Continuous joints.

Information received through correspondence would indicate that many consider the Continuous joint a very satisfactory one. The

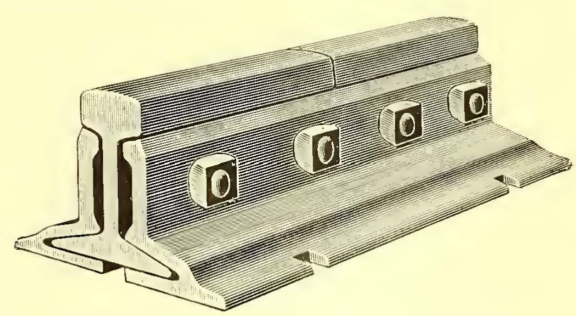


WEBER RAIL-JOINT

following letter, received from H. S. Cooper, general manager of the Galveston City Railway Company, of Galveston, Texas, is an interesting one, and is a fair expression of the sentiment of the country in this matter as nearly as the writer has been able to ascertain:

Dear Sir—We are in receipt of your letter of March 3, enclosing by-laws, etc., of the A. R. M. E. A., and note your inquiries in regard to Continuous rail-joints. In our work here we absolutely could not do without a Continuous rail-joint, or one fully as good. We have in use quite a number of miles of 40-lb. and 45-lb. T-rail, left over from the horse-car days; also our standard for unpaved work—60-lb. A. S. C. E., and in our paved portions a 6-in. 60-lb. T-rail, on all of which we use the Continuous rail-joint. Owing to the saltness and dampness of the atmosphere and soil of this place, exposed rails rust very rapidly, and, with ordinary fish-plate or angle-bar, we find it impossible to get a suitable joint after the rail has started thoroughly rusting, whereas, by using a Continuous rail-joint, we are able to maintain our joints in nearly as good condition as the balance of the rail.

Of course, we have to use great care in the application of the joint,



CONTINUOUS JOINT

making positive that we get a good fit by cleaning the roughness from the rail, by seeing that the joint is thoroughly in contact its whole length and well driven up, and by making certain that the bolts are completely and permanently tightened. On new rail, especially where it is put in paving, we keep on tightening the bolts and slowly driving up the joint as long as it is possible to do so, and until the paving is put in, as we find that, similarly to any joint we have tried, no matter how tight the bolts and plate are made when first put on, there are a number of small "lumps" or inequalities" in both joint and rail, which prevent it being made absolutely tight, and with the running of the cars over the joints for a few days, it seems to cause a motion between the plate and joint that rubs down these inequalities to a certain extent, and allows both joints and bolts to be tightened a little more. In practice, we clean both rail and joint thoroughly and swab the rail surface with some cheap oil, apply the joints with bolts, driving up the joints all that is possible, hammering up the bolts and tightening with from an 18-inch to 24-inch wrench, one man. After a few days we send a man over with a light hammer and wrench, and have him tighten up every bolt by hammering the head lightly while he puts his weight on the nut, and, if there is an opportunity to repeat this operation before the track is closed up by paving or otherwise, we do so.

We have quite an amount of 6-inch rail laid in brick, on all of which these joints have been used, and have had but very little trouble from loose joints in this rail, some of which has been down two or three years. In all, I do not believe that we have had to take up or retighten more than fifteen or twenty joints out of quite a number of hundreds. As stated above, we think it is very largely on account of proper and thorough application of the joint, and the writer personally knows, from a large experience in other places, that where complaints have been made as to Continuous joints, or of the Weber or Atlas types, the trouble has been largely due to imperfect application in the beginning, and to lack of proper inspection afterward.

Properly applied and in proper location, I think there is very little choice between the three types of joints above mentioned, so far as the practical results of keeping joints in good shape are concerned.

H. S. COOPER,
General Manager, Galveston City Railway Company, Galveston, Tex.

The question of electrical conductivity in relation to the mechanical joint affects them all in relatively the same proportion. The method of bonding the rail ends so as to secure the necessary degree of effectiveness is a subject of such importance that we have decided to assign it for consideration in a paper by itself. The writer believes, however, that either of the two types of joint mentioned heretofore lends itself equally to any of the more approved methods of bonding.

The study of the various methods of welding the rail ends is, we believe, more particularly interesting to all those roads which have a large proportion of urban trackage, the rail of which is buried in the dirt, macadam or paving of a public road or street, accommodating itself more thoroughly to the somewhat unusual conditions imposed by the formation of a practically continuous and unbroken stretch of steel.

The writer is aware that the officials of many roads are outspoken in their opposition to any rail-welding process, and in numerous cases claim a more or less disastrous experience either on their own part or within the range of their observation as

COMPLETE WELDING OUTFIT FOR THE THERMIT RAIL-WELDING PROCESS

sufficient reason to warrant their adverse opinion. We believe that all these unsuccessful experiments in rail welding are due either to unusual local conditions, which in no way affect the general proposition, or to a failure to thoroughly appreciate the requirements necessary to a proper and efficient handling of the work; these requirements varying, of course, with the various methods. The correspondence carried on relative to these matters has convinced the writer that each of the four methods mentioned earlier in this article, viz.: thermit welding, zinc welding, electrical welding and cast welding, is capable of successful demonstration, and that track so treated can be made in each case more efficient both as to mechanical strains and electrical conductivity than by any other known methods.

In order that a more general knowledge of the practical application of the welding of joints may be spread broadcast over the country, we have had papers prepared treating on these four approved methods and have been able to secure in each case an engineer whose experience has been such as to insure an article prepared from certain knowledge. These papers follow:

THERMIT RAIL WELDING

BY G. E. PELLISSIER,
Civil Engineer, Holyoke Street Railway Company

The "Thermit" process of welding steel rails dates from the year 1899, and is the discovery of Dr. Hans Goldschmidt, of Essen, Germany.

Thermit, as described by the discoverer, consists of a mixture of powdered aluminum and iron oxide, and its application to welding depends upon the following fact: If the mixture is ignited at a single point by means of a special ignition powder, peroxide of barium and aluminum, combustion proceeds without further supply of external heat and without any combination with the oxygen of the air, at the same time developing a temperature estimated at 3000 degs. C. By the reaction the iron oxide is reduced to nearly chemically pure iron, the oxygen of the iron oxide combining with the aluminum to form aluminum oxide or artificial corundum, the reaction being chemically expressed by the equation $Fe_2O_3 + 2Al. = Al_2O_3 + 2Fe$.

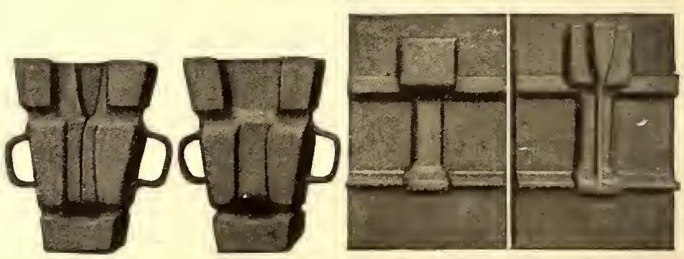
The aluminum oxide, having the lower specific gravity, separates from the iron, rising to the top, where it may be decanted off or the pure iron drawn from beneath. This iron, when poured upon metals to be repaired or welded, has the property of uniting intimately with them, due to the very high temperature to which it is raised. When used for welding, steel or other ingredients, such as carbon, manganese, etc., are added to the thermit mixture to give the resultant metal more or less the properties of the steel with which it unites.

The reaction is carried on in a special crucible made of sheet iron lined with some very refractory material, usually magnesia or aluminum oxide the by-product of the reaction itself.

RAIL WELDING

The complete outfit for welding steel rails consists of the crucible just described, a pair of molds made to fit the section of rail to be welded, a pair of clamps to hold the molds in place, a wire brush to clean off the dirt from the ends of the rails, a small gasoline torch to dry off any moisture which may be present on the parts to be welded and to take the chill out of the metal, and a portion of thermit weighing from 15 lbs. to 25 lbs., depending on the section of rail to be welded. If an absolute butt weld of the ball of the rail is desired, a pair of heavy clamps for upsetting the rails while hot is also necessary. The whole outfit is easily transportable in an ordinary wheelbarrow.

The molds are easily made, being simply sheet-iron flasks filled



PATTERNS AND MOLDS

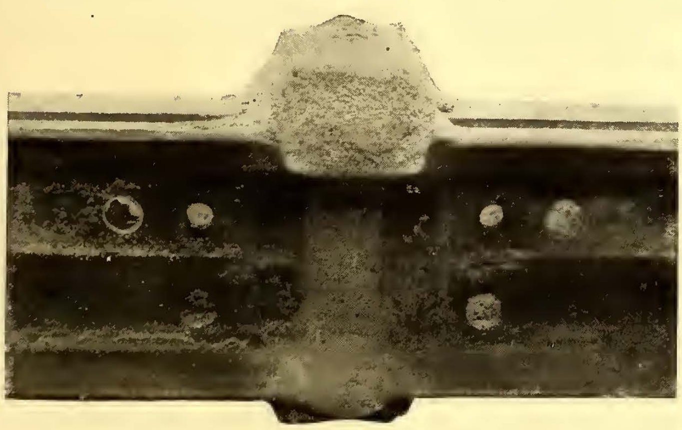
with a mixture of clay and sand, or any other material suitable for steel casting. The only precaution necessary in making the molds is that they should be well vented and thoroughly dried. The flasks may be used repeatedly, of course, but have to be refilled each time after using. One man can fill from fifteen to twenty pairs per day.

In making a weld, the ends of the rails are first cleaned with the wire brush (this simply to get the dirt off, as rust makes no difference), and heated to dispel the moisture. The rails are then brought into exact alignment and the molds put on and fastened with clamps.

All contact lines between the mold parts and the rail are then luted with moist clay. The top of the rail is also painted with a thin paste of clay and water, which, when dry, prevents the slag and iron from adhering to the top of the rail. When a butt weld is desired, a pair of clamps is next adjusted to the ends of the rail so that they may be upset while hot. These are not deemed necessary, however, and are not generally used, as it has been found sufficient to simply weld the base and web of the rail. The molds are then backed up with sand. The crucible, which is set on a tripod, is next placed over the molds, with the tapping hole directly over the gate in the mold. A tapping rod is then placed in the hole, which is then stopped up by means of a couple of asbestos washers, a small iron disc, and finally a little refractory sand. The charge of thermit is then added and a little of the ignition powder placed on top, which is set off with an ordinary storm match. The reaction when once started proceeds rapidly, usually taking about 10 seconds, the molten mass boiling furiously. At the end of about 20 seconds more the boiling has ceased and the iron is separated from the slag. The crucible is then tapped and the metal flows into the molds, followed by the slag, and in less than a minute the joint is made. The joint is then allowed to cool about 15 minutes before the molds are taken off. This can be done three or four minutes after pouring, if necessary, as when welding while the cars are running. Two or three taps of a hammer will separate the slag from the joint, and the work is completed, no chipping or grinding being necessary except when welding old rails where the joints are battered, when, of course, the rails have to be ground down to an even surface. In case the two rails do not come together closely, a shim of steel may be inserted and welded in, completely filling the gap. The writer has made many joints in this manner with perfect success.

TAPPING CRUCIBLE

Four men constitute a welding gang, and eighteen or twenty joints can be made in a day of 10 hours. No skilled labor is necessary.



JOINT ON T-RAIL BEFORE REMOVING SLAG

The first place to experiment with this process was Essen, Germany, the home of the inventor. Owing to the importance of the rail-joint question, however, other European cities were not slow in investigating its merits. In 1900 about 1200 joints were made in various cities on the Continent. The results obtained from these were considered so satisfactory that the use of this method of welding increased very rapidly, some cities introducing it on an extensive scale, notably Leeds, England; Dresden, Austria, and Singapore, India. Twenty-six hundred joints were made in 1902, and 20,000 in 1903. In 1904 a company was formed in the United States to introduce the process here, and at the suggestion of the writer, who had followed the development of the process with considerable interest, the Holyoke Street Railway Company decided to use it on a mile of track about to be reconstructed.

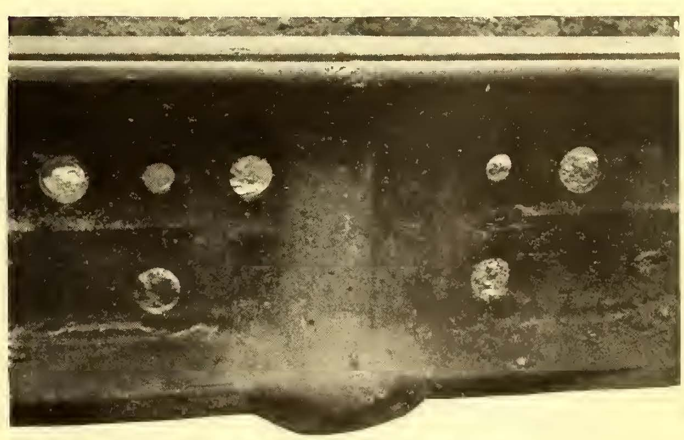
WORK DONE AT HOLYOKE

The rail welded was new 9-in. 107-lb. grooved Sec. P. S. Co., 228, known as Trilby section, the rails averaging about 55 ft. in length. The total number of joints made was 170. All joints were welded except those on the special work. Three joints were also made on the special work as an experiment, two being at the P. C. of a curve of 40-ft. radius, the other at the end of a frog. The longest piece welded continuously was about 2500 ft., both ends being bolted tightly to the special work. The welding was done when the temperature was between 80 degs. and 90 degs. F. in the shade. Of the total number of joints made, but two were imperfect, and these were immediately repoured. The cost per joint was about $6.23, divided as follows:

POURING JOINT

Thermit	$4.98
Molds per pair	.35
Labor and supervision	.60
Crucibles per joint	.25
Incidentals (shims, gasoline, etc.)	.05
Total	$6.23

This work has been down nearly a year now, and not a break has occurred, although the temperature has been as low as 10 degs. below zero. Many of the joints can hardly be detected at the present time, and the wear throughout the rail is perfectly uniform, showing that the rail at the joint has not been softened or injured in any way by the heat to which it was subjected. The alignment of the track has remained perfect both on tangent and on a curve of 300-ft. radius, which was also welded. A prominent street railway official, who has been connected with street railway work for

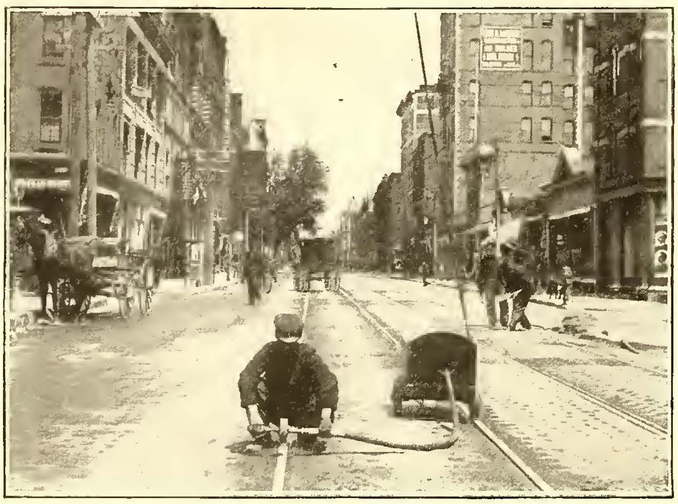


JOINT WITH SLAG REMOVED

many years, made the remark in the hearing of the writer that there was not a better piece of track in the United States.

As this work proved thoroughly successful, the company decided to weld about 1000 joints this summer. Of these, 400 are on 9-in. 107-lb. grooved rail which has been down about four years, 150 on 7-in. 70-lb. T-rail which has been down about six years, 100 on 6-in. 60-lb. T-rail which has been down about five years, and 350 on new 7-in. 90-lb. grooved rail. As nearly all of the rails to be welded are about 60 ft. in length, this will represent about 5 miles of track, all of which is in paved streets.

The work on the 9-in. rail has already been completed. Owing to the heavy traffic over some of the lines, about 200 joints had to be made between the hours of 12 and 5 in the morning,

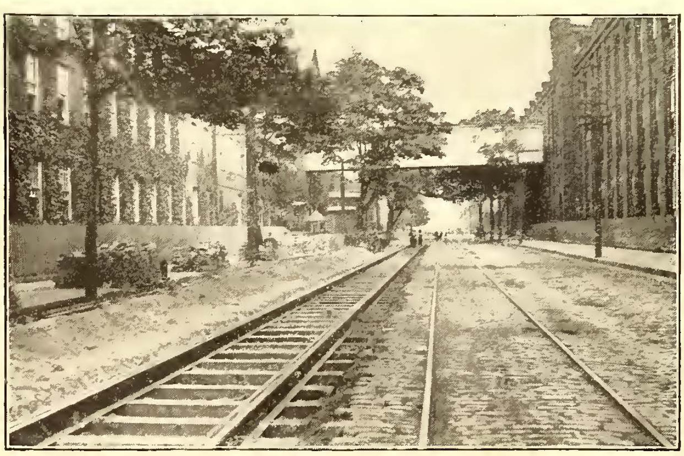


GRINDER FOR SMOOTHING JOINT

three men being able to weld from twelve to fourteen joints in this length of time. Where the time between cars was 10 minutes or over the work was done in the daytime, as the joints can easily be made while the cars are running without interfering with traffic. Of the total number of joints made, three (or less than 1 per cent) were imperfect, and had to be repoured. No breaks have yet occurred. The cost of joints on 9-in. rail made this year has been $5.25, divided as follows:

Thermit	$4.25
Labor	.50
Molds	.20
Crucibles, per joint	.25
Incidentals	.05
Total	$5.25

Data on the other sections of rails are not yet available, as the work is not yet completed, but as the charges for labor, molds, etc., remain practically constant, irrespective of the section of rail, it



TRACK AFTER WELDING

will be safe to say that the cost of joints will lay between $3.50 for 4¼-in. 60-lb. T-rail, and $5.25 for 9-in. 107-lb. grooved rail, these figures being based on present quotations for thermit. To this must be added $1.25 per joint for removing and replacing pavement when welding rails already laid.

Tests of the joint with a Conant bond tester which compares the resistance of 3 ft. of rail with a joint with that of 3 ft. of rail without a joint, show the conductivity of the joint to be practically equal to that of an equal length of rail. Tests of individual joints by determining the drop in voltage at the joints confirm these results. Tests of the joints made last year show no deterioration in conductivity. Mechanically the joint seems to be perfect. The following test will give an idea of the strength of the joint: A section of 9 in. 107-lb. rail 13 ft. in length, with the joint in the middle, was placed in the track on two ties, distance center to center of bearing 12 ft. 6 ins., and loaded double-truck cars weighing about 20 tons allowed to pass over it. The rail cracked through the bolt holes, but no harm was done to the joint.

The fact that we did not have a single break during the past winter shows pretty conclusively that the joint is, when properly made, sufficiently strong to withstand all stresses due to changes in temperature and those due to traffic. Joints sawed through the middle show that perfect amalgamation of the metals has taken place.

From what experience the writer has had with this process of welding, it seems to him to possess the following advantages: Simplicity, no skilled labor being necessary; lack of expensive apparatus, the whole outfit costing less than $100; adaptability to repairs and construction on moderate sized systems where the amount of work done at one time does not warrant the expense of maintaining an extensive apparatus and retention of skilled laborers, the possibility of welding on track already laid without interfering with traffic where the headway is 10 minutes or over, and last, but not least, the excellent results obtained both mechanically and electrically. Another point which has not been mentioned is the ease with which compromise joints of almost any description may be made by simply changing the form of molds.

JOINTS AND TRACK CONSTRUCTION IN PHILADELPHIA

BY H. B. NICHOLS,
Engineer of Way, Philadelphia Rapid Transit Company,
and
C. B. VOYNOW,
Assistant Engineer, Philadelphia Rapid Transit Company

Rail-joints, especially those used in street railway tracks, may be divided into two distinct classes—those which we will call ordinary joints, where the parts comprising them may be assembled and taken apart with ease and comparatively small expense; and those which we will call permanent joints, where the parts are permanently embodied in the joint and cannot be taken apart. The first class comprises practically all of the joints at present in use, and are those that consist of fish or joint-plates of various forms held by bolts or keys. The permanent joints represent a very small percentage of those in use, as they have been introduced comparatively recently, and consist of so-called cast-welded and the electrically-welded joints.

The different kinds of fish or joint-plates used for connecting ends of rails are well known. The principle involved in all of them, is two wedge-shaped plates, that are, by means of bolts or keys, forced on to the rails, the latter having a similar outline; and upon the thorough, continuous and tight contact of these inclined surfaces the solidity and permanence of the joint depends. In any form of rolled steel exact uniformity of section is never obtained; one end is invariably larger in cross-section than the other, even when new rolls are used. This is due largely to the difference of temperature between the ends of the steel when on its final pass through the finishing rolls; and, further, as the rolls wear down, the rolled section becomes larger. This is true even with the simplest section, as a square or round bar, and it is considerably more pronounced in the deep rail sections that are used in street construction. In consequence, when joint-plates and rails are assembled, while theoretically true and exact in their complementary design, in practice they vary greatly—sometimes as much as 1-16 in. But, assuming that the section of plates and rail are correct, as per design, rolled surfaces of steel are not continuous or perfectly smooth planes, but consist of minute elevations and depressions. Therefore, when the two joint-plates are forced by the bolts into the fishing sections of the rail, continuous contact is not obtained, but only an intermittent or point contact. In other words, only the protuberances of the surface of the joint-plate come in contact with those in the surface of the rail. The object of a rail-joint is to bridge over the ends of the rails and hold them against vertical and lateral movements under the load. Were it only for those movements, we believe, joint-plates would be effective for a considerably longer period than they are in practice, for the protuberances mentioned above would hold out considerably longer against flattening under the weight of the load. But, besides the vertical and lateral movement, there is a longitudinal or bodily movement of the rails, due, principally, to contraction and expansion, and also on account of the wave motion of the rail under traffic. This movement acts like a file on the minute irregularities of the surfaces. Although this linear movement is small, maximum ¼ in. to ⅜ in. in severe changes of temperature, yet those point contacts are so small, as compared with the extent of the movement of the rails, that this movement acts upon them like a long-drawn file. The result is that, no matter how tightly the plates were adjusted originally, in a very short time they become loose, and the ends of the rails begin to hammer under the passing wheels. Moisture percolating between the contact surfaces, due to capillary attraction, or otherwise, oxidizes those surfaces and greatly facilitates this filing effect. In steam roads this necessitates constant, almost daily, tightening of the bolts.

We have not mentioned here the loosening of the plates caused by the nuts being jarred loose from vibration, the reason being that we wish to present the fact to you that a joint, even under ideal conditions of fit and construction, could not be maintained in perfect condition very long. In street railway track construction the movement of the rails, due to changes of temperature, is not as great as in steam tracks, because the rails are buried in the pavement; yet it is large enough to cause the same filing effect. On the other hand, this burying of the rails in the pavement entirely precludes the constant tightening of the bolts, for the expense of the constant digging up and replacing of pavements would be prohibitive. The consequence is that the joints are allowed to remain loose a considerable length of time before they are uncovered and bolts tightened. Moreover, the constant hammering of the loose ends of the rails on the plates causes a depression on the surface of the plate and rail to such an extent that the tightening of the bolts does not avail; and the plates first, and very soon the rails themselves, are in such a condition that a renewal is the only remedy. Even before the ends of the rails and the plates have become damaged, the loose joints cause the ends of the rails to droop, and in connection with the rolling action of traffic, which elongates the upper surface of tread, bend the entire rail in a vertical curve by forcing up the spikes or ties in the midlle of the rail. This makes the track a continuous succession of waves, which necessitates, at intervals, the digging up of the entire pavement for the purpose of retamping and respiking it. When once these vertical curves are formed the track can never be restored to good condition. As a matter of fact, rails, after they have been removed for renewal, could in many cases have been used for several years more, as far as the middle part is concerned, were it not for the battered ends. In other words, the life of the track is mainly dependent upon the life of its joints. We shall not discuss here the loss involved in the maintenance of the rolling stock and pavement, but anyone taking a ride on old track will feel the effect on himself of low joints.

Street railway track construction being a development of that of the steam roads, the idea prevalent in that branch was necessarily embodied in it, although there are radical differences between the two. The steam railroads, consisting of vast stretches in the

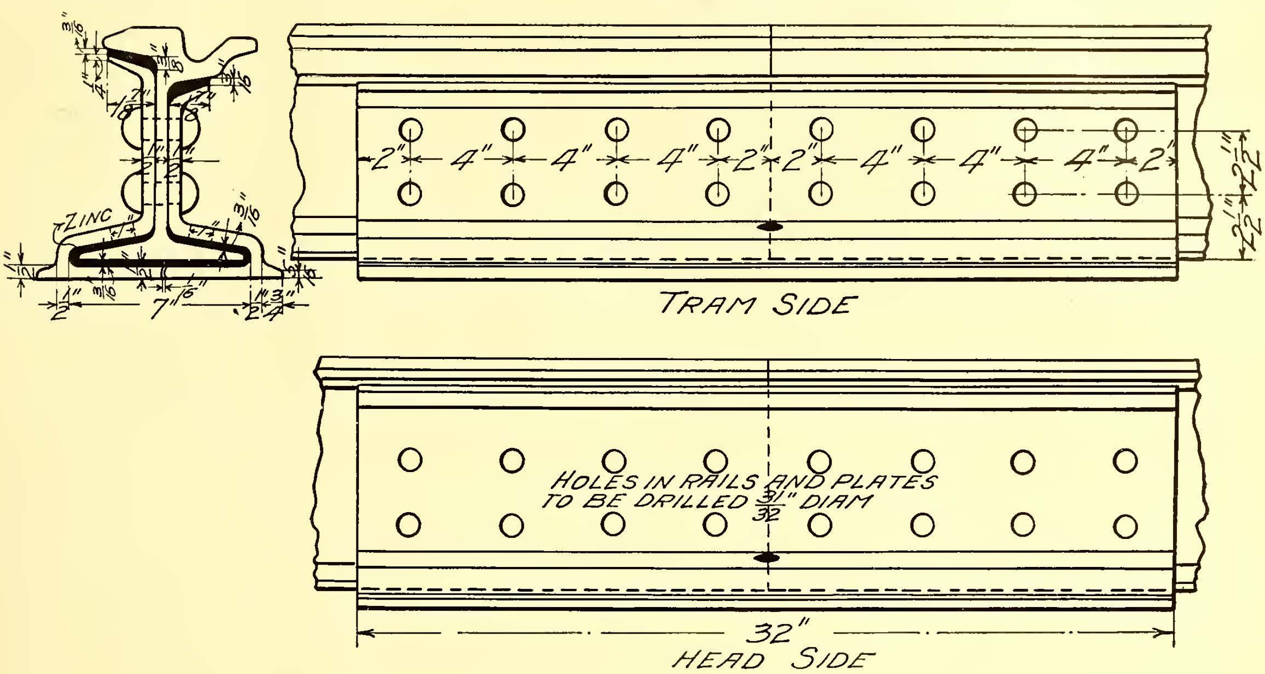


FIG. 1.—COMPOSITE JOINT

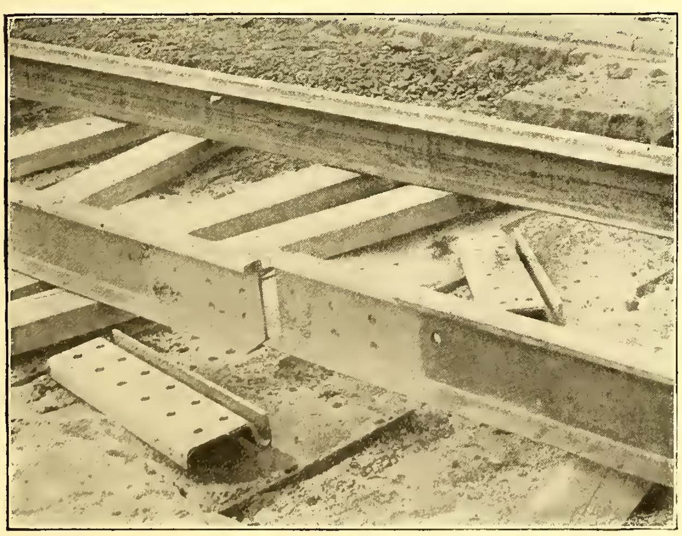


FIG. 2.—JOINT AFTER BEING CLEANED

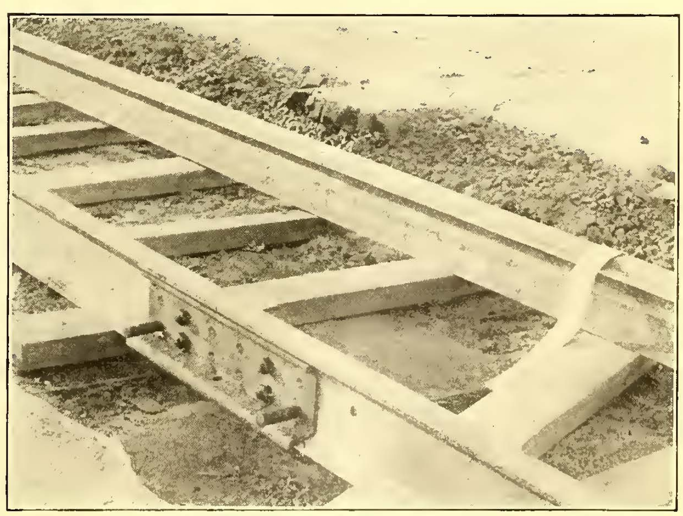


FIG. 4.—PLATES IN POSITION

open country, naturally do not require paving. The rails being entirely exposed on all sides, and therefore directly influenced by changes of temperature, great care must be taken that the expansion in the rails does not distort the alignment of the track. To prevent this, the rails are laid in short lengths, the joint holes in the rails are made considerably larger than the bolts, and spaces are left between the ends of the rails to allow free movement. This was also embodied in street track construction. But it has been

FIG. 5.—REAMING HOLES

gradually acknowledged that in street railways, where the rails are buried in paving, the changes of temperature in the atmosphere do not affect the rail proportionately; the friction between the paving and the rail exerts upon the latter such a force as to a great extent counteract the force of the stress due to expansion. Again, the material of the paving enclosing the rail on both sides helps to keep the rail in permanent alignment and surface. This has involved what we have called permanent joints, viz., the cast-welded joint, which is formed by pouring a mass of molten cast iron around the abutting ends of the rails and the electrically-welded joints, which are made by electrically welding two strips of steel plates to the sides of the webs at three or more points. While these joints have seemingly given better results, they also embody either defects or disadvantages which are quite important. In the cast-welded joint the comparatively large mass of molten metal anneals or otherwise affects, whether physically or chemically we do not know, the texture of the rail ends. This makes the track of an intermittent hardness, which is very soon shown in the difference in wear between the middle of the rail and at the joint. Moreover, on account of the sudden high temperature the rail ends expand vertically, and in cooling do not come back to their original cross-section. This causes either elevations or depressions at the joints. The elevations can be overcome by grinding or filing, but the depressions cannot be remedied, and they remain as permanent defects in the track. We are not as familiar with the electrically-welded joints, and therefore cannot give you the results that have been obtained with them. But the disadvantage that we know of is the fact that the transportation of the machinery and other expenses involved in placing them is considerable. The cast-welded joint does not give a perfect electrical connection, and we know of a railway in the neighborhood of this city where the management is judiciously using large copper plates in connection with this joint. Both of these joints have the further disadvantage that in case of changes in the track layout the joints can only be cut out and thrown in the scrap pile.

The joints that are at present used in Philadelphia are supposed to remedy the above-mentioned defects and disadvantages. This will be seen from the following descriptions. The joint consists of what may be called two Z or special bars (Fig. 1), which are riveted on to the webs of the rail. These plates are not made to fit the fishing section of the rail; on the contrary, spaces are left under the head, tram and around the foot of the rail. These spaces are filled with molten zinc, which enters into and fills out all the irregularities of the rolled surfaces, thus giving an absolutely continuous and perfect bearing throughout the whole length and width of the flanges of the plates. It is obvious that such a continuous contact could not be obtained by the most laborious machining or milling of those surfaces. The adhesion of the molten zinc to the rails and plates, together with the body-bound rivets, hold the joint permanently tight, and at the same time prevent expansion, thus making the rails continuous.

The method of constructing the joint is as follows: After the material has been distributed and the rails placed on ties, but before the latter are spiked, both plates and rails are thoroughly cleaned (Fig. 2) by a portable sand blast (Fig. 3). The plates are next placed on the rail ends and held in place by steel drift-pins, placed one in each end of the plate (Fig. 4). A steel straight-edge is laid on the head of the rail, and the tread brought to a uniform surface by inserting wedges between the plates and the trams, or the plates and the head of the rail. The wedges are then driven in with a light hammer until the straight-edge has a continuous bearing.

FIG. 3.—PORTABLE SAND BLAST

While the plates are held in place by four temporary bolts (Fig. 4), the rivet holes are reamed to 1 1-32 in. diameter (Fig. 5) by a portable pneumatic reamer (Fig. 6). The 12 1-in. steel rivets are then driven by a portable pneumatic riveter (Figs. 7 and 8). This insures the filling up of the holes by the rivets. The next step is to put in place the iron clamps for holding the asbestos cloth pads and clay on the bottom and at the ends of plate and above the base of rail. The spaces between the head and tram and plate are temporarily caulked with asbestos cloth. The plates are then warmed by fuel-oil burners, operated by a portable compressor, to a temperature of about 300 degs. to 400 degs., after which the molten zinc is immediately introduced through a 1-in. hole located in the center of the lower portion of plate, the remaining space underneath head and tram of rail being filled by the aid of dams. These dams consist of aluminum castings padded with asbestos cloth.

From the above description it will be seen that this joint combines the characteristics and advantages of both classes of joints mentioned above, obviating their defects. While it is a permanent joint, in that it holds the ends of the rails permanently together, it can be easily taken apart and the parts replaced at a comparatively small expense. It does not distort the original cross-section of the rail, nor does it effect the physical or chemical nature of the metal. It not only obviates the initial defects in the fit of the rolled section, but also the aggravating cause—that of linear movement, due to expansion. As the plates and rails are thoroughly cleaned and heated before the molten zinc is poured in, the latter galvanizes on to the steel (this was proved on joints that were purposely opened for investigation after having been in the ground for over two years), and, therefore, gives a thorough and continuous electrical connection. We know of very interesting data about the electrical bonding quality of this joint, but as these data are the property of the Franklin Institute, we are not at liberty to divulge them at present. We will only say that, after a thorough test by an electrical expert of this city of joints that had been in the ground over two years, and under the heaviest traffic, the resistance was found to be less than the rails themselves. Another, and we think a very important, feature of this joint is the fact that its initial cost is practically a permanent investment. From the nature of its construction, having an intermediate soft metal between the surface of the steel, the plates cannot be affected by wear, and, therefore, practically the entire material that enters into the construction of the joint—that is, the plates and zinc—can be used over again after the rails have been worn out, only necessitating new rivets.

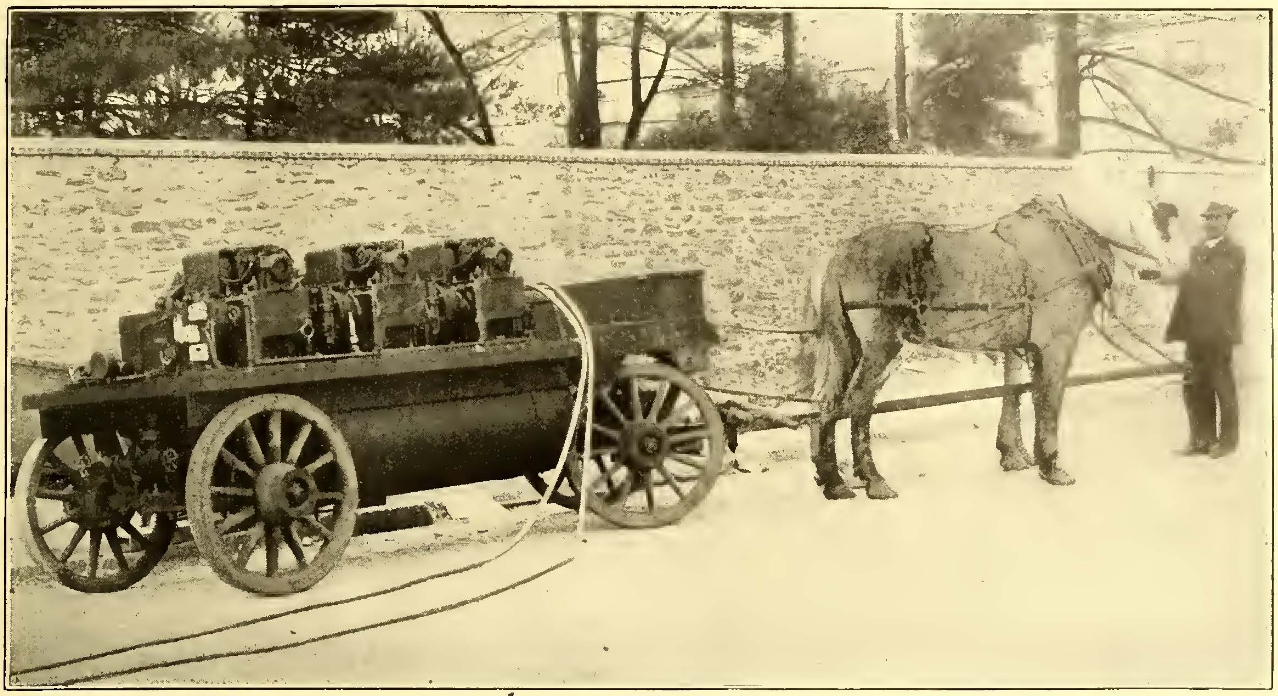


FIG. 6.—PORTABLE PNEUMATIC REAMER

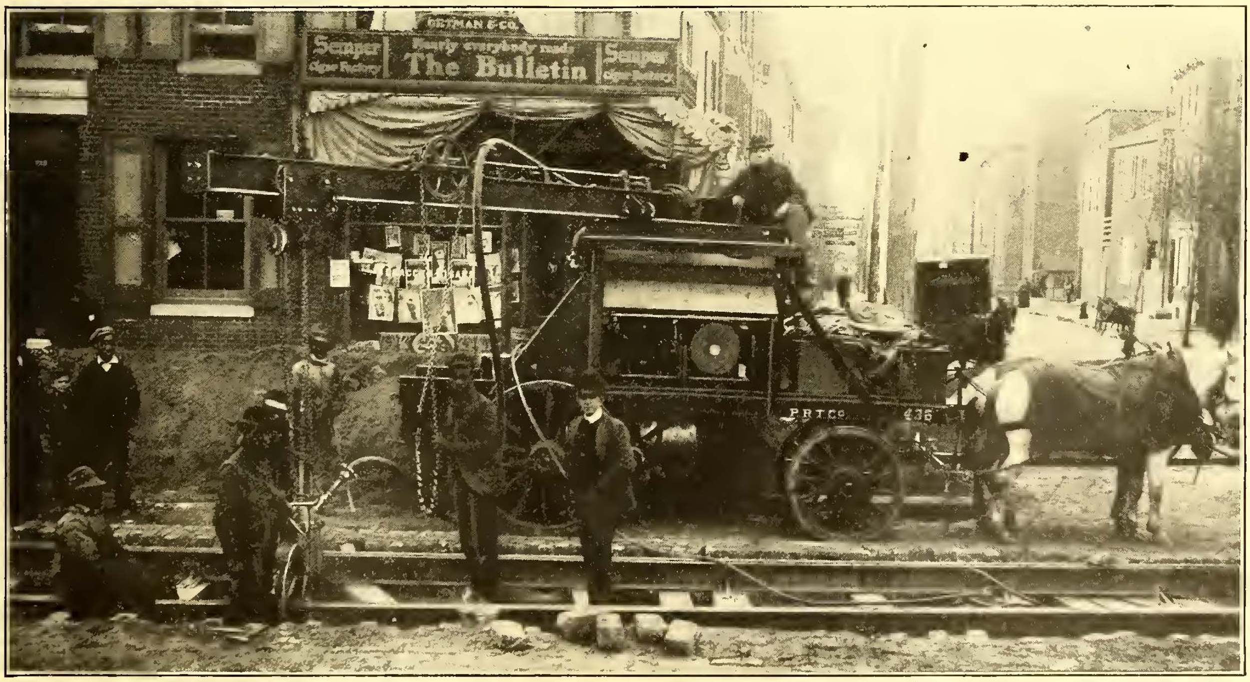


FIG. 7.—PORTABLE PNEUMATIC RIVETER

Before describing the other improvements in track construction, we think that it will be interesting to mention the novel idea involved in the construction of this joint. It seems, at first glance, rather an anomaly that malleable iron, cast iron and even rolled steel plates of a high percentage of carbon have been used, or, in other words, different hard metal substances have been used as a support or foundation for certain vibrating loads, and they all proved more or less a failure. Yet, in face of these known failures, it was proposed to support the same loads by means of a comparatively soft metal, zinc. The fact is that this metal does form a better support. There is a well-known engineering principle which has a similar and close relation to this, and which will explain the seeming ambiguity. Foundations of large and important structures are known to have been built on sand and even quicksand. It is only necessary to dam around the loose material under the foundations and make the area of the latter large enough. The configuration of the plates forming wedge-shaped spaces under the head and tram of the rail, and the enclosed space around the foot is the damming, and the filling in under the entire width of base of rail, and of all the irregularities of the rolled surfaces, is the enlarged area of the foundation.

ELECTRICAL RAIL WELDING

EXTRACTS FROM AN ARTICLE UPON TRACK CONSTRUCTION

BY T. W. WILSON,
of Buffalo

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The electrically-welded joint was adopted as a standard in 1899, and since that time 30,216 joints (representing 106½ miles of track) have been welded. Numerous descriptions of the process have been published, so all that is necessary here is to give a statement of results obtained and the number and cause of breakages. In this connection the question is still asked as to "what we do with expansion." Probably the best answer is that we "forget it," the same as we do the joint after it is welded. Scientifically it may be said that the rail is held in every infinitesimal part of its length by the concrete base, which covers about 1 in. of the base of the rail, and by the paving, and the track cannot expand or contract. The force is taken up in internal strain in the metal of the rail. When the strain becomes greater than the ultimate tensile strength, the rail breaks.

A tabulated statement follows which explains itself:

Kind of Rail	First Year Joints Welded in 1899	Number Broken
Old, 6-in.	4,787	18
Old, 7-in.	8	0
Old, J. Co., 9-in.	2,658	49
Old, P. S. Co., 9-in.	74	3
New, 6-in.	0	0
New, 9-in.	3,882	45
	11,349	115

Kind of Rail	Second Year 1900	Joints Welded in 1899-1900	Number Broken
Old, 6-in.	11,973	16,760	127
Old, 7-in.	566	574	7
Old, J. Co., 9-in.	1,894	4,552	25
Old, P. S. Co., 9-in.	146	220	6
New, 6-in.	619	619	2
New, 9-in.	2,234	6,056	16
	17,432	28,781	183

Kind of Rail	Third Year 1901	Joints Welded in 1899-1900-1901	Number Broken
Old, 6-in.	482	17,242	8
Old, 7-in.	0	574	1
Old, J. Co., 9-in.	356	4,908	7
Old, P. S. Co., 9-in.	0	220	1
New, 6-in.	0	619	0
New, 9-in.	597	6,653	3
	1,435	30,216	20

Of the 183 broken joints, winter of 1900-01, twenty-three were on welding done in 1899 and 160 were on welding done in 1900 (17,432 joints were welded in 1900). The joints which broke have all been carefully inspected, and in no case did the break occur through the weld, nor did the weld pull off. The break almost invariably occurred at the end of a welding bar, the rail breaking usually through old bolt or bond holes beyond the bar. By welding with bars long enough to cover and reach over all such holes, this source of breakage has been eliminated since 1900. The forty-nine breaks in 1899 and the twenty-five in 1900 in old Johnson Company 9-in., as shown above, were directly due to this cause. The large number of breaks in 1900 old 6-in. (127) we could only account for by attributing them to some quality in the chemical composition of the rail which did not lend itself readily to the weld. They nearly all occurred in the same street—viz.: East Ferry Street—and this would seem to help that hypothesis.

Referring again to the table, we note 183 broken joints at the end of 1901 winter. These were all rewelded in the summer of 1901, so that to-day the number of broken joints is twenty. These have been cut out and a piece of rail 10 ft. long inserted, full bolted and bonded. Next summer these plates will be taken off and the rails rewelded. It has been found that it is not always necessary to cut in a piece of rail in place of a broken joint, as a very neat patch can be welded in a great many cases which gives very satisfactory results.

As an average, therefore, on all welding done in Buffalo, the breakage has been about 1 per cent. The welding done in 1901 and 1902 in Rochester and other cities shows even better results, and of 5308 joints welded in Rochester in 1901, there were but six broken rails in the spring of 1902. When it is considered that the quality of each weld depends entirely upon the personal equation of

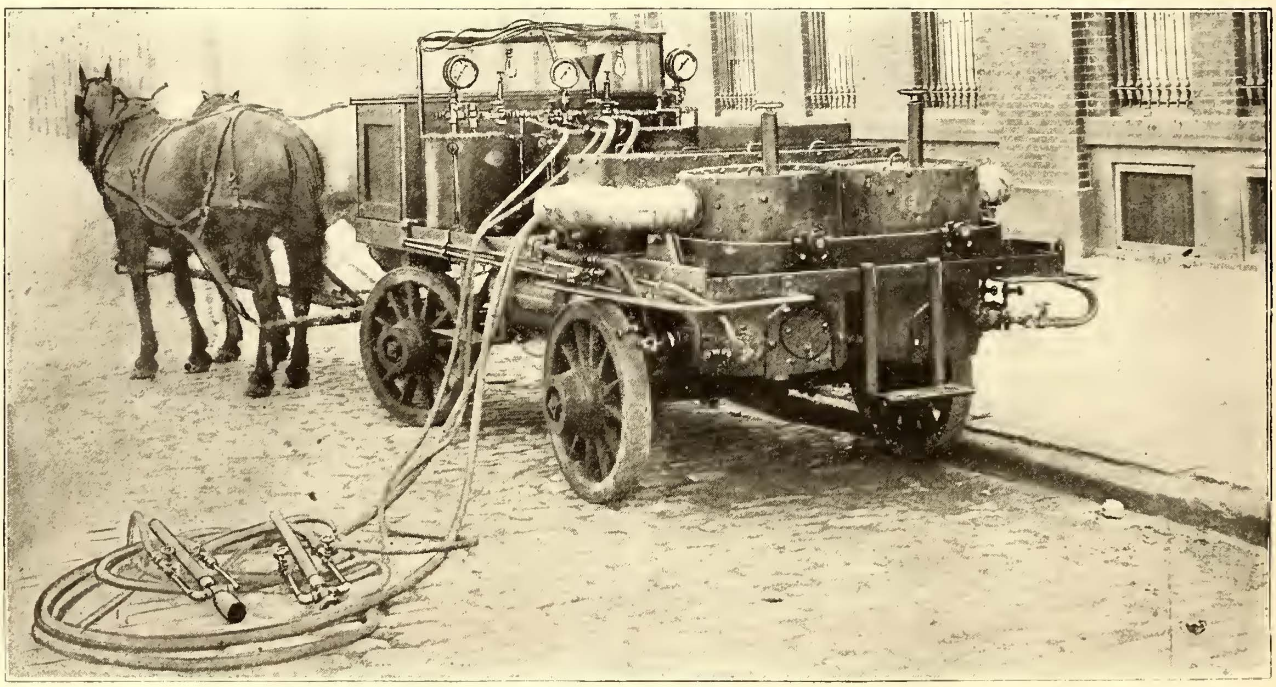

FIG. 8.—SECOND TYPE OF PNEUMATIC RIVETER, PHILADELPHIA

the welder (since it is by a cherry-red color alone that the proper point of fusion is known), it seems wonderful that such remarkable results are achieved.

In addition to welding our joints, the ground return around special work has been taken care of by welding or electrically brazing copper ground cables to the rails. For this purpose a copper block, 1½ ins. thick, with a suitable groove across one face to pass over the cable, is provided. The cable is placed against the rail-web and the copper block over the cable.

The welder is then brought into position, a Bessemer steel plate about ⅜ in. thick is interposed between the copper block and the contact of the welder. This acts as a heat insulation and enables the copper block to be brought up to proper heat for brazing. Hard spelter is used. By this means a 500,000-circ. mil cable can be attached to a rail so that the full carrying capacity of the cable is realized, the area of union between the copper and the steel being ample to allow for the difference in carrying capacity of the two metals.

ELECTRIC WELDING OF RAIL-JOINTS

(From the "Iron Age")

A DESCRIPTION OF THE MACHINES USED AND METHOD OF OPERATION

The process of electrically welding rail-joints, as applied by the track-welding department of the Lorain Steel Company, Lorain, Ohio, comprises three distinct operations. The machinery is mounted on trolley cars of suitable design, the running gear of which is provided with threaded axles so that the machines can be used to weld track of different gages. New rail is welded either before or after the paving is in place, space being left at the joints to permit the entrance of the welder. In old rail the paving is removed around the joint, and the old plates and bond wires are removed. The rail ends are then brought up to the proper grade.

In the welding process the first operation is that of sand blasting, by means of which all dirt, rust and foreign matter is removed from the rails at the points where the welds are to be made and from the bars used in making the joint. The apparatus for this work consists of a 10-hp motor driving an air compressor, a tank for the storage of air and a bin for holding a supply of sand. A sand mixer of the Tilghman type is also provided. By means of a hose and nozzle the operator directs the blast of air carrying the sand against the rail until all foreign matter has been removed. The bars are similarly treated and the joint is ready for the actual operation of welding.

The apparatus for welding is carried in two cars coupled together by a special form of slip coupling, which permits of sufficient range of movement for the car carrying the welder proper to be moved from one weld to another of the three welds necessary in making a joint without the necessity of moving the second car. The welder itself is hung from a bail on a crane extendnig out beyond the end of the car. This crane permits of lowering and raising, so that the jaws of the welder can engage the sides of the rail and also to shift the welder from one side to the other to engage both rails of the track. The crane is operated by friction clutches from a shaft in the car, which is kept running continuously by a 5-hp motor. This motor also drives a small rotary pump for circulating water through the welding transformer and the faces of the contacts to keep them cool. After the water has passed through the welder it goes to a cooling tank on top of the car, is forced under the false bottom and made to blow in from the middle and passes around and around until the outer circumference of the tank is reached. A false bottom is provided, and air, from a blower in the car, is forced under the false bottom and made to blow up through numerous holes. The hot water from the welder passes into the outer portion of the serpentine and gradually finds its way to the center. From there it is conducted to one of the tanks in the car. In this passage along the serpentine path the air is forced up through the water and forms a most efficient method of cooling, depending somewhat on the humidity of the atmosphere, being most efficient when the atmosphere is dryest.

The welder itself is an alternating-current transformer, the primary winding of which consists of two coils in parallel of forty-four turns each. The secondary coil is a single loop of copper of large cross-section, the terminals of which form the contacts, or jaws, which engage each side of the rail and between which the weld is made. The secondary winding is so made as to entirely inclose the primary coils, which are insulated in oil. On each side of this transformer and supporting it, but insulated from it, are the two large levers, hinged together at about two-thirds the distance from the top, for transmitting the necessary pressure to the weld.

These levers are connected at the top by an hydraulic jack. A hand pump for forcing water into the jack is bolted to one of the levers. A pressure of 4100 lbs. per square inch is obtained on the 3⅞-in. diameter rams of the jack, the leverage on the arms increasing this so that about 37 tons pressure is developed at the weld.

In making a joint, flat-rolled steel bars are used, having at each end a boss, or projection, on one side, which form the contact points between the bars and the web of the rail and confine the welded area to these sections. A flat strip of steel ⅛ in. thick by 1 in. wide is placed across the middle of the bars on the same side with the bosses. The bars are supported on small blocks and placed across the joint so that the middle strip engages the web of both rails. The middle weld is a vertical one and made the full width of the bar; the end welds are horizontal.

The welding train of two cars is moved up to a joint. The welder is swung into place and the jaws made to press against the bars on each side of the rail. The current is then turned on, and flows from contact to contact through the bars and the rail web. By altering the pressure on the jaws the resistance of the several junctures is increased, and the whole is soon brought up to a welding heat. As soon as this point is reached the current is cut off and simultaneously the pressure is brought up to the full

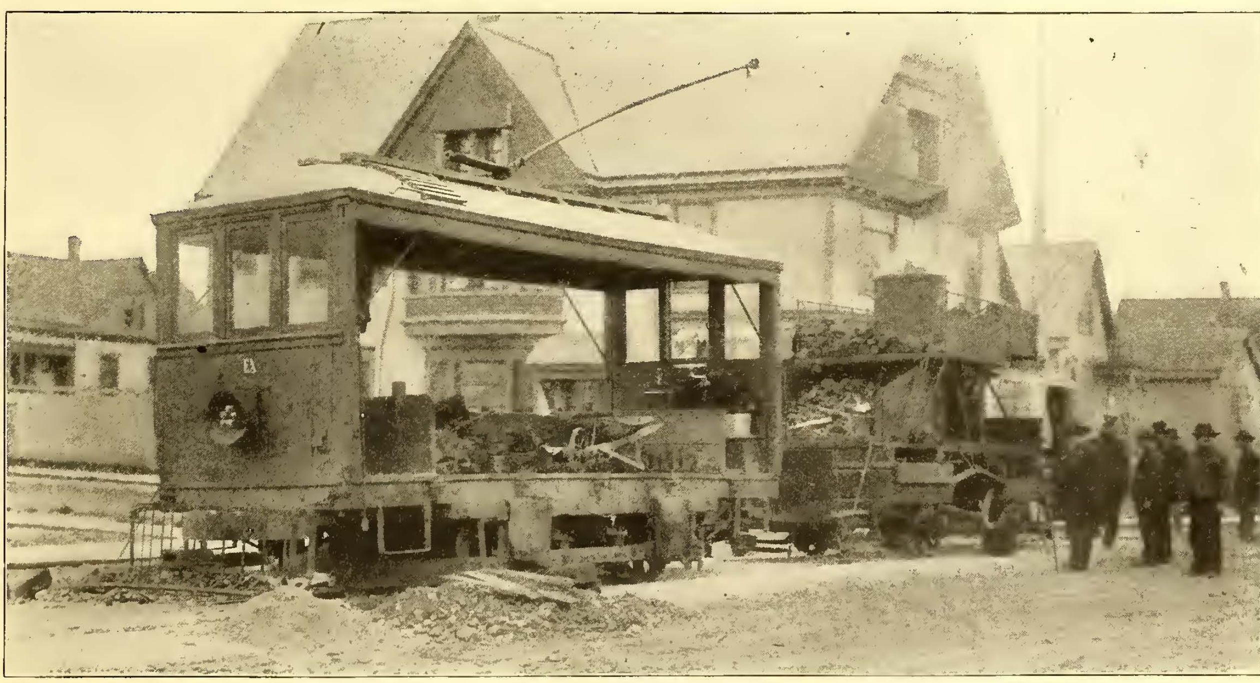

FIG. 1.—UTILITY CAR, CAST WELDING IN MILWAUKEE

amount. The pressure is then loosened and the welder car moved back to bring the jaws opposite the extremity of the bars. The same process is again followed here, except that when the final pressure has been applied it is held there and the weld permitted to cool under pressure until the metal has cooled sufficiently not to show any glow. The welder is then moved forward to the other end of the bar and the process repeated, after which the welder is raised and moved to the other side of the car to engage the opposite joint.

By holding the pressure after the weld is made a remarkably tough weld is secured. It will be noted that only the end welds are thus treated. As the center weld is not subjected to any strain, it is not essential to have toughness there. It has been found desirable to weld the ends of the bars while the bars are in an expanded state. By making the center weld first and not stopping to cool it under pressure, the greatest elongation of the bars is secured. After the ends are welded and the bars cool off they shrink and exert a powerful pull to bring the abutting rail ends together, thus closing the slightest opening and leaving practically no joint at all. This is an important point in the manufacture of a continuous rail, for if the abutting rail ends are not brought firmly together, the metal in the head of the rail will have a chance to flow into the opening between the rails, and this in time will cause a low spot in the head of the rail. As the bars are always in a state of tension, it follows that the rail itself, inclosed between the bars, is in a state of compression. Any contraction of the rail itself between the joints will be transmitted to the end welds, and it is therefore necessary to have these welds exceedingly tough to withstand the strain. The object of the center weld is simply for vertical stiffness and to prevent any movement of the rail ends. The actual current used in welding is about 7 volts and from 25,000 to 30,000 amps.

In the car coupled to the welder is carried a rotary converter for changing the direct current from the trolley to an alternating

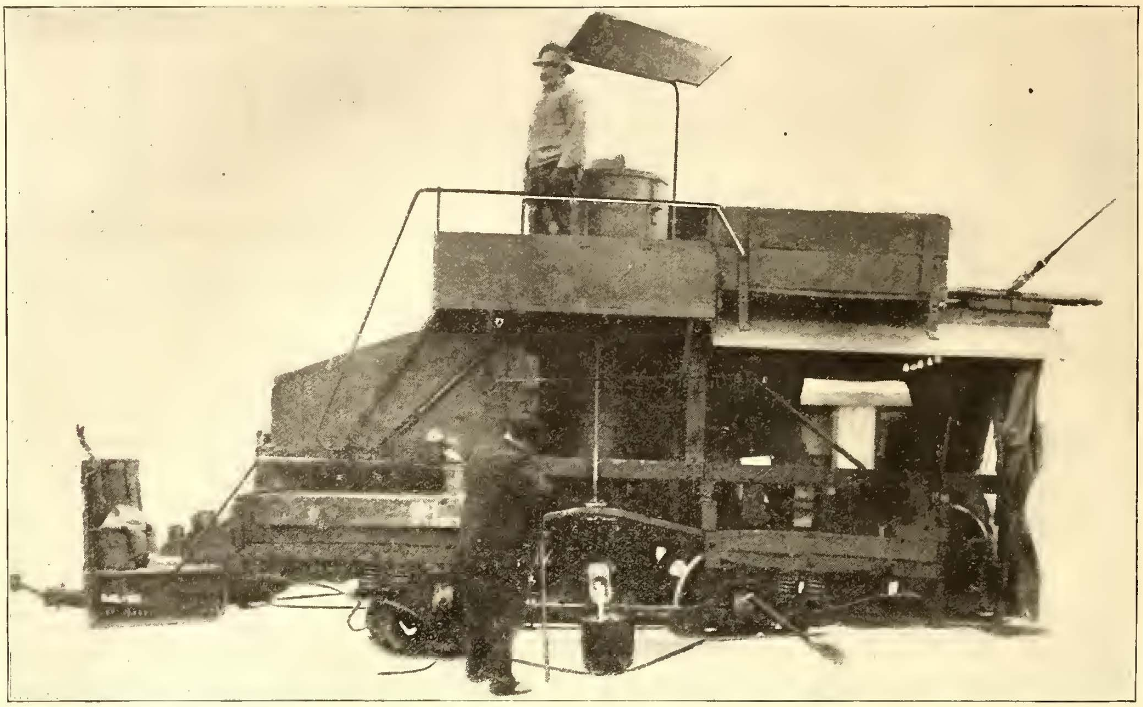

FIG. 2.—CUPOLA CAR, CAST WELDING IN MILWAUKEE

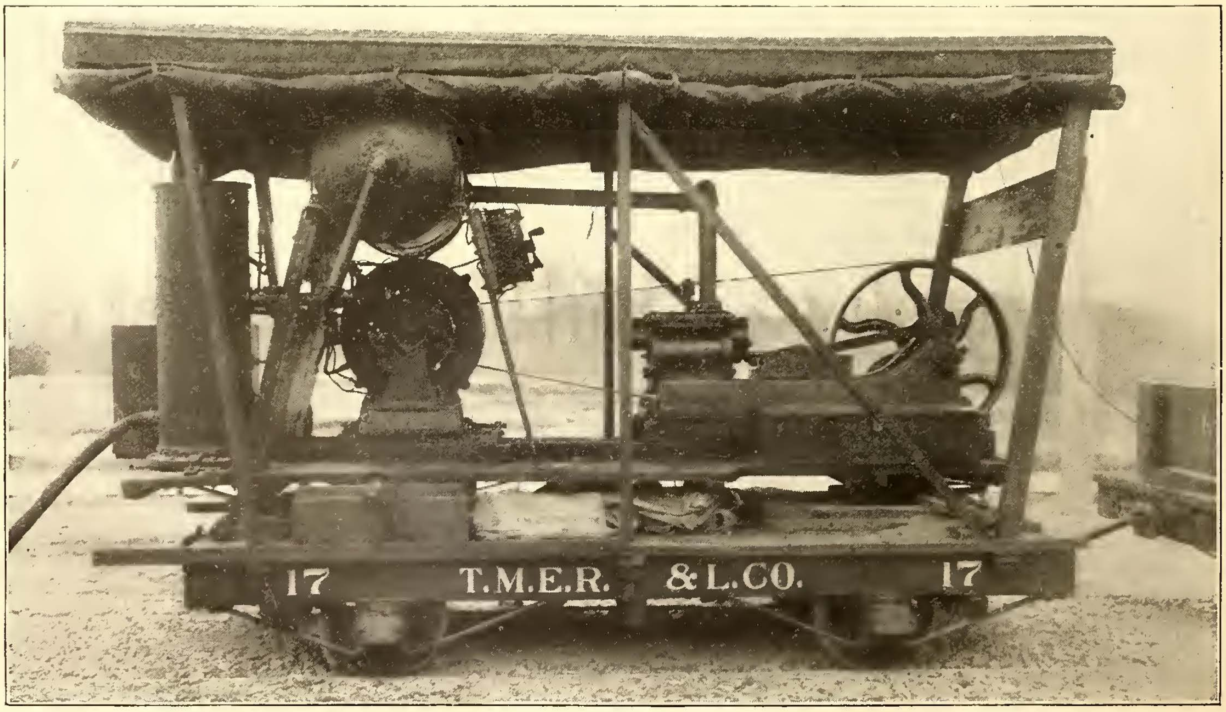

FIG. 3.—SAND-BLAST CAR, CAST WELDING IN MILWAUKEE

current. The current in the primary coils of the welder is 300 alternating, 40 cycles. The direct current side of the rotary will take current from 325 to 600 volts from the trolley, and by means of suitable regulating apparatus the output on the alternating side, to the welder, is kept practically constant at 300 volts, without regard to the fluctuations on the line. On a line voltage of 500, about 225 amps. are required, or it takes about 125-kw to make a weld, the current being on about two and a half minutes to each weld.

The third and last operation in the process consists in grinding the head of the rail to a true surface. In welding new rail there is little need for this tool. In old track, where the rail ends have been battered, the receiving rail is purposely welded higher than the other. The grinder is then used to grind out the inequalities in the rail head and bring it back to a true surface. The grinder

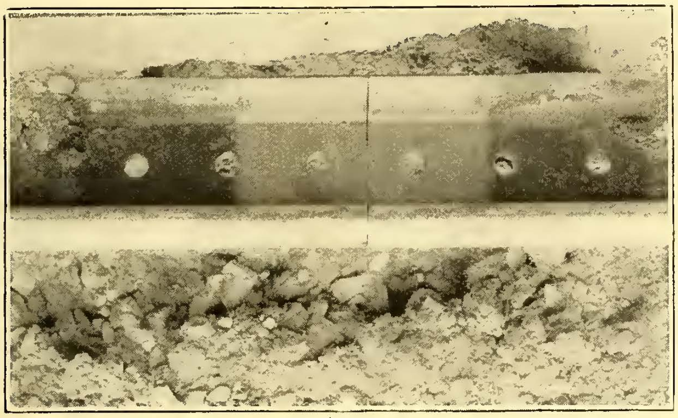

FIG. 4.—JOINT AFTER BEING CLEANED, MILWAUKEE

consists of an emery wheel mounted on a carriage having two rollers, which are about 4 ft. apart. This carriage is let down on the rail so that the rollers roll along the head of the rail, the emery wheel being over the uneven portion at the joint. The carriage is connected with a motor on the car by a swing frame, thus enabling the operator to move the emery wheel back and forth over the joint while the car remains stationary. By means of a hand wheel the emery wheel is gradually fed down, and as it is moved forward and back grinds off the high places until the whole joint is brought to a true surface. The principle is very much the same as a carpenter's plane. With the final operation of grinding the joint is left complete.

Carried on as a continuous process, it takes from 12 to 15 minutes to complete a joint. The work is carried on day and night,

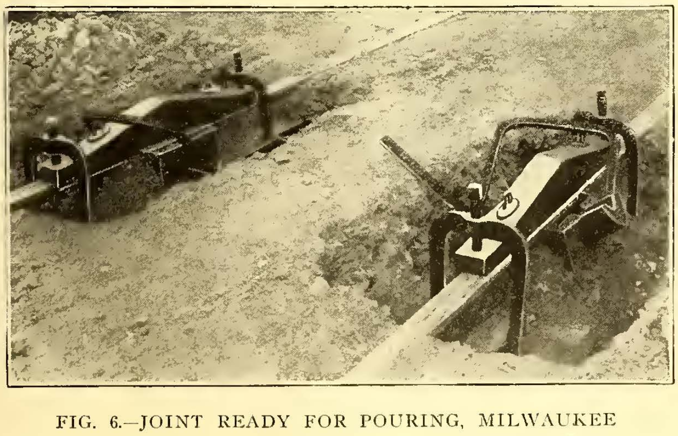

FIG. 6.—JOINT READY FOR POURING, MILWAUKEE

about 80 joints in 24 hours being a fair average. The bars used are 1 in. x 3½ ins. and 1⅛ in. x 3 ins., the length varying with the form of joint previously used. On new rail, where the ends are left blank especially for welding, the length is 18 ins. On old rail the bars must be long enough to reach back of the old bolt and bond holes, in some cases requiring bars as long as 48 ins.

In addition to welding joints the same apparatus is made use of in welding or electrically brazing copper ground cables to the rails. For this purpose a copper block, about 4 ins. square and about 1½ ins. thick, with a suitable groove across one face to pass over the cable, is provided. The cable is placed against the rail web and the copper block over the cable. The welder is then brought into position. A Bessemer steel plate, about ⅜-in. thick, is interposed between the copper block and the contact of the welder. This acts as a "heat insulator," and enables the copper block to be brought up to a proper heat for brazing. Hard spelter is used. By this means a 500,000 circ. mil cable can be attached to the rail so that the full carrying capacity of the cable is realized, the area of union between the copper and the steel being ample to allow for the difference in carrying capacity of the two metals.

The improved process of electrically welding rail joints and bonds has been in use since 1897. Further improvements were made in the winter of 1900, and the welding done the following season amply demonstrated the value of these improvements. While the breakage on all welding done had not exceeded 1 per cent, the breakage on welding done in 1901 was hardly one-tenth as great as before. Of 5308 joints welded in Rochester, N. Y., in 1901, there were but six broken rails in the spring of 1902. In no case has a joint broken through the bars or a weld pulled off; nearly all breaks have occurred through old bolt or bond holes beyond the

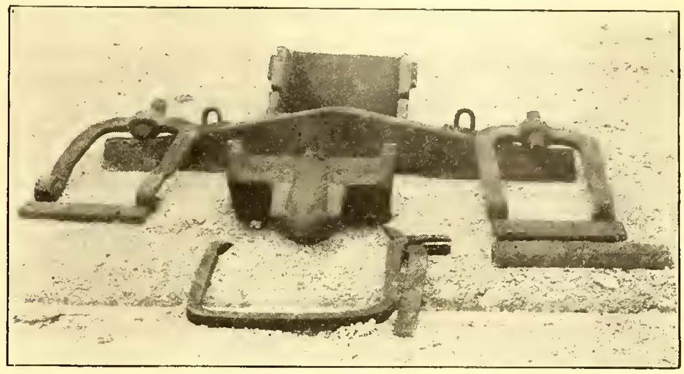

FIG. 5.—MOLDS AND CLAMPS, MILWAUKEE

bars. By welding bars long enough to reach over the holes, this source of breakage has been avoided since 1900. The excellent showing made at Rochester, N. Y., on last year's welding proves to what a remarkable state of perfection the process has finally been brought. When it is considered that each weld depends on the judgment of the man making it, and that every bad weld must necessarily remain in the track, to be subsequently revealed when the strain of winter comes on it, and that but about one out of a

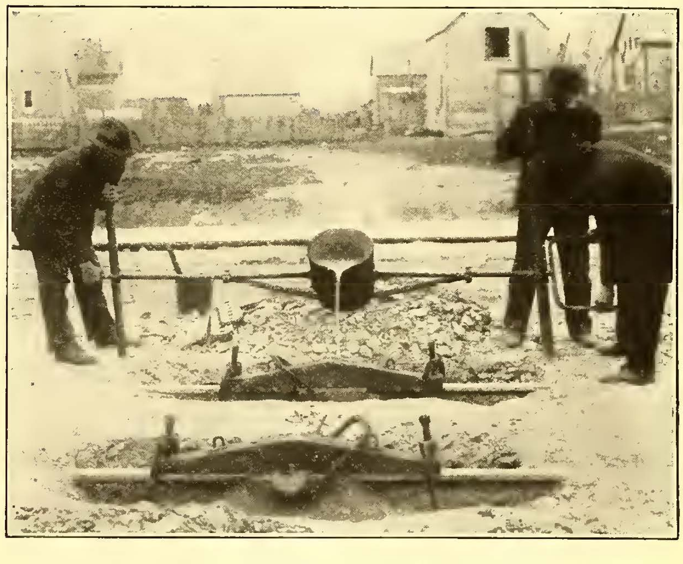

FIG. 7.—POURING JOINT, MILWAUKEE

thousand is a bad weld, it proves that by no other method of welding can such uniformity of results be attained. In the last three years the Lorain Steel Company have welded at Buffalo, N. Y., alone, over 100 miles of track.

THE CAST-WELDING OF RAIL-JOINTS

BY FRED G. SIMMONS,
Superintendent of Construction and Maintenance of Way, the Milwaukee Electric Railway & Light Company

Among the first joints cast-welded under contract were those on Chippewa Street, St. Louis, on the lines of the Southwestern Railway, during the months of Oct. and Nov., 1894. The first 744 joints applied at this time were very satisfactory, less than one-half of 1 per cent breaking. During the following year the work of cast-welding joints on the street railway lines of Milwaukee was commenced, and some of the track welded at that time, consisting of a 5-in. 58-lb. tram-girder rail, is still in place, and in first-class condition after continual service for ten years. It is not the intention of the writer to claim superiority in point of efficiency for the cast-welded joints, as compared with several other methods of accomplishing the same result.

We do, however, believe that many engineers and managers have avoided the use of the cast-welding process on account of the numerous erroneous arguments advanced against it, and it is the

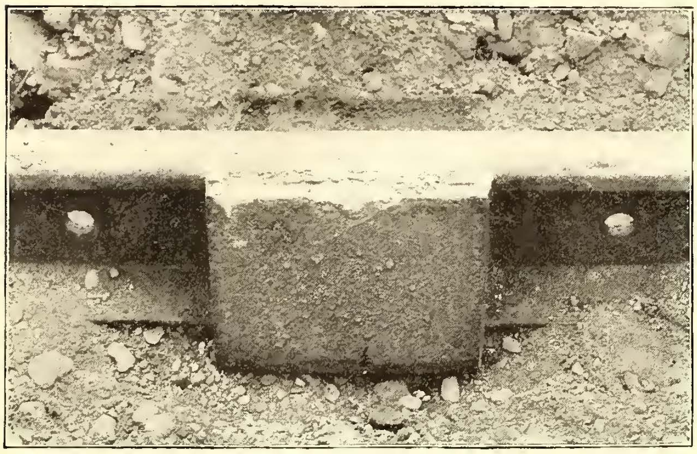

FIG. 8.—COMPLETED JOINT

purpose of this article to lay before the public a simple description of the results obtained in the cast-welding of rail-joints by the Milwaukee Electric Railway & Light Company, within the personal experience of the writer and under his supervision. This description and the results obtained, we believe, conclusively show the possibility of cast-welding the rail-joints in a manner absolutely satisfactory both as to efficiency and economy.

It is claimed that the mass of molten iron poured around the rail ends effects either a chemical or molecular change in the metal

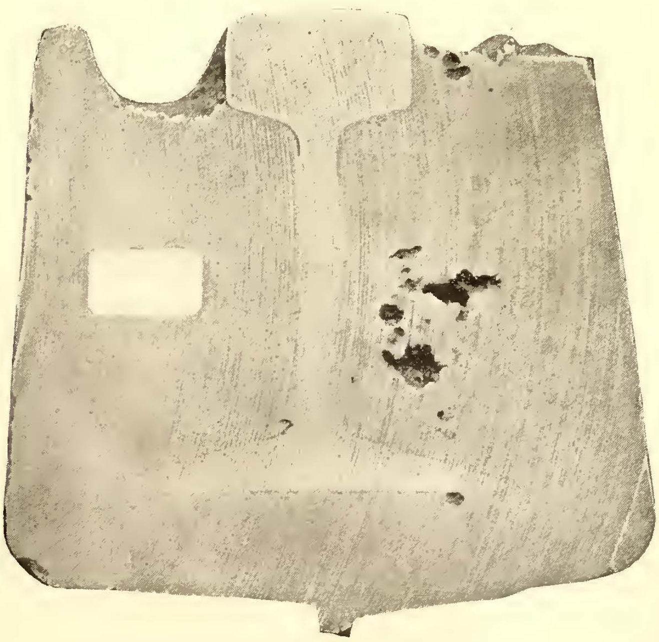

FIG. 10.—SECTION OF JOINT

of the ball of the rail, which makes this section of the rail softer than the remainder, the inference being that the carbon is burned out. With over 150 miles of cast-welded track, some of which has been in service ten years, and with many miles replaced on account of the entire wearing out of the rail, no instance of a low cast-welded joint has been encountered. In fact, when the work was properly and thoroughly handled, absolutely reversing this claim, we have found that as our old girder rail wore out the cast-welded joint became the highest point in the rail, the thin metal on each side of it ironing down into depressions, leaving the rigidly supported metal of the joint high. The picture herewith is from a photograph of such a joint, clearly showing the conditions as stated.

The entire process of pouring a cast-welded joint is illustrated in the accompanying cuts, made from photographs taken during the actual progress of the work.

Fig. 1 (page 579) shows the utility motor car used in transporting the apparatus and material, and the cupola, with the molten iron flowing, is attached behind this car. The thin stream of white, hot iron may be plainly seen on close inspection of the picture.

Fig. 2 (page 580) is an enlarged view of the cupola, showing this piece of apparatus in greater detail.

Fig. 3 (page 580) gives a very comprehensive view of the car containing the sand blast apparatus used to clean the rail ends.

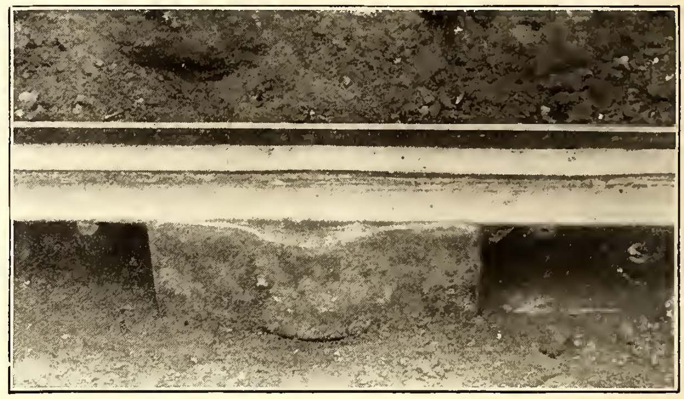

FIG. 11.—FINISHED JOINT

Fig. 4 shows a joint after it has been cleaned by this process, the steel having assumed an almost silver whiteness.

Fig. 5 shows the moulds, car and clamps used in preparing the joint for the pouring of the metal. Attention is called to the strength of this apparatus and especially to the bar. The purpose of this bar is to prevent "cocking" or "kinking' of the joint while cooling, and it has been found entirely efficient.

Fig. 6 shows two joints prepared for the pouring operation, the gate on one side and the vent on the other being very clearly discernible. Fig. 7 clearly shows the actual pouring of the joint. (These last four engravings are on page 581.)

Figs. 8 and 9 are of a completed joint, showing particularly the ease with which paving of any kind may be abutted thereto.

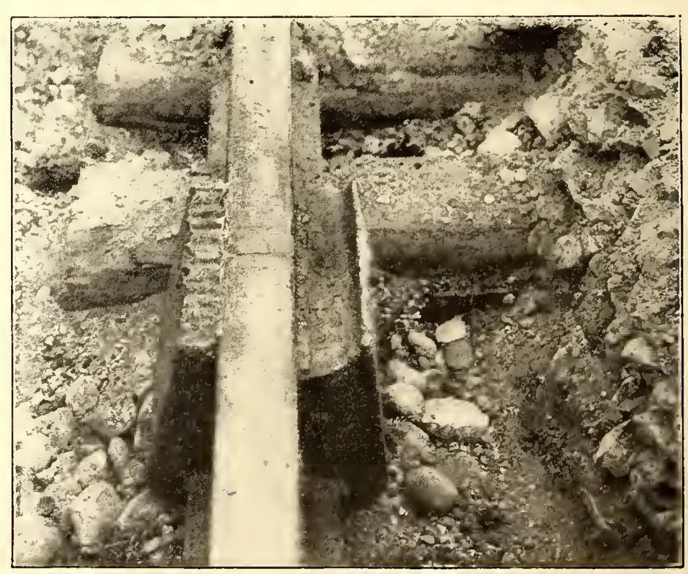

FIG. 9.—COMPLETE JOINT

Fig. 10 is of a section of a joint showing clearly the perfect bond of the metals.

The process is so fully outlined in the above set of cuts that I will presume to make but few explanations. The heating of the iron in the cupola is in no sense different from the operations of any ordinary cupola, and the mixture used is the only point requiring special mention. This consists of 75 per cent good pig iron and 25 per cent soft scrap.

The sand blast is of a simple construction and requires no particular mention. The importance of thoroughly cleaning 6 ins. or

8 ins. of each rail end to be welded cannot, however, be overestimated, as it is necessary to remove all scale as well as dirt, and the sand blast process is, of course, the most economical as well as the most efficient.

The heavy clamp-bar already referred to is also a very essential feature, as this weight of metal not only prevents "cocking" and "kinking" of the joint, but helps prevent an overheating of the ball of the rail. This bar is kept in place until all semblance of red heat has left the joint.

An absolute fusion of a portion of the ball and stem of the rail is necessary in achieving a successful cast-welded joint (a sleeve-joint is of no value), and this is not a difficult result. During the last three years we have welded our own joints, having purchased the apparatus shown above from the contracting company which had previously done the work, and during that time, although we have welded 6000 to 8000 joints, we have not had one pull or break.

Our electrical tests show the conductivity through these joints to be from 100 per cent to 140 per cent of the conductivity of the abutting rail, and in no case of a proper weld does this conductivity fall below 90 per cent. This applies with equal force to track just welded, and track that was welded six to ten years ago, and is borne out by regular periodical tests.

The latest rail adopted as a standard by the Milwaukee Electric Railway & Light Company is a 7-in. "Shanghai" section of T-rail, weighing 95 lbs. to the yard. The work shown above and the joints illustrated in Figs. 8 and 9 are upon a section of track built of this rail. The weight of cast iron used in this joint is 200 lbs. The total cost of the joint approximates $3.50 for the joint proper and $1.00 for the opening and closing of the street; upon new track this last item is almost eliminated.

Our cast-welding work is treated as a business by itself, and the fairest method of showing the cost of these joints to us is to quote from our yearly report for the calendar year 1904:

CAST-WELDING--OUTPUT 2414 CAST-WELDED JOINTS

			Per Joint
Account No. 180	Operating wages	$1,590.78	$ .659
Account No. 181	Repairs	704.83	.292
Account No. 182	Power and lighting expenses	40.10	.016
Account No. 183	Supplies	3,041.30	1.260
Account No. 184	Injuries and damages, 5 per cent	362.10	.150
Account No. 185	Interest, taxes, insurance	288.00	.119
Account No. 186	Miscellaneous	653.35	.271
		$6,680.46	$2.767

The operating wages, repairs and supplies shown above contain a certain percentage of increase over actual amounts to cover general depreciation. The 2414 joints were applied to rail ranging from 5 ins. to 7 ins. in height. In addition to the above an average of $1.00 per joint must be added as expense in opening and closing the street. A large proportion of the above were scattered over a wide area and were really welded under adverse conditions.

The above is given as being an exact statement of fact, and is the reason for our belief that in the present development of any of the methods of welding rail-joints, the cast-welding process comes most nearly striking the true average between economy and efficiency.

SUMMARY

To provide a summary of the foregoing papers is necessarily an undertaking which can result in little definite.

A few correlated ideas assembled and arrayed for purposes of comparison is more exactly what we may hope to accomplish; and in so arraying this correlated data, the fact that the information upon which it is based may not in all cases be complete, or the deduction drawn may not be the true one, serves only to accomplish the end desired, namely, a discussion of the entire subject matter.

Of the four methods of forming permanent joints illustrated above: three are properly designated as "welded," while the other (the zinc joint) cannot be classed exactly in this category. The deduction which the writer draws from the four papers, however, is, primarily, that it is possible, with the best knowledge, and by the use of sufficient and correct apparatus, to produce an almost absolutely satisfactory joint (as to efficiency) by any one of the four methods. Thus narrowing down the field of speculation, the question of amount and availability of apparatus becomes a vital one, which seems clearly outlined as follows:

The electrical welding operation appears undoubtedly to require the most cumbersome and very much the most expensive equipment, to such an extent, indeed, that, except in case of the very largest systems, private ownership would be virtually impossible, and all work would necessarily have to be done through contractors.

The zinc joint appears to rank next in point of expensive apparatus, but is followed very closely in this respect by the cast-welded joint.

The thermit welding process certainly requires very much the least expensive apparatus, and from this viewpoint stands in a class by itself. The relation of the joint to the abutting pavement in city streets is a much agitated question, but it has been shown beyond dispute that this agitation is needless, as the shape of the joint can be regulated to meet the condition.

There are many minor points which might be taken up, and which can be brought out in discussion, but in the opinion of the writer the meat of the entire subject, as it affects the great majority of the electric railway interests, is in the relative cost of an efficient joint by any one of the methods. There are, of course, local conditions which may, in isolated cases, warrant a departure from the seemingly economical method, but our object is at all times to serve the majority, and, therefore, while a much more exact comparison of cost will be easily obtainable during the discussion of this subject, such data as we have been able to secure is here assembled.

ZINC JOINTS

No figures as to cost obtainable; these joints are controlled by the Lorain Steel Company.

ELECTRICALLY-WELDED JOINTS

Information received from the Lorain Steel Company as follows: "Our prices are from $6.00 to $5.50 per joint, depending on the number of joints contracted for. Ordinarily we do not care to accept contracts for less than 3000 joints, on which, of course, the price of $6.00 per joint applies; contracts for 10,000 or more joints are made at the lower figure."

THERMIT-WELDED JOINTS

Mr. Pellissier's figures show that a joint on a rail of average size will cost about $4.50, of which the major share is the price of the thermit welding portion. To this he adds $1.25 for opening and closing the street.

CAST-WELDED JOINTS

The figures in this case show that the entire expense of applying a weld on a rail of average size (under disadvantageous conditions) is but little in excess of $2.75, with $1.00 additional for opening and closing the street. This, including interest, taxes and depreciation charges on the capital valuation of the apparatus. Therefore, in conclusion, and in advance of future enlightenment on this subject, which it is our earnest wish the forthcoming discussion may evolve, the writer seems to see that under present general conditions the cast-welded joint is so much more economical, from both the viewpoint of mechanical efficiency and actual monetary expense, as to recommend itself for first consideration.

If, however, the first cost of the portion of thermit required to make a joint can be reduced to the extent of 50 per cent or more than quoted, the other inducements held out by this method are sufficient to give it first rank in point of desirability.

THE POWER STATION

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Since the advent of the direct-connected generator, the tendency in power-station design has been toward a more systematic and compact organization of the generating apparatus and the utmost simplicity of the entire plant consistent with the highest efficiency. The practice of different engineers has gradually worked toward a type of station which is now so generally adopted for street railway work where limitations are not placed upon the design by the size or shape of the available site, that it can fairly be said to represent standard practice in modern power station engineering. It embodies the following essential principles:

1. Simplicity of design.
2. Subdivision of the plant into separate sections, so as to localize the effect of trouble to any part of the generating apparatus.
3. Provision for the symmetrical extension of the plant to provide for future power requirements.

This station in its simplest form consists of a boiler room, engine and generator room, and switchboard gallery, arranged in parallel lines and separated from each other by substantial fireproof walls. In stations of very large size the boilers are frequently arranged in two tiers, or in groups, each group having its own chimney and flues and independent systems of feed and steam piping. This arrangement of the station is now generally referred to as the unit system, the distinguishing feature of which is that the boilers, engines and generating apparatus are arranged in separate units or groups, each one of which embodies all of the essential features of a complete generating plant, and the great advantage of which lies in the fact that trouble with any single piece of apparatus is localized, so that its effect is felt only in that unit of which it forms a part. Provision for carrying the load in the event of a breakdown of any important part of the apparatus is made by installing an additional or spare unit.

While the unit system is now almost universally employed in the larger power stations, it is usually somewhat modified for smaller plants where the liability to interruption of the service is not so great or the results so disastrous, the chief difference being in the arrangement of the steam and feed piping. The steam piping from the boilers is run to a longitudinal header, from which the connections to the engines are taken off at convenient points. This steam header is divided into sections by means of gate valves, which permit of any section being cut out at the convenience of the operator for the purpose of making repairs. Usually two systems of feed piping are provided, one of which supplies hot water to the boilers through the heaters and economizers, while the second, or auxiliary system, supplies cold water, or water direct from the heaters, in case of trouble with the main system. This arrangement of piping provides sufficiently against interruption in small and medium-sized plants, and in a system carefully laid out with due consideration for the troubles which are likely to arise, it is hardly probable that the disarrangement of any one part will cause serious interruption of the service.

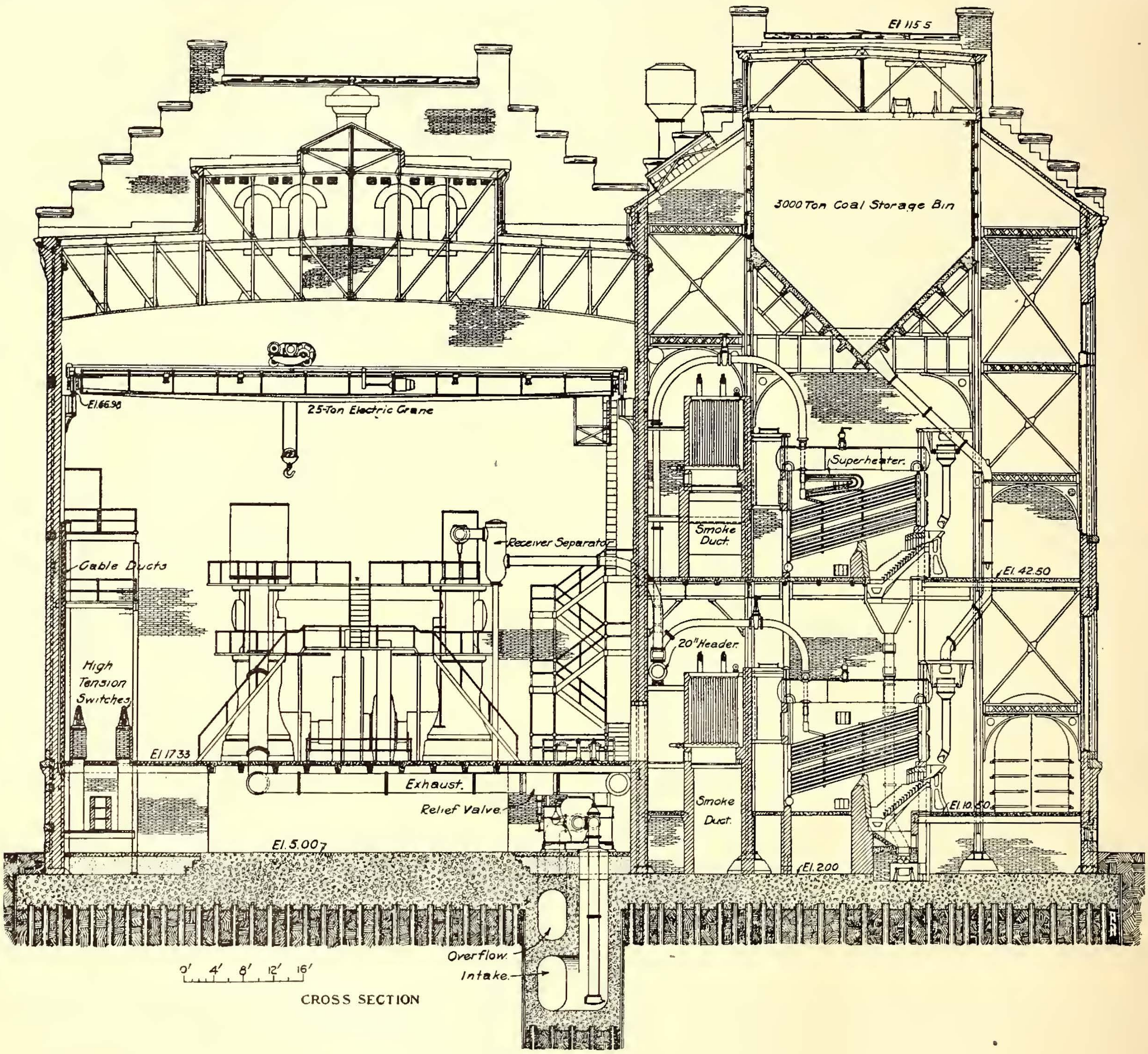
At the present time alternating-current generating stations and distributing systems are regarded as the most efficient to install in large cities where heavy traffic is distributed over a very large area, requiring current to be delivered to the line at a number of points, and where the interest upon the investment in direct-current feeders and cost of their maintenance would amount to more than the same charges plus the conversion losses in an alternating-current system; and for long suburban or interurban railways where the power required at any one point is small as compared with the total power generated. The use of alternating-current apparatus has steadily increased since its introduction, until at the present time approximately 60 per cent of the total power used by electric railways in the United States is generated by this type of apparatus.

In cities where the bulk of the business is within the economical radius of distribution for direct-current lines, and where direct-current generators form the larger part of the present equipment, the common solution of the problem is to use this type of apparatus for city work, adding alternating-current apparatus to supply the more distant portions of the system, or roads operating through outlying districts.

There is undoubtedly a great advantage in having all the apparatus of a uniform type. This simplifies the wiring and switching part of the electrical equipment, and permits of a more efficient distribution of the load in the station. But there can be no conversion of energy without loss, and in cases where a considerable part of the system can be supplied with direct current without the use of rotary converters, the composite type of station will frequently be found to offer advantages in lower first cost and higher efficiency.

The location of the power station, its general character, and the type of apparatus to be installed, depend to such an extent upon local conditions, that it is difficult to offer suggestions covering these points except in a general way.

If possible, the station should be located near an ample supply of water for condensing purposes, in order to secure the advantages from the use of the most efficient types of steam apparatus, and if possible, convenient also to a steam railroad or tide water, where the coal can be received and handled for the least expenditure of



CROSS SECTION OF POWER HOUSE OF RHODE ISLAND SUBURBAN RAILWAY COMPANY labor. Its location in reference to the distributing system will depend upon the extent and type of the system employed. If the direct-current system is used, it will be desirable to select a location as near as possible to its center of gravity, in order to reduce the investment in copper, but in the case of an alternating-current distributing system, this is of less importance, and greater consideration will be given to the cost of the available site, the nature of the soil, cost of foundations, etc.

The building should in all cases be of fireproof construction and of neat and attractive design, appropriate to and suggestive of the purpose for which it is used. In determining upon the dimensions of the building, it is important that ample room be provided for all of the apparatus to be installed, so as to avoid unnecessary crowding. Passageways should be provided between each battery of boilers, and at the rear for the convenience of attendants in cleaning the tubes and connections and for making necessary repairs. Sufficient room should also be provided around each piece of apparatus in the engine room, so as to enable the attendants to inspect it regularly and keep it thoroughly clean, and to provide for the removal of any part in case of repairs.

In large cities, where land is extremely valuable, or the available area limited, the amount of power which can be generated per unit of ground area occupied is frequently the controlling factor in deciding upon the power station plans, and in such cases it is not always practicable to provide all of the space usually regarded as desirable for the convenience of attendants. This condition rarely exists, however, except in the larger cities, and in a great majority of cases no excuse can be offered for crowding the machinery to such an extent that it cannot be kept in proper condition and conveniently repaired by those responsible for the management of the plant.

Cleanliness is absolutely essential to the successful operation of an electric railway power station. It is necessary that the building itself be kept free from oil and dirt, and each piece of apparatus thoroughly clean at all times, in order to maintain it in its highest state of efficiency. The designing engineer should contribute his share towards this result by providing ample light throughout the building—boiler room as well as engine or generator room. All the walls of the building should be painted in some light shade, preferably with some kind of enamel paint which can easily be washed down and kept clean. This will be found to reflect the light into dark corners of the building or spaces around the machinery, which might otherwise form receptacles for dirt and rubbish. It will add very much to the cleanliness and general appearance of the plant, and will contribute toward its successful running.

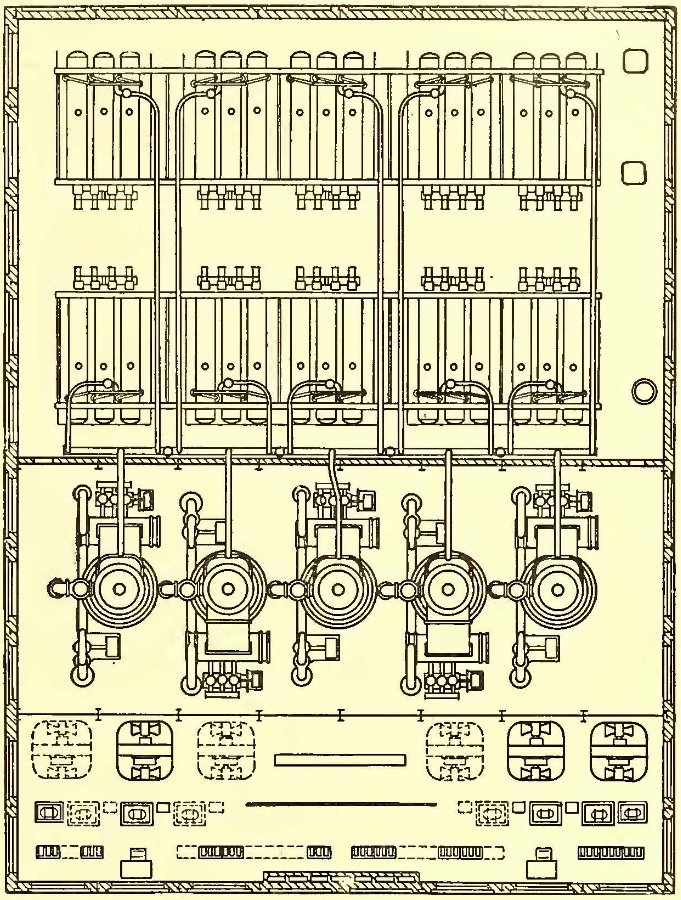
In designing a power station, the primary object in view is to deliver power at the bus-bars for the least expenditure of money, due importance, of course, being given to reliability of operation, which is the controlling principle in power station work. The fixed charges—interest, depreciation, insurance and taxes, should be as carefully considered as the cost of fuel, labor, supplies, repairs and other items which make up the operating expenses. Consideration should be given to each of these elements in proportion to its importance as a factor in the cost of power. In the great majority of cases fuel is the most important item of expense, frequently amounting to more than all other operating costs combined, and the perfection of these details of design and management which will effect the greatest economy in its use will usually make the best return for the time and labor expended.

Electrical apparatus has now been developed to such a state of perfection that in a well-designed and carefully managed power station over 90 per cent of the power of the engines is converted into electrical energy and delivered to the transmission system for the operation of cars. It appears, therefore, that no very great gain in coal economy is to be expected from the further improvement of electric generators or switching apparatus, and engineers are directing their efforts more than ever before to the steam portion of the power station, which offers a more promising field for a reduction in the cost of power.

The number and size of units to be installed is one of the most important problems bearing upon fuel economy which the engineer is called upon to solve. In order to obtain the maximum efficiency from the prime movers and their auxiliaries, it is necessary that they should be proportioned to the load they are intended to drive, so that if possible they may be operated at all times at or near their rated capacity.

In electric railway power stations it is not regarded as practicable to change the speed of the air or circulating pumps, or to alter the quantity of cooling water, to suit the varying loads upon the station, and these auxiliaries are usually operated at a point sufficient to take care of the maximum load. The power required to drive them is therefore practically constant, and their steam consumption per unit of output will vary indirectly as the load on the main engines. Under ordinary operating conditions, where the exhaust steam is used for heating the feed water, only about 12 per cent of the heat in the total steam generated can be used for this purpose, and all steam used by the auxiliaries in excess of this must go to waste; and it follows that in addition to the losses due to the reduced efficiency of the prime movers at light loads, the percentage of loss in the auxiliaries will increase very rapidly as the load upon the main engine decreases, and the best economy of the entire plant will be obtained only when the engines are operated at or slightly above their rated capacity.

The writer has before him the operating statistics of two railway power stations, a comparison of which illustrates the importance of proper attention to this subject. For convenience they will be referred to as Station A and Station B. Both stations furnish power for suburban railways upon which sufficient cars are run to provide a fairly uniform load during the greater part of the day, although subject to more or less violent temporary fluctuations. The general designs of these stations and their equipments are such that the fuel used per kilowatt-hour should be practically the same,

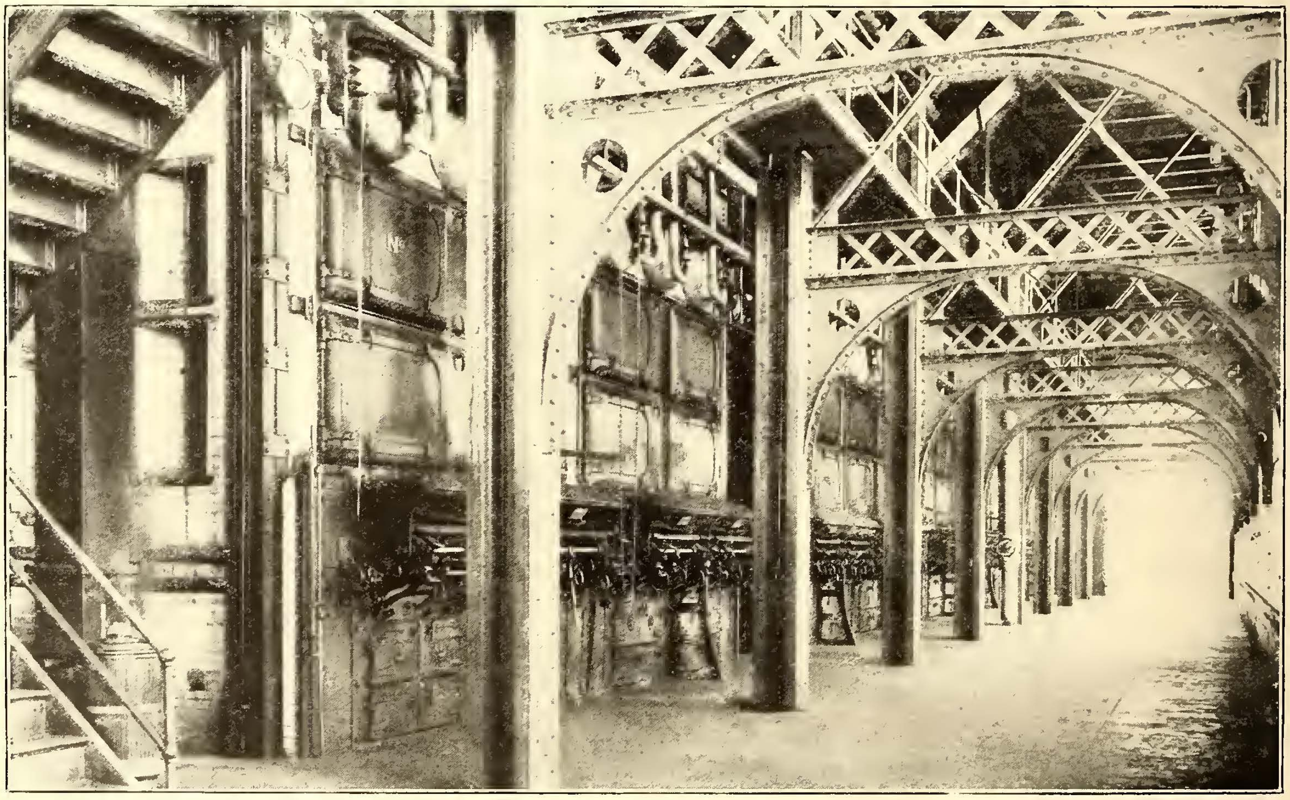


PLAN OF QUINCY STATION, OLD COLONY STREET RAILWAY COMPANY

provided the engines could be kept well loaded in both cases. In Station A there are three units, and the load conditions are such that one unit is operated during the night and early morning, when the travel is light; two are operated during the greater part of the day, and three at the peak of the load, which occurs shortly after 6 o'clock in the evening. By careful attention to the changes in the load, it is always possible to keep the running engines fairly well loaded.

In the case of Station B there are two units. The load at night and early morning is very light, so that the engine used is only about half loaded for this period, whereas for the greater part of the day the load is a little more than one engine should be required to carry, and it is therefore necessary to run both engines. The result, of course, is that the average load on the station is only a little more than 50 per cent of the rated capacity of the running engines, and they are, consequently, extremely wasteful of steam; and, too, the exhaust from the auxiliaries is probably quite a little in excess of that required to heat the feed water, which will also account, in a measure, for the low efficiency of the plant. Five pounds of coal per kilowatt-hour is the record of this plant, as compared with 3.8 lbs. for Station A. The greater part of this discrepancy is undoubtedly due to the more efficient load conditions in the latter station. It is probable that had a storage battery been added to the equipment of Station B, the load on the engines could have been regulated so as to have made a much better showing in coal consumption, but it is still problematical if there is any net gain from the use of storage batteries in railway work, and the writer is disposed to think that the use of three smaller engines in place of two large ones would have been the proper solution of the question. Undoubtedly a saving in coal of from 15 per cent to 20 per cent would have resulted from the use of engines better proportioned to the load.

In deciding upon the number and size of units, therefore, it is necessary that a careful study should be made of the load conditions throughout the entire day. In providing an increase of power for existing roads, data will be available from which station load curves under varying conditions of traffic can be constructed, and a fair average decided upon as the basis for determining the size of the units. In the case of a new railroad proposition, this information will be more difficult to obtain, and an approximate load curve will have to be constructed from a study of all of the conditions bearing upon the subject. This involves decisions upon such matters as the location of track, with special reference to grades and curves, the distribution of copper in the feeder system, the weight and equipment of cars and train schedules, all of which are important factors in determining upon the power required.



BOILER ROOM IN STATION OF THE RHODE ISLAND SUBURBAN RAILWAY COMPANY

It is often necessary to estimate the size of a new power station before the final survey of the road is completed, or the details of the feeder system or train schedules definitely decided upon. In such cases the engineer will have to apply such data as he is able to obtain from other roads in which the conditions of track and the operating conditions are similar. But such data should always be used with the utmost caution, as vital differences in grades, in the feeder system, or in train schedules, must necessarily exist, which will render it extremely difficult to make comparisons sufficiently accurate for a final decision upon the size of the station.

Having ascertained the power required during the different hours of the day, the plant should be divided into as few units as will enable the engines and generators to be operated at or near their rated capacity, while at the same time a sufficient number should be installed so that in the event of trouble one can be shut down without causing interruption of service. A 3-unit station will permit of a fairly uniform distribution of the load in small plants, and in case of accident to one unit, the other two should be able by overloading, to supply sufficient power until repairs are completed. This number of units is therefore regarded as the minimum which should be installed in any power station.

The type of apparatus to be used, whether alternating or direct current, will not materially affect the design of the station except in so far as the question of the use of reciprocating engines or steam turbines is involved. Up to this time the steam turbine, which is rapidly growing in favor for electric railway work, has been designed almost exclusively for use in connection with alternating-current generators, and the manufacturers of electrical apparatus have held out scant encouragement that its speed could ever be so modified as to make its use with direct-current generators, particularly the larger sizes, practicable. Reciprocating engines have, therefore, been regarded as the only type of steam motor available for this class of work. It is probable that this will be the case for some time to come, but it is interesting to note that considerable progress is being made in the development of direct-current turbo-generators. A number of machines of this type as large as 500-kw capacity are in operation, and work is well advanced upon units as large as 2000 kw. There seems to be good ground for the belief that this problem will be successfully solved, and that in the near future this type of apparatus will be available in sizes as large as are generally required for direct-current work.

Engineers and steam users generally have been prepared for some time to welcome any form of prime mover which could be shown to possess any considerable advantage over the reciprocating engine, as the latter had come to be regarded as having largely fulfilled its possibilities, and no very great improvement in economy was to be looked for. The steam turbine seemed to offer the solution of the question, and while, at the time of its introduction into this country, its superior economy had not been demonstrated, its great simplicity as compared with reciprocating engines, lower first cost, and less floor space occupied, insured its prompt adoption by a large number of power users, and from the first its progress has been rapid. In a report of the committee for the investigation of the steam turbine made to the National Electric Light Association last June, it was stated that there were in operation at that time 224 turbines of an aggregate capacity of over 350,000 hp, the greater number of which had been installed in the last two years. The writer is informed that the orders for turbines taken by the largest two manufacturers in this country aggregate (July 1, 1905,) over 800,000 hp.

The remarkable progress made in the manufacture of these machines, and their general adoption by many of the most progressive railways in the country, proves them to be a most formidable competitor of the reciprocating engine, if, indeed, it does not indicate that they have already established their commercial superiority.

It is to be regretted that most of the data upon the efficiency of steam turbines has been derived from tests covering very short periods of time, usually only a few hours, and that so little data is available of their performance under actual service conditions. To the street railway manager or engineer, power station records for long periods, showing the coal consumed per kilowatt-hour, or, better still, the efficiency of the plant expressed in percentage of heat energy in the coal converted into electrical energy at the switchboard, are of much greater interest and value than the record of any number of short-time tests for steam consumption only, as it provides him with a much more practical means of making comparisons with the performance of other stations with which he is familiar. The data which has been published illustrating the relative economy in steam consumption of turbines and reciprocating engines rarely ever shows comparisons between units operating under identical conditions as to steam pressure, superheat, or vacuum and therefore does not fairly represent the relative performance of the two types, and, too, the steam consumption of the auxiliaries is also invariably omitted, so that it is impossible to form an intelligent opinion as to the additional cost of the higher vacuum required for the turbine.

Up to this time most of the turbines installed in electric railway power stations are operated in connection with reciprocating engines, and owing to the difficulty of separating the operating charges, it has been practically impossible to obtain reliable information as to their performance under commercial conditions.

One of the plants where turbines are exclusively used is the Quincy power station of the Old Colony Street Railway Company, and through the courtesy of P. F. Sullivan, president of this company, the writer is permitted to publish some information regarding the performance of this station. This information was kindly furnished by C. F. Bancroft, superintendent of motive power and machinery.

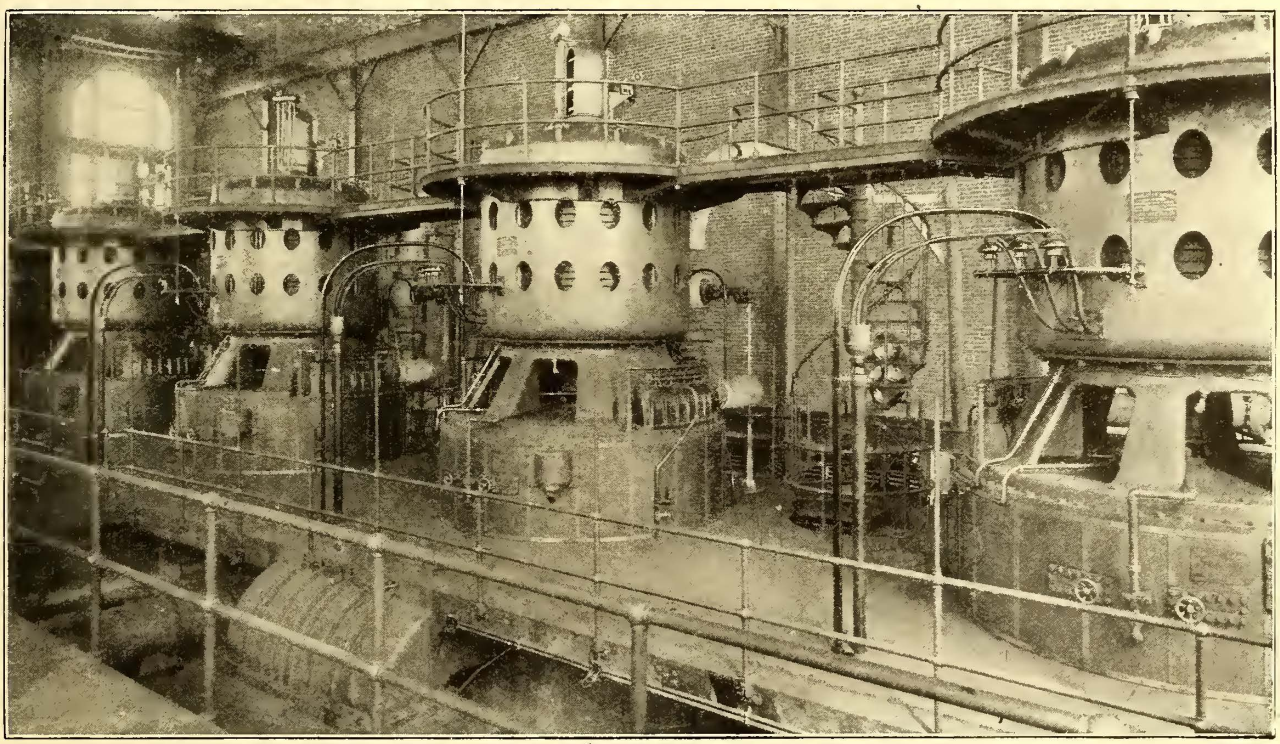
It should be stated at the outset that this station, which will eventually furnish power for that portion of the Old Colony Street Railway Company's system, extending from Quincy on the north to the city of Fall River on the south, is not yet in full operation. Its connection with the latter city, where a large part of the current is to be used, has not yet been made, so that at present it furnishes power for only about one-third of the number of cars which it will eventually drive. Only two of the five turbines in the station are required for this work. One of these machines is run for 17 hours per day, and two for 24 hours per day. When the station is in full operation there should be a more uniform load, and it is expected that the station efficiency will be considerably increased.

The station contains five 2000-kw, 4-stage vertical turbines, running at 750 r. p. m., and connected to 13,200-volt, 25-cycle alternating-current generators. The steam pressure is 200 lbs. There are ten horizontal water-tube boilers of 750 hp each, equipped with internal superheaters, giving to the steam an average of 65 degs. superheat. Under-feed stokers are used. There are no economizers. One turbine is supplied with steam-driven auxiliaries; the other four have motor driven auxiliaries. At present, while only two units are in operation, the feed water is heated to 200 degs. F. by the exhaust from the steam auxiliaries. The average daily output is 52,500 kw-hours, giving a load factor of 54.7 per cent for the two machines. Georges Creek Cumberland coal is used, having an average calorific value of 14,000 B. T. U. per pound. The average coal consumption for this station, operating under the conditions outlined above, is 2.94 lbs. per kilowatt-hour, showing an efficiency of 8.36 per cent. This record covers a period of six months, ending June 30, 1905.

While this performance does not furnish conclusive evidence of the superiority of the turbine over reciprocating engines in electric railway work, it compares favorably with the results obtained in a large number of the better class of stations using the latter type of prime movers, and gives some force to the opinion that in actual practice there will be found to be very little difference in the coal consumption of steam turbine and reciprocating engine plants operating under similar conditions.

In order to develop the highest efficiency of the steam turbine, it is necessary to operate with a very high vacuum. It is claimed that each inch of vacuum above 26 ins. will increase the economy from 3 per cent to 4 per cent, and condensing apparatus is usually recommended which will produce a vacuum of about 28 ins. of mercury, or 2 ins. to 2½ ins. higher than that regarded as the most efficient for reciprocating engines. The type of apparatus generally installed consists of a surface condenser with a centrifugal circulating pump, dry vacuum pump and hot-well pump. In practice no trouble has been experienced in obtaining the high vacuum desired with this type of apparatus, but whether the gain of 3 per cent or 4 per cent in coal is sufficient to warrant the additional first cost and cost of operating this rather complicated system, is a question which would seem to be open to discussion. In cases where the cost of feed water is a material factor in the cost of power, or where it contains a large percentage of calcium or magnesium carbonate, or other scale-forming materials, there will be great advantage in using a surface condenser on account of the pure distilled water returned to the boilers, but where these conditions do not exist, it will frequently be found to be practicable to use some simpler form of condensing apparatus, such for example as the injector or barometric type of jet condensers. These types of condensers offer very great advantages over the surface condenser in the matter of lower first cost, space occupied, greater simplicity and less cost of maintenance. Up to this time they have not been very generally used, but there seems to be no good reason why they should not work as satisfactorily in connection with steam turbines as with reciprocating engines, and when properly proportioned to the work and installed with tight piping throughout, it is believed that in many cases they will prove to be as satisfactory as the more complicated types.

A considerable economy in the steam consumption of both reciprocating engines and steam turbines has been shown to result from the use of superheated steam. In plants equipped with either of these types of prime movers using dry saturated steam, the introduction of superheated steam can generally be depended upon



TURBINE ROOM, QUINCY STATION, OLD COLONY STREET RAILWAY COMPANY to effect a saving in steam of about 1 per cent for every 8 degs. or 10 degs. of superheat. Where the quality of the steam is not so good, and the conditions are such that the condensation in the pipes or cylinders of the engines is excessive, the saving may be much greater than this, sometimes amounting to 1 per cent for every 4 degs. or 5 degs. of superheat.

With reciprocating engines, condensation in the cylinder resulting from the great difference in temperature between the incoming steam and the surfaces of the cylinder which have just been exposed to the temperature of the exhaust steam, has been recognized as one of the greatest sources of loss. Various means have been employed to reduce this loss, such, for example, as the use of steam jackets and reheaters, but these devices add materially to the complication of the engine, and under the most favorable conditions only affect a partial saving. For these reasons they have not been generally adopted in power station work. Superheated steam has been found to be a much simpler and more effective method of accomplishing this result.

Our knowledge of the subject of steam turbines is still so limited that it is impossible to state with any degree of positiveness just where the various losses occur, or to what causes we must attribute the gain in efficiency from the use of superheated steam. Undoubtedly a portion is due to thermodynamic reasons, and it has been suggested that a large portion is also due to the diminution of fluid friction within the turbine. Owing to the very high steam velocities in this type of apparatus, the friction of the steam passing over the surfaces of the buckets must cause a considerable loss, and this probably very much greater where the steam carries a large percentage of moisture than when it is dry or superheated. It is probable, therefore, that the larger part of the gain due to superheating can be attributed to this cause.

The prevention of the deposit of water on the inside of the turbine casing, also, must effect some saving, although this gain is probably small as compared with that resulting from the diminution in the friction of the steam as it passes over the surfaces of the buckets.

Whatever the causes may be, there can be no doubt that there is a very marked gain in efficiency in steam turbines from using superheated steam, amounting to about as much per degree of superheat as in the better class of reciprocating engines.

The following table, compiled by R. M. Neilson, shows the reduction in steam consumption in steam turbines and reciprocating engines due to superheating. These statistics were obtained from a number of tests made in this country and in Europe. The apparent discrepancy in these tests is explained by the statement that there was considerable difference in the quality of the steam in the different cases, and the engines were of different types and of different sizes:

Steam Turbines			Reciprocating Engines		
Degrees Fahr. of Superheat	Percentage Reduction of Steam Consumption	Percentage Reduction per Degree Fahr.	Degrees Fahr. of Superheat	Percentage Reduction of Steam Consumption	Percentage Reduction per Degree Fahr.
13	6.1	0.47	31	7.86	0.25
50	8.0	0.16	40	8.65	0.22
60	5.4	0.09	50	12.00	0.24
66	12.1	0.18	100	20.55	0.20
70	7.5	0.11	100	13.00	0.09
84	7.7	0.09	216	36.4	0.17
100	14.0	0.14	225	33.7	0.15
140	12.6	0.09	225	33.1	0.15
150	19.0	0.13	440	30.9	0.07
200	23.0	0.115			
260	24.5	0.09			

Unfortunately, superheated steam is now known to be rather expensive to produce, particularly at the higher temperatures, and consequently economy in steam consumption does not necessarily mean economy in the consumption of coal. The chief advantage in its use is obviously in the saving which can be made at the coal pile, and unless this saving can be shown to be sufficient to pay for installing and operating the necessary superheating devices, it will be extremely difficult to convince a careful street railway manager that it will be profitable to use it.

This is a subject upon which there is a vast amount of conflicting information. In a number of instances the use of superheaters has been discontinued either on account of mechanical difficulties or because there was not a sufficient saving in coal to pay for keeping them in service. In other cases no mechanical difficulties have been experienced, and the saving in coal has been all that could be reasonably expected.

It is noteworthy that manufacturers of reciprocating engines and steam turbines, as well as engineers, while still recognizing the value of superheated steam, are disposed to be much more conservative than formerly in recommending its use. At this time, the weight of opinion seems to be in favor of a moderate amount of superheat, say not exceeding 125 degs. Within this limit there should be a sufficient saving at the coal pile to justify its use, while the temperature is not sufficiently high to cause serious mechanical difficulties with any of the various types of steam apparatus generally used.

For many years after the inauguration of the electric railway industry, power station engineers seemed disposed to devote the greater part of their energies to perfecting the arrangement of engines, generators and switching apparatus, frequently neglecting the more important, though less showy, boilers and their accessories. In recent years they have come to realize that a larger percentage of saving can be made by a proper attention to the design and management of the boiler room than in any other department, as it is here that the greater number of preventable losses in a power station occur.

The designs of the standard types of steam boilers which are now generally used have been perfected to such a degree that efficiencies as high as 70 to 75, and even 80, per cent have been attained under favorable conditions, and there are very few improvements which the power station engineer can suggest which will produce any considerable saving in fuel.

The design of the furnace, as distinguished from the boiler, on the contrary, is one requiring careful thought and study, to make it conform to the conditions required for the perfect combustion of the specific kind of fuel which is to be used. Anthracite coal, owing to its small percentage of volatile matter, can be satisfactorily burned in almost any kind of a furnace, provided the grate area and the draft are sufficient to burn the quantity required to develop the desired capacity, but in the case of semi-bituminous and bituminous coals and lignites, containing a much larger percentage of volatile matter, the furnace should be so designed that this volatile matter, as well as the fixed carbon, will be completely burned in order to develop the full heating value of the fuel.

The following conditions are necessary to insure the complete combustion of the fuel:

1. A sufficient supply of air.
2. Thorough mixture of air and fuel.
3. A sufficiently high temperature of the air and the combustible gases to insure their ignition and perfect combustion before they come in contact with the cooling surfaces of the boiler.

The principal source of loss is due to imperfect combustion of the volatile gases, which are distilled very rapidly after fresh coal is placed upon the fire, and not being mixed with air at a temperature sufficient to cause ignition, pass off unconsumed; or the air supply and the temperature being sufficient, they are allowed to come in contact with the comparatively cool surfaces of the boiler, and their temperature reduced below the ignition point before combustion is completed, so that they escape when only partially burned. The mixture, temperature and time are therefore important factors in the combustion of the volatile gases, and it follows that the combustion chamber should be of sufficient size to allow the gases to become thoroughly mixed, and that they should be raised to a sufficiently high temperature and be protected by fire-brick walls and arches from the cooler surfaces of the boiler shell or tubes until the combustible portion has been entirely consumed.

As to the proper place to admit the air for the combustion of the volatile gases, D. K. Clarke says:

"It is a matter of perfect indifference as to effect in what part of the furnace or flue it is introduced, provided this all-important condition be attended to, namely, that the mechanical mixture of the air and gas be continuously perfected before the temperature of the carbon of the gas, then in a state of flame, be reduced below that of ignition."

A number of furnaces have been devised in which the air has been admitted at the bridge wall or at the sides or front of the furnace above the grate, and there have been many ingenious plans for heating this air to the proper temperature before its admission to the combustion chamber. Some of these furnaces have been fairly successful as a means of reducing the smoke, but it is doubtful if the admission of air above the grate has ever materially increased the efficiency of the furnace. By far the most common practice is to admit all the air through the grate, that required for the combustion of the volatile gases being heated to the proper temperature by passing it through the bed of incandescent fuel.

In many of the larger railway power stations the flue gases are regularly analyzed to ascertain the amount and distribution of the losses due to incomplete combustion and the amount of excess air admitted to the furnace, which information is necessary to enable those in charge to operate the boilers in the most efficient manner. The only way in which the waste which takes place in the furnace can be detected is by such an analysis, and its importance as a means of reducing boiler room losses is so great that it merits a much more general use.

In the combustion of coal the object in view is to produce the highest possible percentage of carbon dioxide per unit of fuel burned. The higher the percentage of carbon dioxide, the more perfect will be the combustion of the fuel and the higher the furnace temperature, as is shown from the fact that a pound of carbon burned to carbon dioxide will produce 14,600 B. T. U., while only 4450 B. T. U. will be produced when, on account of an insufficient supply of air, carbon monoxide is formed. The gas analysis will show the percentage of carbon dioxide, carbon monoxide and oxygen. This information will enable the chemist to determine the total heat in the escaping gases, the amount of unconsumed gas, and the losses due to an excess air supply, and will also indicate the cause of these losses and suggest the proper remedy.

A low temperature of escaping gases is frequently regarded as an indication of efficient furnace conditions, but it is quite as likely to be caused by an excess of cold air, due to too strong a draft, uneven fires, or leakages through the boiler settings. The true condition of affairs can only be revealed by means of an analysis of the flue gases. Anything which will increase our knowledge of the conditions which take place within the boiler setting, and will permit a more intelligent use of fuel, should be encouraged, and for that reason the practice of analyzing the flue gases is recommended in all railway power stations where the cost of fuel is an important factor in the cost of power. It is always preferable to have this analysis made by an experienced chemist, but in small stations where the saving to be made is not sufficient to warrant the employment of such a man, it is said to be possible to obtain fairly satisfactory results from the use of one of a number of automatic or semi-automatic devices which are now manufactured for the purpose.

Mechanical stokers are now almost universally employed in electric railway power stations, on account of the increased efficiency over hand-fired furnaces and the reduced cost of operation. In a properly constructed furnace of moderate size, equipped with flat grates, an intelligent and careful fireman will produce results equally as satisfactory as any which have been obtained with any of the various types of mechanical stokers; but the trouble is that such firemen are not plentiful, and it is extremely difficult to secure men who will produce uniformly good results for long periods of time. For this reason the average fuel economy in a railway power station will generally be found to be somewhat better where the firemen are assisted by some form of mechanical stoking device.

It should be borne in mind, also, that in order to economize in space and the initial cost of the plant, the size of the boilers and the rate of combustion has steadily increased in the last few years until they have now reached a point where it is doubtful if the larger sizes can be properly stoked by hand, even by the most competent firemen.

The use of mechanical stokers is necessary in connection with these large sizes of boilers, in order to drive them up to the capacity required in electric railway plants.

There can be no doubt that mechanical stokers accomplish a considerable saving in boiler house labor. A reasonable day's work for a fireman is the shoveling of sufficient coal for about 500-hp of boilers, which in a railway power station will amount to from six to eight tons every twelve hours. Where automatic stokers are used, and coal is delivered to the hoppers by gravity, one man should be able to take care of about 2000-hp of boilers, which is equivalent to a reduction in labor of 75 per cent. The cost of maintenance of automatic stokers is somewhat greater than that of flat grates, and additional labor is required for repairs as well as for tending the coal handling machinery usually installed in connection with them, so that the net saving in labor will be somewhat less than that indicated above. There is a point, of course, at which this saving is not sufficient to pay for the additional fixed charges and repairs upon the mechanical stoking devices. This point is reached in a boiler plant of about 2000-hp capacity. In a plant of greater capacity than this, automatic stokers can generally be shown to return a sufficient net saving to warrant their use, while in smaller plants it will frequently be found to be profitable to use them on account of the cheaper grades of fuel which can be burned and the greater capacity which can be gotten out of the boilers.

Perhaps the most difficult problem to be solved in connection with the power station is to secure proper attention to details of operation by the subordinate employees. In the most carefully designed plant, equipped with the most efficient types of machinery, the results which the railway manager and designing engineer may reasonably expect in the way of economy will not be achieved unless the utmost care and vigilance are exercised by the operating forces. The successful operation of the station will depend largely upon the way in which the forces are organized, and discipline maintained. Just how the station organization should be made up is a question which can only be decided for each plant after a careful study of all the conditions; but it is safe to say that however the various departments may be organized, there should be one man in supreme authority, possessing considerable executive ability as well as a thorough practical knowledge of steam and electricity, whose decision should prevail in the event of disagreement among the heads of departments or at times of emergency. As he is the one who will be held responsible for the successful performance of the station, it is essential that whatever regulations there may be regarding the employment of his subordinates, he should have full authority to dismiss any who prove to be incapable or are not disposed to be attentive to their duties. It will be practically impossible to maintain proper discipline if among the employees there are those who feel a certain sense of security in their position through the influence of someone higher in authority than the man in charge of the station.

The work of the greater number of station employees is necessarily of a routine character. It is nevertheless important that they should be thoroughly instructed in their duties and required to perform them with the utmost regularity. For example, an oiler employed upon an engine should receive instructions as to the minutest detail of the work that he is required to do. He should not only be required to see that his lubricators are full and working properly, and that every part is receiving a sufficient quantity of oil or grease, but he should feel of every bearing and should observe every part of the engine as he passes around it to assure himself that it is in proper operative condition. He should be required to perform these duties at regular intervals of every 20 or 30 minutes, and his attention should be called to the time for him to commence his rounds by a bell or whistle, or some other form of signal. If there is any part requiring attention, it should be immediately reported to the engineer in charge, who will thus be given an opportunity to apply the proper remedy before the trouble has developed to such an extent as to cause damage or interruption to the service. If the oiler attends to his duties properly, there will be no trouble from hot bearings, from keys, pins or bolts working loose, or from any change in the adjustment of any part which it is possible to discover when the engine is running.

The work of all other station employees should be systematized along the same lines. The watch engineers should report in writing to the engineer in charge details of the apparatus which in their judgment require attention, and as soon as the machinery can be shut down, these parts should be carefully inspected, and if they show signs of weakness or excessive wear, immediately renewed or repaired. An examination of the enclosed parts of the engines and other working machinery should also be made at frequent intervals and before there are any outside evidences of trouble.

It is necessary that all subordinate employees should be under constant supervision to insure a proper attention to their duties, but this is especially true of the fireroom forces. Firemen are not generally disposed to take as much interest in their work as employees in other departments. They seem to be content to remain as firemen, and rarely endeavor, by excelling in their work, to advance their positions. It is in this department that the greatest losses will occur through indifference on the part of the attendants, and it is therefore of the utmost importance that their work should be carefully done. The only way to accomplish this known to the writer is to place this department in the immediate charge of an intelligent and capable man, whose salary and the knowledge that the permanency of his position will depend upon the results produced, will be sufficient for him to keep constantly in touch with those immediately under him and insist upon their performing their duties properly.

In most power stations records are kept of the coal and water consumption, the temperatures of the feed-water and flue gases, and the station output, by which the performances of the station from month to month can be compared. These records furnish a check upon the condition of the station, the manner in which it is operated, and assure its being maintained in a high state of efficiency. The writer has found that in addition to these records, an occasional test of the entire plant under actual operating conditions for periods of say, 24 to 48 hours, are also of great value as a means of furnishing definite knowledge as to just what the station is capable of doing. Such tests also have a certain educational influence upon the employees, particularly the firemen, as they illustrate to them what can be done when all engaged on the work are exerting their best efforts to secure the most efficient results possible.

At the Rhode Island Suburban Railway Company's Manchester Street station all of the usual records are kept, and the quantities and costs carefully determined for each month, and tests of the entire plant are also made as suggested above. The writer believes that these tests have a sufficient influence upon the regular performance of the station to justify a brief description of it, and the publication of the results in the matter of coal consumption from the time it was placed in commission, showing the gradual improvement in efficiency.

This station was originally designed for the Rhode Island Suburban Railway Company to furnish power for its lines operating in the vicinity of Providence. It was intended to use horizontal units, and two 1500-kw alternating-current units and one 1600-kw direct-current unit were purchased. Before work on the building had progressed beyond the foundations, however, it was decided to increase the capacity of the station by installing two additional direct-current units of 2500-kws each. This required a number of changes in the structure, and necessitated double-decking the boiler room in order to provide the necessary additional boiler capacity. The present equipment of the station consists of fourteen horizontal water-tube boilers of 520 hp each, eight on the lower floor and six

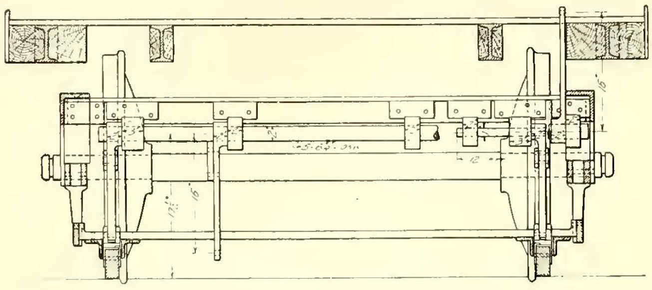


FIG. 2.—CROSS SECTION OF TRACK BRAKE APPLIED TO PECKHAM TRUCK

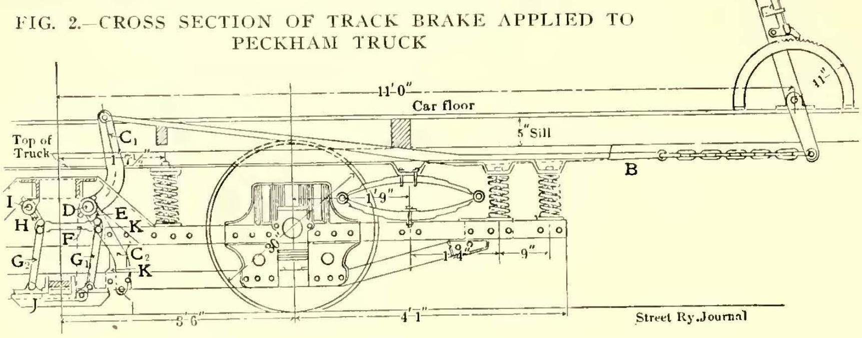


FIG. 1.—TRACK BRAKE APPLIED TO PECKHAM TRUCK

on the upper floor. The boilers on the lower floor have no superheaters, but those on the upper floor are equipped with internal superheaters, each made up of eighty-four 2-in. tubes, suspended below the boiler drums. The superheaters on two of the boilers were designed for only 125 degs. of superheat, and contain 615.3 sq. ft. of effective heating surface each. Those on the other four boilers were designed for 150 degs. of superheat, and contain 855.5 sq. ft. of heating surface. Each boiler has 5159 sq. ft. of heating surface.

Roney mechanical stokers are used, each containing 112 sq. ft. of effective grate surface. A 280-tube Green fuel economizer is installed directly back of each battery of boilers, the flue being so arranged that the hot gases may be passed through the economizers or directly to the main flue as desired. The heating surface per square foot of grate is for boilers 46 sq. ft., for economizers 15 sq. ft., or a total of 61 sq. ft. Natural draft is used. The boiler pressure is 145 lbs. There are three horizontal compound engines with cylinders 32 ins. and 64 ins. x 54 ins., operating at 94 r. p. m., and two vertical compound engines with cylinders 42 ins. and 86 ins. x 60 ins., operating at 75 r. p. m. All of the engine auxiliaries are steam driven. Jet condensers are used, the air pumps being of the twin vertical type. The average vacuum in the engine cylinders is 25½ ins. of mercury. There are two alternating-current generators each of 1500-kw capacity, delivering current to the line at 11,000 volts, and one 1600 kw and two 2500-kw direct-current generators delivering current at 600 volts. The normal capacity of the station, therefore, is 96,000 kws. Direct current is furnished for 24 hours per day, and alternating current from 5 a. m. to 1 a. m. There are no feed-water heaters between the engine cylinders and the condensers, but the exhaust steam from the auxiliaries is carried to two heaters located in the basement on the suction side of the feed-pumps. These heaters are made up of horizontal U-tubes arranged in series, the steam entering at the top and discharging at the bottom, while the water enters at the bottom and discharges at the top. Each heater contains 750 sq. ft. of heating surface, and in practice all of the steam from the auxiliaries is condensed and is discharged at a temperature only about 35 degs. higher than the incoming cold water. The average daily output of the station is 102,500-kw hours.

The following is the performance of the station under actual service conditions from the time it was started in regular service, February, 1904. It should be borne in mind that the first battery of boilers with superheaters was installed eleven months after the station was started, and four months thereafter two additional batteries of boilers with superheaters were commissioned, and the performance of the station is therefore given for the period covered by these different conditions.

Eleven months, saturated steam, 2.87 lbs. of coal per kw-hour.

Four months, slightly superheated steam (no record of temperature kept), 2.73 lbs. per kw-hour.

Three months, superheated steam, average temperature at engine throttle 465 degs. (102 degs. superheat), 2.46 lbs. of coal per kw-hour.

The apparent reduction in coal consumption per kw-hour with steam superheated about 100 degs. is 14.3 per cent, but all of this saving cannot be attributed to this cause. A large part of it is undoubtedly due to the increased efficiency of the fireroom attendants. Probably not over 8 to 10 per cent should be credited to the use of superheated steam.

AN EMERGENCY TRACK BRAKE

BY F. F. BODLER,
Master Mechanic, United Railroads of San Francisco

The emergency track brake hereafter to be described is used on practically all of the cars in San Francisco. While San Francisco is an ideal city for operating street railways in many respects, especially as regards the absence of snow, ice and sleet, yet it has its drawbacks, namely, an enormous number of steep grades. In order to operate safely over these in wet weather and on slippery rails it was necessary to provide another means of braking a car than the wheel brakes.

In 1895, G. W. Douglas, then master mechanic of the Market Street Railway Company, started to experiment with a track brake on electric cars. Twelve single-truck cars were equipped with track brakes, and operated successfully until 1899. In that year Mr. Douglas reconstructed his brake, and made it successfully applicable to double as well as to single trucks.

Primarily, the brake (see Fig. 1) consists of a hand lever A connected by a brake rod B to an arm C-1, keyed on a rocker shaft D extending clear across the truck. This shaft is connected on each end by means of a short lever E keyed to the shaft, to a connecting link F and to a toggle lever G-1. The connecting lever F is connected to a lever H keyed to a short shaft I, and to a toggle lever G-2. The shell J for holding the shoe is connected to the toggles G-1 and G-2 by means of two heels.

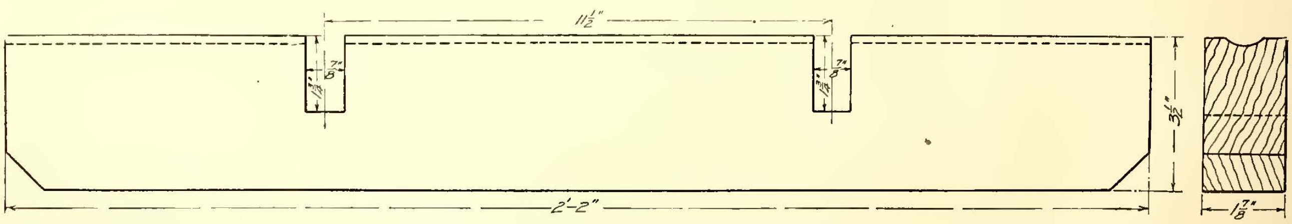


FIG. 6.—STANDARD TRACK BRAKE-SHOE

By pulling back on lever A the shaft D turns from left over to right, tending to make the short lever E assume a vertical position. This motion is transmitted to lever H by means of connecting lever F. The simultaneous parallel movement of levers E and H causes the toggle levers G-1 and G-2 to assume a vertical position and to force the shoe to the rail. The heels on the shoe, one on each side of a channel-iron across the truck, act as a guide and allow the shoe to travel only in a vertical direction. A lever with a counterweight attached to it, keyed to shaft D at any convenient position or bolted to arm C-1, acts as a release.

In order to adapt this brake to a Peckham or Brill single truck it is necessary to fasten a flat iron K, bent as shown, to the side frames, using the holes on each side of one of the spiral body springs. Two angle-irons are placed transversely across the truck, and fastened to the bent flat iron K. To these angle-irons the brass boxes for holding shafts D and I are bolted. The large shaft D is held in position by three boxes, one on each end and one near the arm C-1. The short shaft I is held by two boxes, one on each side of lever H.

To operate the track brake from the opposite end of the car an arm C-2 is keyed to the shaft D, the brake and rod being placed under and on one side of the motor, as shown in Fig. 2.

Fig. 3 shows the brake applied to a Brill single truck. This brake is placed on double trucks practically as on a single truck, except that each truck has an independent brake, operated from the end nearest the truck. On double trucks the rocker shaft boxes are fastened directly to the transom angle-irons. The arm C-1 has to be placed in middle of shaft D, on account of the swing of the truck.

Fig. 4 shows a Brill 27-G truck, and Fig. 5 a Peckham 14-B-3-S truck with this brake.

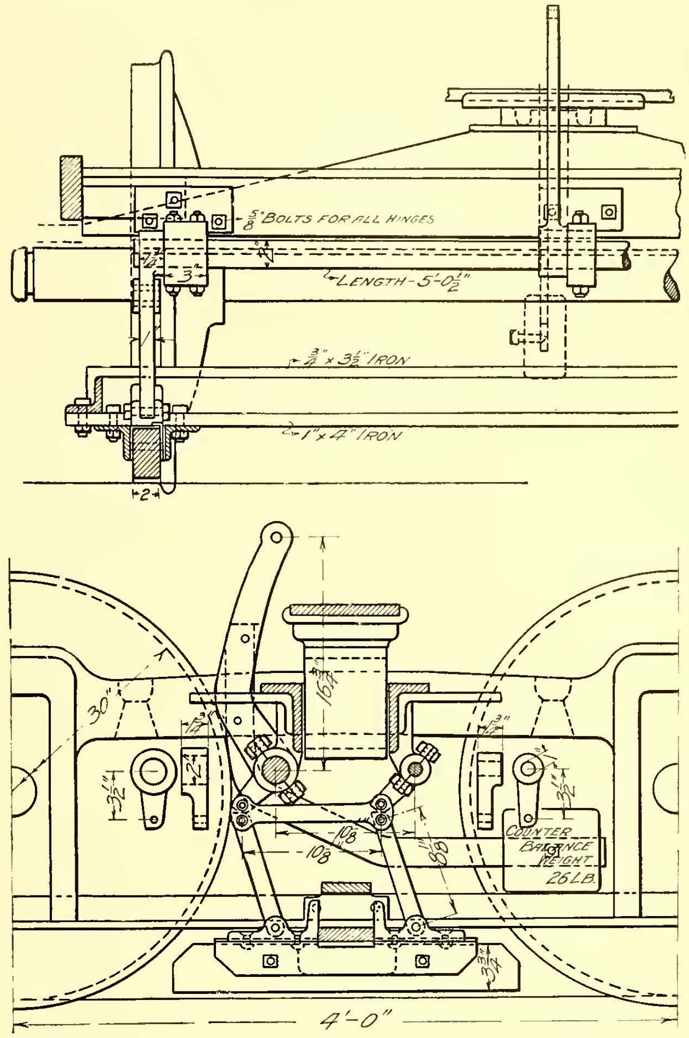
Fig. 6 shows a standard track brake-shoe. This shoe is made of Oregon pine, costs about $.0275 and lasts about one week. All kinds of wood, all kinds of metal, combinations of wood and metal, and metal with all kinds of inserts were experimented with, but for cheapness, general utility, and highest braking efficiency the Oregon pine shoe was found to be the best. The shell for holding through the holes shown in the shell and through the recesses shown in the shoe, not only clamping the shoe by means of the shell, but also preventing the shoe from slipping backward or forward. In order to facilitate the removal of wornout shoes, sections of rail slightly longer than the shoe are sawed off and hinged on the car house tracks. The cars are placed with the shoes over these hinged rail sections, the hinged rail is swung out, and by loosening the two bolts the shoes drop out. The time required for replacing four shoes on a double-truck car is about 2 minutes. The shoes can be adjusted when partly worn, by inserting wooden shims between the top of the shoe and shell.

As seen by various sketches this brake can only be applied on trucks having outside-hung wheel brakes. On double trucks it can only be used when the bolster spring is half elliptic and hung under the side frames. It can not be used on M. C. B. bolsters, on account of lack of room. In fact it requires close figuring to adapt it to the above mentioned trucks, in order to prevent the bolster from coming down on the connecting lever, F.

It has been proved that the brake is most effective when brake levers as shown in sketches are used. The efficiency of the brake is proportionate to the rapidity and force with which the shoe is brought down on the rail. An ordinary ratchet handle with the ordinary spindle is of little use. With a cam on the spindle it is decidedly more efficient.

The strong points of this brake are: Extreme simplicity; high efficiency; low cost of maintenance; independence of all other brakes, and its being purely a mechanical contrivance. It can readily be operated by compressed air, by adding a brake cylinder.

Whether it would be as successful in cities where there is much snow, ice and sleet as it is in San Francisco, the writer would not care to say, yet there seems to be no reason why it should not. It may appear to some that on account of taking considerable weight off the wheels, there would be danger of skidding the wheels, yet the number of flat wheels has steadily decreased since these brakes were put on. The reason for this is probably that there is no need of "cinching" the wheel brakes up so tight as formerly.



FIGS. 4 AND 5.—SECTION AND ELEVATION OF TRACK BRAKE APPLIED TO BRILL 27-G DOUBLE TRUCK

Cars are operated over one 17.5 per cent grade, four 14.5 per cent grades, and any number of 10 to 12 per cent grades.

A single-truck car, weighing 10 tons, can be stopped on the steepest grade over which electric cars are operated in the city, in a reasonable distance, by first applying the wheel brakes, and then the track brake. This brake originally was intended only for emergencies; it has been found so serviceable, however, that it is used almost as much as the wheel brake is. It ought not to be used on curves, switches, or crossings, but should it be used, about the only damage resulting would be a split shoe.

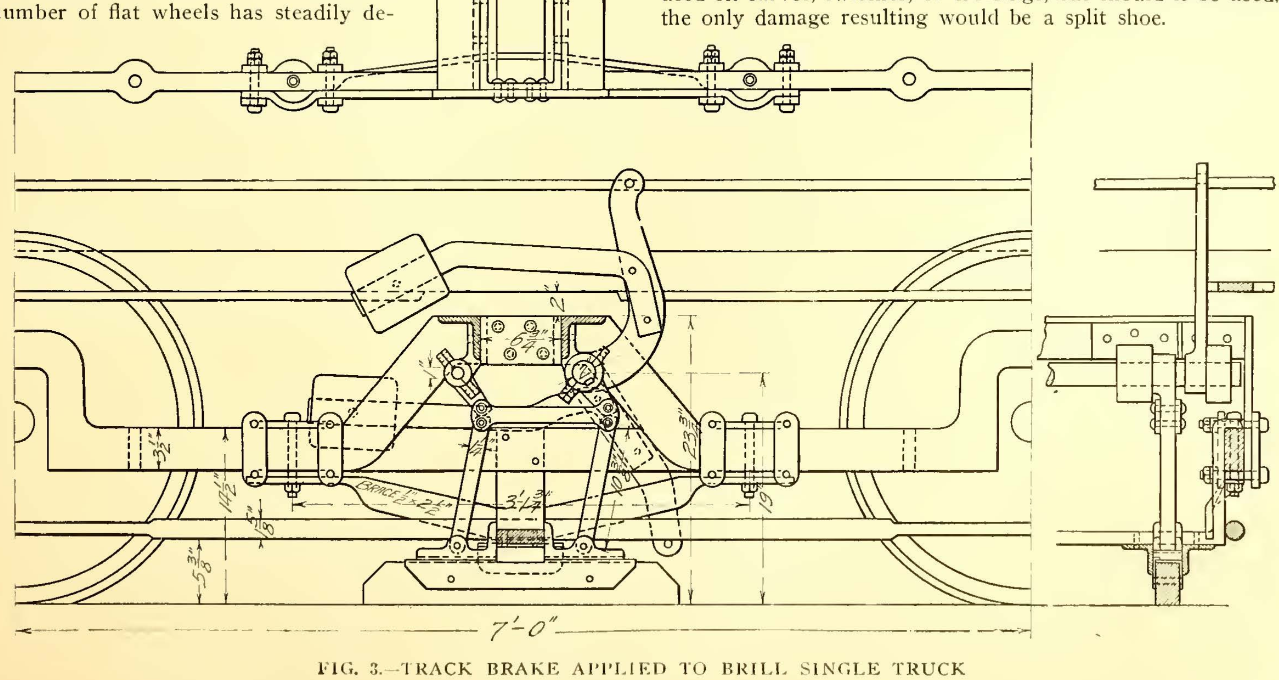


FIG. 3.—TRACK BRAKE APPLIED TO BRILL SINGLE TRUCK

PAPERS READ AT THE PHILADELPHIA CONVENTION OF THE AMERICAN STREET RAILWAY ASSOCIATION

NOTES ON THE DESIGN OF LARGE GAS ENGINES WITH SPECIAL REFERENCE TO RAILWAY WORK

BY ARTHUR WEST

The following remarks, as the title indicates, are applicable to large size gas engines only. The smaller sizes are unsuited to important electric railway installations on account of first cost, multiplicity of parts and greater expense for attendance, etc. The tendency of the modern plant is constantly in the direction of large size units. This is indicated by the rapid increase in the size of steam turbines installed in modern stations. Similar reasons will, it is believed, cause a demand for large size gas engines for electric railway work in conjunction with producers to operate them.

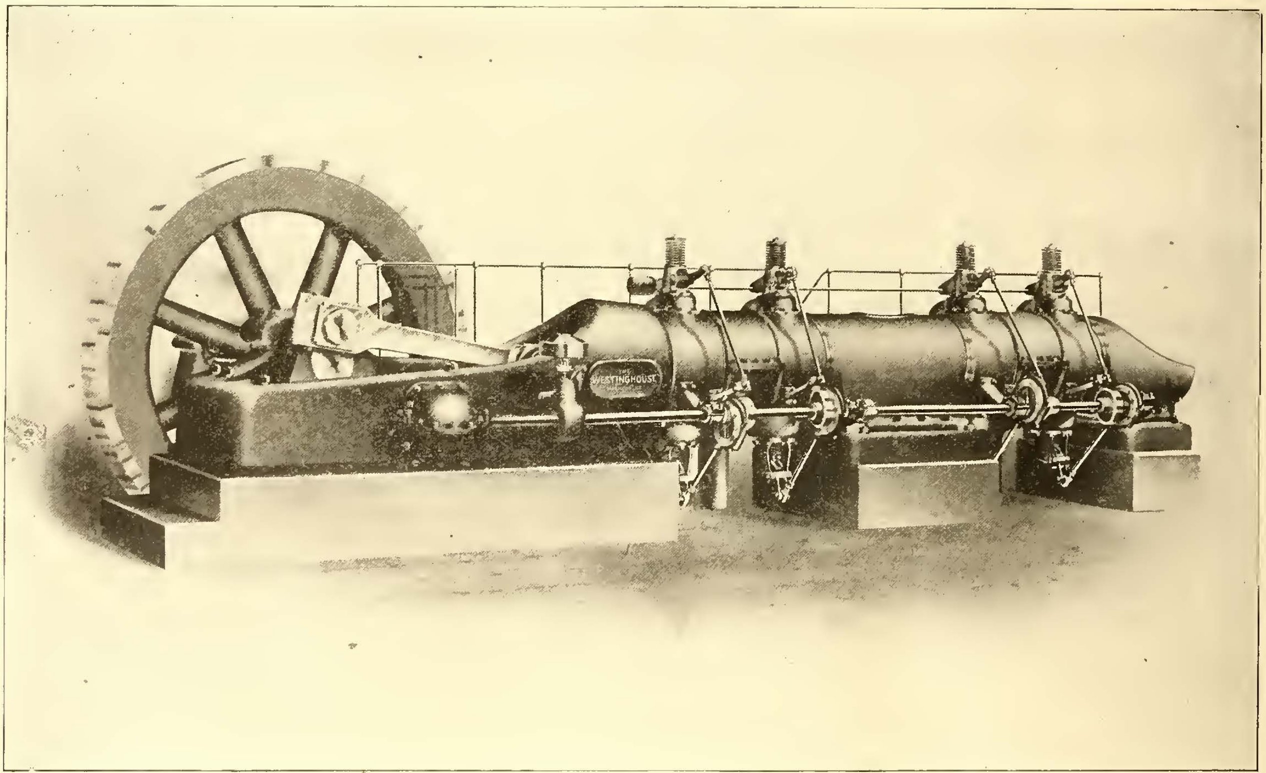
One of the most important considerations in the design of large gas engines is the arrangement of the cylinders. In a single-cylinder, single-acting, 4-cycle engine an explosion takes place once in every two revolutions. In order, therefore, to get the same rotative effect as with a double-acting steam cylinder, it is necessary to work four single-acting cylinders on the shaft or two double-acting gas cylinders tandem on one crank pin. With this arrangement four explosions are obtained in two revolutions, or an explosion every 180 degs. of crank angle. In case of a misfire or premature ignition due to bad gas, the crank can only move one-half a turn before another explosion takes place. In a single-cylinder, single-acting engine the crank must move two whole turns before the next explosion, while with two single-acting cylinders opposed to each other or one double-acting cylinder, the crank may be required to move one and one-half turns before the next explosion. The relative evil effects of a premature or misfire are, therefore, in the following ratios:

Two double-acting cylinders	1
Two single-acting cylinders, opposed type	3
One double-acting cylinder	3
One single-acting cylinder	4

Gas engines and producers to be commercially successful must be designed to be run with the same class of help as is employed on Corliss engines and boilers. This being the case, misfires and prematures are liable to occur occasionally, and the designer must minimize their possibilities for evil. These considerations, as well as the capacity for caring for heavily swinging railway loads, have caused our adoption of tandem double-acting cylinders for railway work.

It is sometimes argued that cylinders so arranged are inaccessible. If, as is the practice of the Westinghouse Company, ample space is arranged between the cylinders, and if the inlet and exhaust valves are not located in the heads, but in the cylinder body and entirely above the floor level, such a gas engine is as accessible as a tandem-compound Corliss engine or as a Corliss engine driving an air compressor.

The speed of a gas engine must be adapted to the kind of generator to which it is to be directly connected. In a general way, its speed will usually somewhat exceed that of a Corliss engine of the same cylinder dimensions. In my experience, the speed of large steam engines is limited by the inertia and consequent wear and tear of the valve gear rather than by the inertia of the reciprocating parts themselves, which is absorbed by the compression. Inasmuch as in a 4-cycle gas engine the valve gear only moves at half the speed of the engine, somewhat higher speeds are permissible than would be the case with a steam engine having the same dimensions of cylinders.



GAS ENGINE FOR UNION TRACTION COMPANY, INDEPENDENCE, KAN.

The speed regulation adopted for large Westinghouse gas engines is especially suitable for generator driving, in that no conditions of changeable load or variable friction of valve gear affect the regulator. Our gas engine regulator governs the speed by means of a relay cylinder, and therefore produces results similar in type to those obtained with the relay governor used by the Westinghouse Machine Company on steam turbines. The advantage of such a relay governor with the gas engine is that the varying friction of valves with different qualities of gas does not affect the sensitiveness of the governor. Without a relay cylinder, the only way in which this result can be accomplished on large gas engines is by some form of a drop cut-off controlling the gas. This is objectionable on a gas engine, as any slight change in the speed of the dash pot very seriously affects the mixture of gas and air, with corresponding bad effect upon the regulation. Such small changes in speed of dash pots are frequent in a Corliss engine, where they cause no bad results. The Westinghouse arrangement employs no releasing gear of any kind, but secures all the advantages of regulation without its use.

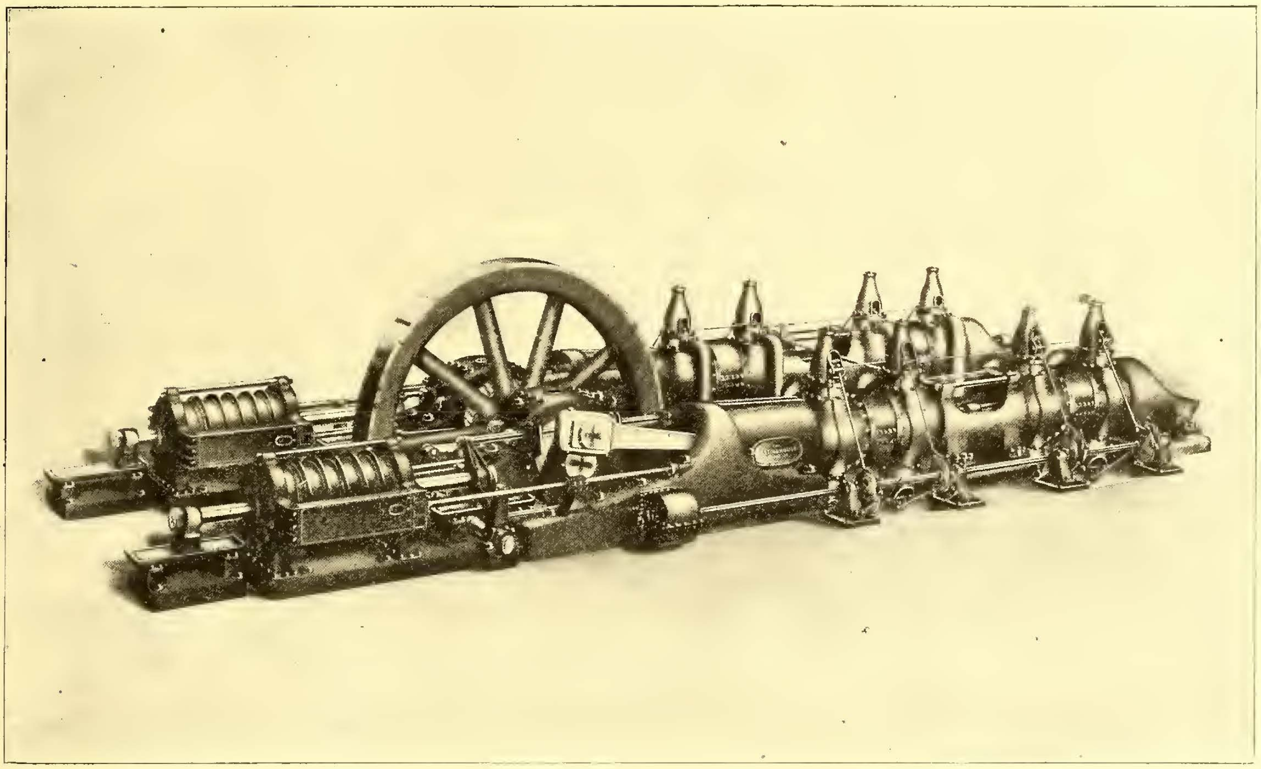
The question is frequently asked as to whether large gas engines will drive a. c. generators successfully in electrical synchronism or "parallel." This has been done for several years past in Germany with entire success, and it has also been done in a number of instances very successfully by our company. We have at the present time orders for several such plants on our books, one of which is to drive an electric railway from Warren, Pa., to Jamestown, N. Y., which we expect will be in operation some time during the autumn.

It is sufficient for our purpose to observe here that the cyclic variation—i. e., the degree of departure from absolutely uniform rotation—is sufficiently small to conform with the design of generators now built for steam driving.

The European designer of gas engines has allowed himself an amount of complication in valve gear which would not be permissible under American operating conditions. The successful American machine must be as nearly "foolproof" as is the large Corliss engine. If it is not, it will fail to be a success from the purchaser's point of view—no matter what thermal efficiency may be claimed by the builders—as a consequence of such complication as the European engineers have been prone to adopt. In the designing of valve gear for large gas engines, wide range of quality of gases must be considered. In this respect the design of the gas engine is very different from that of a steam engine, inasmuch as the steam used has practically constant characteristics, differing only in such minor points as pressure and superheat. With the different kinds of gas to be met with, however, the proportions of air and gas, and sometimes of compression, are radically different, and no gear can hope to be a universal success which does not provide for meeting the widely varying conditions to be encountered in the market.

We are frequently asked, "What is the overload capacity of your gas engine?" A clear understanding on the part of the purchaser of the limitations in this direction is very desirable, from the point of view both of the buyer and the seller. A gas engine and producer is thermally very much more efficient than a steam engine and boiler. It is, perhaps, not amiss to say that, with a well-designed producer and gas-engine plant, a horse-power can be delivered with one-half the cost of fuel that is possible with a well-designed steam-engine plant. The power of the gas engine, however, is limited by the total volume of explosive mixture which can be drawn into the cylinders during the suction stroke, compressed and finally ignited. This condition sets a limit which does not allow of a large temporary increase of the power, such as obtained with the Westinghouse steam turbine by the automatic operation of the secondary admission valve. Such overload capacity is, of course, convenient for the purchaser, but it is unobtainable on a gas engine, unless the engine is largely underrated, and the purchaser should consider that this is one of the prices that he pays for the enormously increased output obtained with the gas engine per pound of coal. The overload capacity is, therefore, simply the amount which the builder rates his machine below its ultimate capacity. It has been our practice to rate our gas engines in such a way that they would have a safe overload capacity of 10 per cent. Our machines are ordinarily good for somewhat more than this, but conservative engineering requires that there be a margin of power in order that overloads may not materially reduce the speed. The above remarks on overload furnish a general guide which may be of service in selecting suitable generator capacity for a gas engine. For ordinary cases the overload capacity of the generator and that of the gas engine should be about equal, although the gas engine will indefinitely carry its overload, while the generator will not, in all cases, unless it is bought with that understanding.

The mechanical efficiency of a large gas engine is very much greater with a 4-stroke cycle than with a 2-stroke cycle, this being one of the arguments against the 2-cycle engine. It is no uncommon thing to see 2-cycle engines which do not realize as brake horse-power more than 60 per cent of the work actually done by the combustion in the cylinders. The efficiency of a 4-cycle engine varies considerably, but it may be said in a general way that a well-designed engine will deliver about 85 per cent of the gas indicated horse-power in the form of brake horse-power. This 15 per cent of power lost is not exclusively composed of frictional resistance of journals, cross-head slides, etc., as is the case in a steam engine. The 4-cycle engine has, of course, to draw in its own mixture of air and gas and compress the same, and its functions, therefore, combine those of a pump, a compressor and a motor. It is the pumping and compressing work which causes the mechanical efficiency of the gas engine to be somewhat lower than that of a steam engine. The actual friction of the working parts need be no greater than with a well-constructed Corliss engine, viz., 90-95 per cent. In order to keep down the friction and increase the reliability of the machines, it is the practice of the Westinghouse Company to design large gas engines with provisions for attaching a continuous return oiling system. The large amount of oil put through the journals increases the safety, requires less attendance and keying up, and washes out dust if the engine is required to operate in an atmosphere which is not clean.



TWIN TANDEM FURNACE GAS-BLOWING ENGINE FOR CARNEGIE STEEL COMPANY

(Foot Note)

$$\text{(Efficiency} = \frac{\text{Heat equivalent to work done.}}{\text{Heat input.}}$$

The thermodynamic efficiency of the gas engine varies so much with different kinds of gas that it is hard to say just what the average value would be. It is probably not far from the truth, however, that its thermal efficiency is about 25 per cent, though in favorable cases gas engines have obtained efficiencies well over 30 per cent.

There is an impression rather prevalent that a gas engine is uncertain and hard to start. A properly designed engine, supplied with fairly decent gas, can be started as easily as a steam engine. Large Westinghouse horizontal gas engines are started by means of compressed air, the only operations required being: (1) open the main gas valve; (2) close the igniter circuit; (3) open one compressed air valve, similar in construction to an engine throttle. The compressed air puts the engine in motion, which draws the charge into the cylinder and compresses the same, after which the first explosion takes place. Air is shut off and the engine is in full operation. We find no more difficulty in starting our gas engines than a steam engine of comparative size. I desire to lay stress on this point, as one of the stock arguments against the gas engine is that it is difficult to get into operation.

With certain kinds of gas, inspection of the interior parts of the cylinders is often desirable at regular intervals of, say, a couple of months. This is especially the case with blast furnace gas, and also with producer gas made from certain kinds of fuel. We have taken particular pains to arrange our cylinders so that no parts of the valve gear or valves are below the floor. The inlet valves being located directly on the top of the cylinder, easy access can be had to either end of either cylinder by removing the inlet bonnets. The exhaust valves are also a part of the engine which need occasional attention for regrinding. Especial care has been taken to render these quite easily removable. The cylinders are, therefore, directly accessible from the top through the inlet openings and from the bottom through the exhaust openings. The fact that all the valve parts are entirely above the floor line renders these operations much easier than if a large part of the valve gear extended downward into foundation parts. It is not necessary to remove the cylinder heads, except to examine the piston rings themselves, which is not often required. Inasmuch as clean gas cannot always be secured, the importance of such easy entrance to the gas cylinders cannot be overestimated.

The general type of engine commented on above is shown in the two accompanying illustrations. The first shows the type of two engines being built by the Westinghouse Machine Company for the Union Traction Company of Kansas, Independence, Kan., one being of 500-brake hp and one of 1000-brake hp. The second photograph shows one of two twin-tandem furnace gas-blowing engines now under construction for the Edgar Thomson plant of the Carnegie Steel Company. For electric railway work, no change would be made except to omit the blowing tubs. As electric units, these engines would have a capacity of about 3500-brake horsepower each.

The large size gas engine has come to fill such an important place in Europe, and has there proven itself to be so reliable and serviceable, that there is no question about its being adopted in this country in the near future, in a form suited to American operating conditions.

It is hoped that these general observations will be found of interest to intending users of gas power in large quantities.

THE APPLICATION OF GAS POWER TO ELECTRIC RAILWAY SERVICE

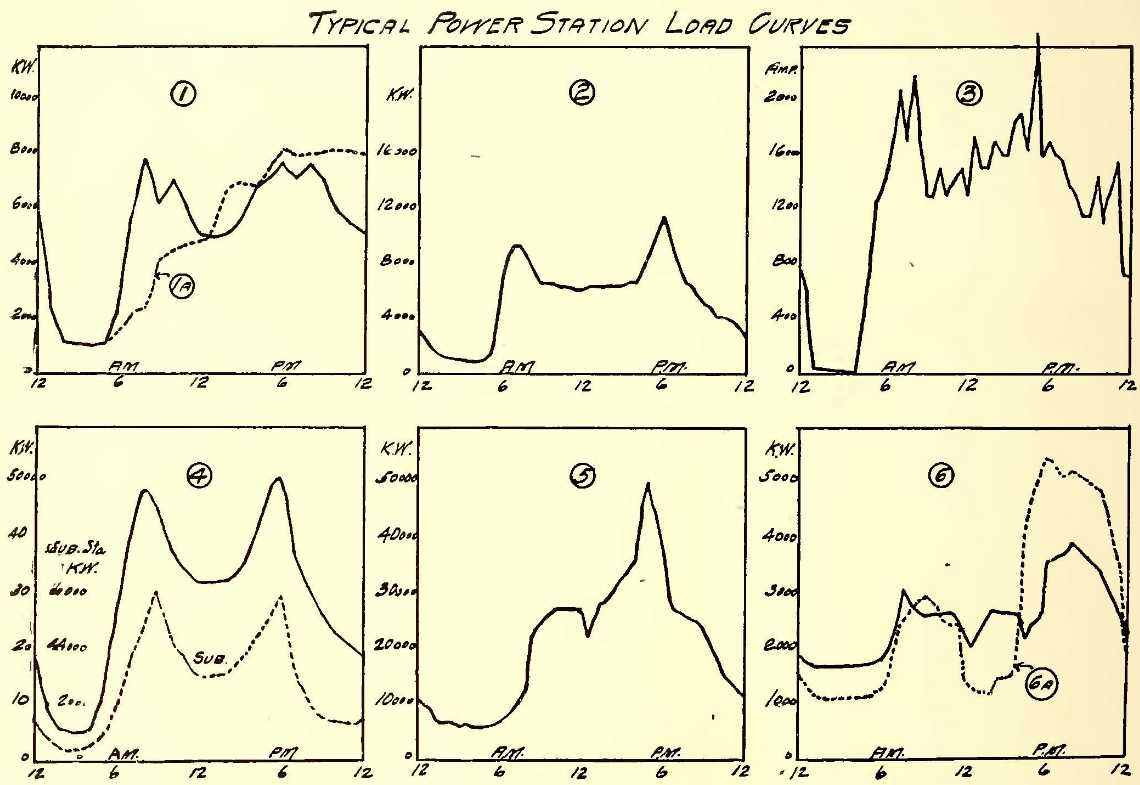
BY J. R. BIBBINS

In bringing this subject before you, we do so with the conviction that the problem of ultimate adoption of gas power is a present and serious one. You may not be in entire accord with our present optimism. In fact, on few subjects does engineering and commercial opinion exhibit greater conservatism (possibly due to lack of direct experience with gas power or to the influence of adverse reports from small and inadequately equipped plants). Yet, we feel that the practical difficulties incident to the development of such an important power system have not been so far overcome as to warrant the fullest optimism. We have but to look abroad for complete vindication.

Primarily, our objective is to place before you, as fully as possible, results that have already been attained, leaving to your own judgment the soundness of our opinions upon the topics discussed in this paper.

CHARACTERISTICS OF STREET RAILWAY SERVICE

In a paper read last year before your association we considered steam turbines, in their special application to railway work. Three important characteristics for a prime mover were mentioned, viz., close speed regulation, considerable overload capacity and high economy over normal ranges of load. Although these qualifications are, indeed, most desirable, entire success may only be attained through the harmonious working of the entire plant, whether steam or gas; in fact, in the case of the latter successful operation may be attributed in almost equal proportions to the gas and power generating sections of the plant. Unfortunately, it is true that the faults of the one may all too readily be charged to the other; yet a careful study of practical operation shows the futility of such distribution of responsibility.



FIGS. 1 TO 6.—TYPICAL POWER-STATION LOAD CURVES

A perspective view of railway service, as distinguished from electric lighting service, may be had by examining the daily load curves from typical power stations. See Figs. 1 to 7 and Table No. 1.

From the data presented it is obvious that, as a whole, a generating plant for railway service, especially for suburban and heavy duty work, must be unusually responsive to sudden power demands; to accomplish this the two sections of the plant must be peculiarly well fitted to operate together under normal load conditions. The plant should also be quick in starting, capable of standby for long periods without excessive loss of heat, and, above all, should show high all-day fuel economy. This is admittedly a formidable list of requirements; yet we may

TABLE No. 1.—LOAD CHARACTERISTICS.

Fig. No.	Character.	City.	Load Factor %*.	Ratio Loads. Max / Min.	Ratio Loads. Max. / Avg.	Approx. Fluctuation%.	Remarks.
1	Metropolitan.	Pittsburg..	68.	7.7	1.48	10–15	300–400 cars at rush hours, single and double truck part trailers Storage battery at sub-stations.
1a	Metropolitan. (Holiday)	Pittsburg..	60.	8.5	1.66	.....	Fourth of July.
2	Metropolitan.	Detroit....	55.8	10.9	1.79	15–25	Cars max. Single truck and high speed interurban. Battery at main and sub-stations.
3	Interurban...	Cleveland.	56.	100.†	1.78	36–60	Double truck. High speed. Cars. No battery.
4	Rapid Transit (Elevated)	New York	60.	9.7	1.67	40% at sub-stas.	Multiple unit trains. Six cars. Battery at sub-stations. 1,337 cars maximum.
5	Lighting.....	New York	47.	....	....	Steady..	Central and down-town district. Battery at sub-stations.
6	Lighting.....	Pittsburg..	65.8	2.26	1.52	Steady..	Central and down-town district. Avg. day cloudy. No battery.
6a	Lighting Max	Pittsburg..	46.7	4.85	2.14	Steady..	Christmas, 1904.
	Railways.....	Pittsburg..	66	7.44	1.52	Fluct...	Week ending July 1st, 1905.
	Lighting.....	Pittsburg..	71.2	2.11	1.4	Steady..	Week ending January 7th. 1905.

$$\text{* Load Factor} = \frac{\text{Average Load.}}{\text{Steady Max.}}$$

not dodge the issue with gas power any more than with steam.

ADAPTABILITY OF GAS ENGINE AND PRODUCER PLANT

Does gas power fulfil in every respect the conditions imposed? As the old and much-abused saying goes, "The proof of the pudding lies in the eating thereof." This phase of the subject may best be approached through comparison, step by step, with steam power with which every one is familiar. This is done not for the purpose of discrediting the latter, but merely to obtain a clearer conception of the points involved.

THE GAS ENGINE

Primarily, the fitness of the gas engine for driving electrical machinery must be demonstrated beyond question. This has repeatedly occurred in practice, examples of which will be later cited. The paper by Mr. West has already treated important points in detail. He has observed that with certain cylinder arrangements, rotative speeds, uniformity of turning moment and speed regulation are as well suited to both d. c. and a. c. generator driving as the standard cross-compound steam engine; that the gas engine is as simple a machine to operate; that its efficiency as a mechanism is as high, and as a heat motor far higher; and that its overload capacity is largely dependent upon the dimensions of the customer's purse. Assuming, then, that the gas engine is already established in its position, we come to the gas generating plant, which, in many respects, is the crucial point of the system, except in special localities where natural gas is available at reasonable prices.

THE PRODUCER

We believe ourselves conservative in the statement that the future of the gas engine in its general application depends largely upon the development of a producer gas system especially suited to the use of low-grade bituminous coal. Anthracite producers have already reached a high state of perfection, are reasonable in price, simple to operate and are usually unencumbered with much auxiliary apparatus. They do not deteriorate rapidly, and generally show an efficiency considerably higher than the best steam boiler and furnace, viz., 75-80 per cent.

The ideal bituminous producer is yet to come, viz., one in which the volatiles are completely converted into fixed gases without serious loss and without complication of the operating system. There are a number of makes now on the market intended to be used with bituminous coal, but when the gas is to be used in engines they are attended with special, and often complex, cleaning apparatus for the removal of suspended impurities. The efficiency of bituminous systems is also generally lower than anthracite, not only owing to the fact that some of the valuable distillates are lost, but on account of the distillation of volatile matter requiring heat for its accomplishment. Present types, however, sometimes exceed 70 per cent efficiency, which rivals that of the best boiler plant.

FUEL ECONOMY

In actual running, fuel consumption, gas power presents its most striking advantage over steam. It is difficult to obtain statistics truly comparative in every respect. Some data, trustworthy in the aggregate, are available from the tests conducted during the past year at St. Louis by the United States Government. Table 2 gives a resume of these tests, covering seventeen different grades of coal, all of bituminous character. The most remarkable result is that the poorest grade coals and even lignites are entirely suitable for producer work. Thus, Montana, North Dakota and Texas lignites, averaging only 8242 B. T. U. per pound (11,400 dry), yielded a gas of 169 B. T. U. per cubic foot, a gross producer efficiency of 66 per cent, and a duty of 2.5 lbs. per kw-hour dry, or 3.6 lbs. per kw-hour as fired. The best coals

TABLE No. II.
SUMMARY OF RESULTS—PRODUCER GAS TESTS.
U. S. Government, St. Louis, 1904-1905.

175 kw.—235 H. P. Producer Gas Plant—Belted—Full Load.

Approximate Calorific Value Dry Fuel	14,000	13,000	12,000	11,000	10,000	Sum'ary
No. of Tests	4	5	3	3	2	17
Average Length in Hours	17½	32¾	22⅓	23¾	23¾	25
FUEL						
Name	W. Va.	Ind., Ill., Ala., Ky., Ind. Ter.	Ind., Ill., Col.	Mont., N.D. Texas.	Wyo. and Texas.	U. S.
Character	Bit.R.M.	Bit.R.M.	Bit. & Black L.g.	Lignite.	Bit. and Lig.	Bit and Lig.
B. T. U. per lb. Dry	14,501	13,225	12,667	11,425	10,792	12,854
B. T. U. per lb. Actual	14,223	12,303	10,942	8,242	8,458	11,346
GAS						
Yield cu. ft. per lb. dry	66.4	51.06	50.5	31.9	32.7	49.0
B. T. U. per cu. ft.	145.3	154.6	153.3	168.5	160.4	155.3
Prod. Effcy.—%	65.4	64.9	70.8	65.9	62.1	65.9
PLANT DUTY						
Lbs. per BHP Hour, Actual	1.16	1.51	1.44	2.28	2.12	1.62
Lbs. per KWH, Actual	1.82	2.38	2.27	3.59	2.83	2.50
Lbs. per KWH, Dry	1.79	2.21	1.95	2.52	2.55	2.16
B. T. U. per BHP Hr., Actual	16,498	18,580	15,755	18,780	17,920	18,375
B. T. U. per KWH, Actual	28,890	29,295	24,838	29,600	23,915	28,350
B. T. U. per KWH, Dry	29,975	29,225	24,725	28,800	27,505	27,790

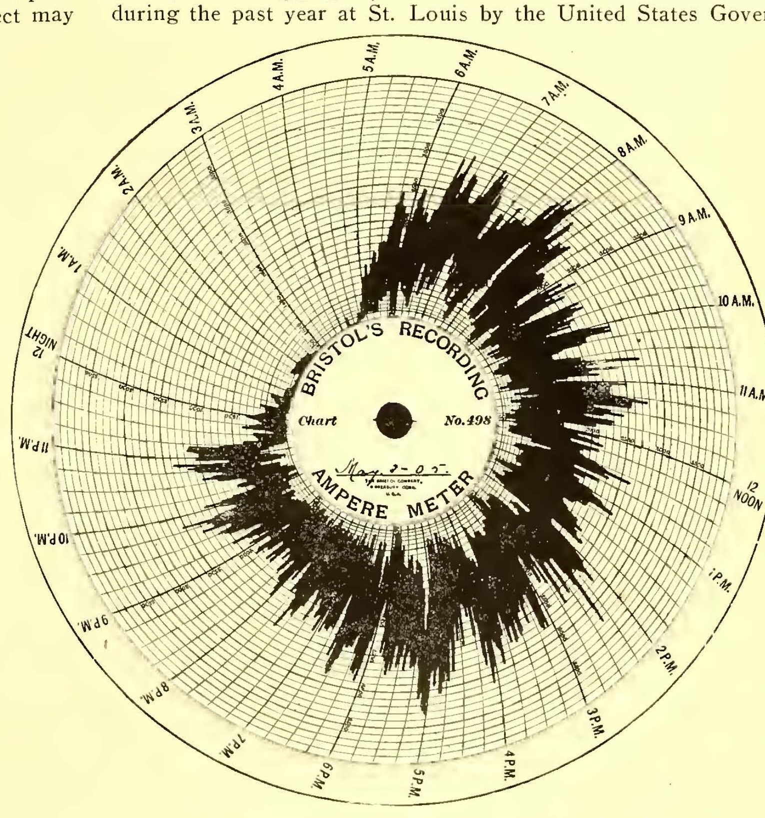


FIG. 7.—RECORDING METER CHART, SHOWING FLUCTUATIONS OF INTERURBAN LOAD

(West Virginia) gave an actual duty of 1.57 lbs. per kw-hour, and the poorest 3¼ lbs. to 4½ lbs. as fired. The average of the seventeen tests showed a plant duty of 2.2 lbs. per kw-hour dry, or 2.5 lbs. as fired. Fig. 9 shows, in a general way, the rapid decrease in coal consumption with higher grade coals.

It is fortunate that the government extended these tests to embrace steam* as well as gas power. Fig. 10 shows the results of comparative economy tests with practically the same size plant under identical conditions and with identical coal. Taking a common heat value for average bituminous coal, 13,000 B. T. U. per pound, we observe that the plant duty is less than 2 lbs. per kw-hour with gas and 5½ lbs. with steam. Furthermore, the fuel consumption of the steam plant increases much more rapidly in the comparison with the poorer grades of coal. This is reasonable, owing to the greater difficulty in securing proper combustion. In this particular the producer has a decided and important advantage over the steam boiler.

Many more results might be cited which would strongly emphasize the high gross economy of the producer gas power plant; yet it is not the formal efficiency test at full load, but the long period test, which reveals to the operating man the fullest economy of gas working.

The following results may be of interest, as obtained from a large gas power railway and lighting plant at Walthamstow,† England, which will later be mentioned in further detail:

TABLE NO. 3.—RESULT OF TWELVE DAYS' OPERATION, WALTHAMSTOW, LONDON, JANUARY, 1902

Average output per day in kw-hours	1,525
Average load in kilowatts	64
Average load factor, per cent	35
Coal (anthracite) per kw-hour, in pounds, including fuel for boiler and banking	1.78

A striking series of comparative observations‡ between a steam and gas station operated by the same company at Guernsey, England, is summarized in Fig. 11. With approximately the same load factor, which is high, owing to power supply, the gas power plant consumed about 2.25 lbs. per kw-hour, and the steam station 5.5 lbs., although a much larger station and equipped with triple-expansion high-speed engines.

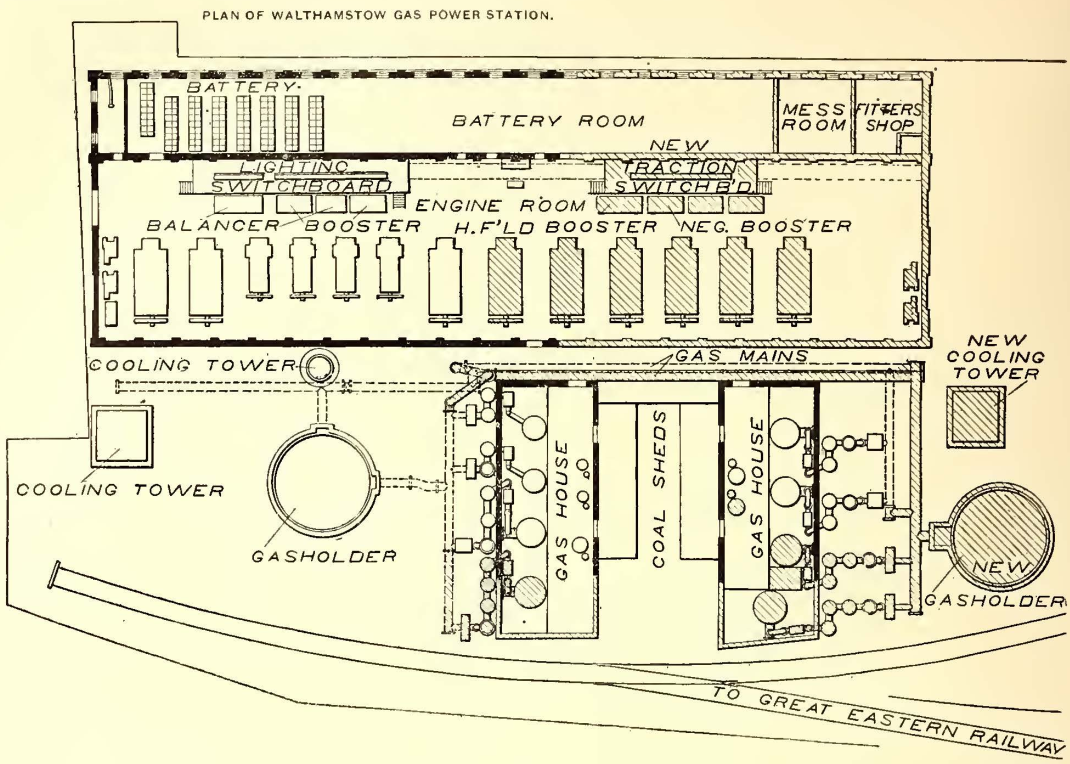


FIG. 8.—PLAN OF WALTHAMSTOW GAS POWER STATION

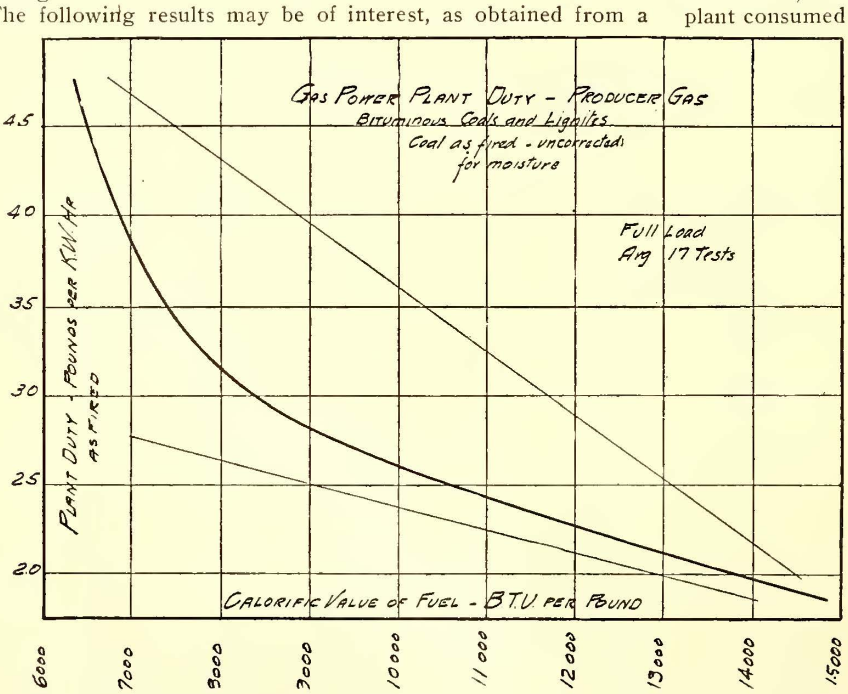


FIG. 9.—SHOWING THE RAPID DECREASE IN COAL CONSUMPTION WITH HIGHER-GRADE COALS

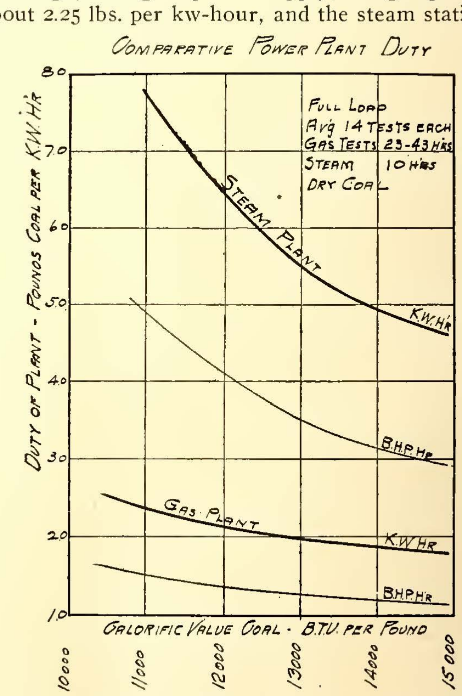


FIG. 10.—COMPARATIVE ECONOMY TESTS OF STEAM AND GAS PLANTS UNDER SIMILAR CONDITIONS WITH LIKE FUEL

RESPONSIVENESS

Passing to some of the practical points, a producer, if provided with an automatic blast control, may be made almost instantly responsive to variations in demand for gas. This is shown by the success which the suction producer has attained in small sizes; and in this respect the steam boiler is quite outclassed, owing to the

* Non-condensing.

† Walthamstow is one of the largest suburban districts of London, having a population of 116,000, and served by a gas-driven central station.

‡ Campbell, Mechanical Engineer, Dec. 3, 1904.

more direct effect of the blast in transferring the heat content of the coal to the working medium—gas. In one type of producer familiar to us as possessed of this automatic feature the steam blast, and consequently the gas generated, is controlled entirely by the pressure in the delivery gas main and in inverse proportion. It combines this feature with the conservation of the sensible heat of gases leaving the producer. By this means steam is generated at a rate proportional to the demand for gas without requiring extra boiler equipment or fuel. This largely increases the producer efficiency. In some types of producer we recall that the fuel for steam amounts to as much as 15 per cent to 20 per cent of the total coal gasified.

This producer is designed for use without a gas holder and has been successful in this particular. The especially severe conditions of heavy railway work, however, prescribes storage capacity at some part of the system. Owing to the limitations of gas-engine capacity, dealt with in the preceding paper, electric storage is evidently the most desirable, as it relieves the machinery of the wear and tear of fluctuating loads. There is ample precedent the world over for the use of a storage battery auxiliary in railway plants, and it should prove even more desirable in a gas power than in a steam power plant. In fact, gas storage is often to be desired in many plants where the gas demand varies greatly, simply as an insurance against poor gas, due to careless operation. This, however, simply relieves the gas generating equipment, while electric storage relieves the entire station.

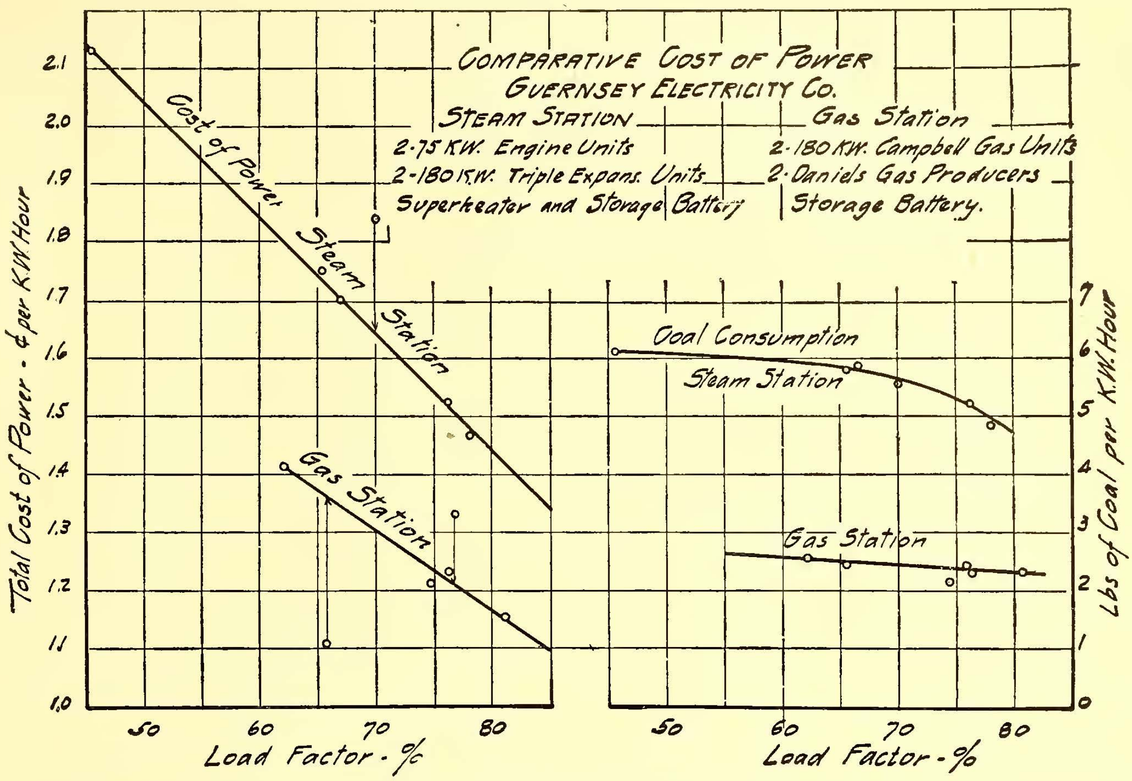


FIG. 11.—RECORD OF COMPARATIVE OBSERVATIONS BETWEEN STEAM AND GAS AT GUERNSEY, ENG.

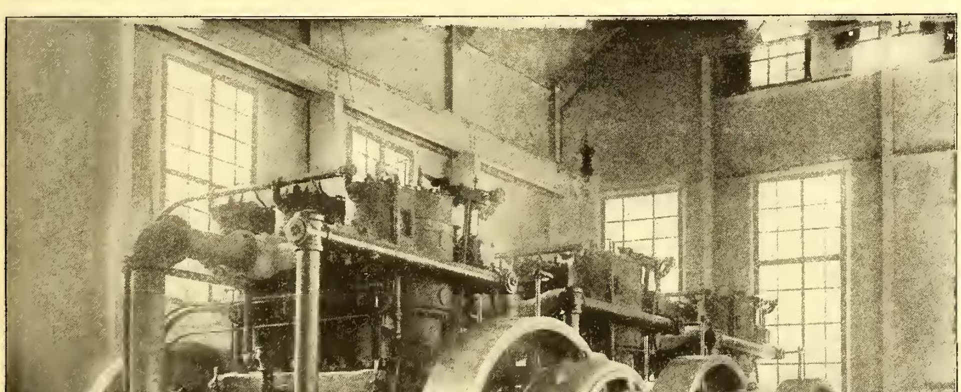


FIG. 12. SECTION OF 1900-HP INDUSTRIAL GAS PLANT OF THE WINCHESTER REPEATING ARMS COMPANY, SHOWING SOLE-PLATE PIER CONSTRUCTION

LOSSES

Standby losses in a steam power plant are an important source of inefficiency and difficult to determine accurately. Mr. Dowson has made some comparative observations* with eight steam plants and several producer plants, averaging about 250-hp capacity. The actual standby fuel consumption of the boilers was 35-180 lbs. per hour, and of the producers 2-4 lbs. per hour. Whether the exact ratio holds for larger plants is immaterial. We do know that the producer losses are almost inconsiderable, which is reasonable, owing to the great heat content of the fuel bed and small opportunity for loss of heat by radiation when the producer is shut off from the atmosphere. Running losses are evidently also much less. We may pipe gas for great distances with small loss. Not so with highly superheated steam under high pressure. When a gas engine plant is shut down the losses practically cease; with steam, condensation is uninterrupted.

LABOR

The comparative cost of labor and supplies for gas and steam plants is difficult to state in definite terms. With the same character of labor there should be no appreciable difference between the two. We have compiled Table 4 (page 598) to show the operating costs of eleven London district stations, as compared with the gas plant at Walthamstow. These plants have been chosen, as they are located similarly in respect to accessibility of fuel. The table shows labor cost slightly in favor of steam, but it must be remembered that this is a comparison of one gas plant, having small units, against a number of larger steam plants, which might readily be more favorable in larger gas installations. With an up-to-date steam plant, using high-pressure steam, superheaters, economizers, high-grade condensing apparatus and the like, the labor item should, if anything, exceed that of a gas plant equipment of the same grade. At the two Guernsey

* Journal of Institution of Electrical Engineers, April, 1904.

stations referred to above the labor cost averaged very nearly the same for steam or gas.

It is true that a gas plant cannot be successfully operated by an ignoramus, any more than can a high-grade steam plant, which, however, if allowed, results sooner or later in a swelling of the repair account. A fair comparison will not admit of any but intelligent labor in either steam or gas plants, so there is no reason why steam engineers, after proper instruction, cannot take charge of a gas plant, as has been proven in practice.

TABLE IV.—OPERATING COSTS*

London Metropolitan Boroughs.—Year Ending March 31, 1904.

	Plant Capacity, kw.	Output Sold.	Ratio Sold Generated %	Load Factor %	Operating Cost—d per K. W. H. sold. Fuel.	Supplies**	Labor.	***Repairs	Works.	Total.
Average of 11 Steam Plants †.	2,799	2,997,500	83.9	17.25	597	.059	.214	.218	1.09	1.41
Walthamstow....	810	1,019,326	80.0	15.45	.368	.152	288	.048	0.856	1.05
Savings % (favor gas)........					+38.4	††	-13.5	+78	+21.5	+25.4
Operating Expense Items—% Works Cost (Steam)..					55	5.4	19.6	20	100	129
Operating Expense Items—% Works Cost (Gas)....					43	17.8	33.6	5.6	100	123

*Data from "Electrical Times" Financial Reports.
**Oil, waste, water and miscellaneous supplies.
***Includes repairs to buildings, electrical equipment and distribution system.
†Steam Plants—Hackney, Stepney, Poplar, Battersea, Hammersmith, St. Pancras, Fulham, Shoreditch, Southwark, Hampstead Islington.
††Artesian well not in service. Water paid for

TABLE No. V.—OPERATING COSTS—800 HP. GAS POWER STATION, BRADFORD, PA.

	1904.	1903.
Annual output, K. W. H..........	804,032	780,300*
Station load factor, per cent..........	19.54	......
Gas consumption, cubic feet..........	20,056,000	18,162,000
Plant duty (including heating), cubic feet per K. W. H..........	24.9	22.4
Average price of gas, cents per M cubic feet..........	12.32	16.5
OPERATING COSTS—CENTS PER K. W. H. GENERATED.		
Fuel (including heating)..........	0.307	0.384
Labor, power station only..........	0.380	0.392
Supplies..........	0.059	0.072
Repairs, engine and electrical equipment..........	0.079	0.050
Repairs, gas engines only..........	0.010	0.013
Total works..........	0.825	0.898

* Estimated from nine months metered output.

TABLE No. VI.—WORKING COSTS—GAS POWER STATION, WALTHAMSTOW DISTRICT COUNCIL, "GARCKE'S MANUAL."

Population—110,000. Supply commenced September 20th, 1901.
System—Three wire, D.C., 230–460 volts.
Capacity Station—2,890 B. H. P.—2,000 kw.
Equipment:—
Gas Generators—8-Dowson-Anthracite.
Engines—4-115 B. H. P. Westinghouse 3 cylinder vertical engine type.
3-250 B. H. P. Westinghouse 3 cylinder vertical engine type.
6-280 B. H. P. Westinghouse 3 cylinder vertical engine type.
Generators—Helios-Engine type.
Batteries—Tudor-2x254 cells 1,000 amp. hr. capacity.

SUPPLY RECORD (Year ending March 31........	1904.	1903.
Number of lamps connected (16 c.p. equivalent)........	21,000	16,070
K. W. Hrs. generated........	1,019,326	659,796
K. W. Hrs. sold........	814,187	542,423
Gross efficiency system—per cent........	80.	82.25
Maximum load on feeders—kw........	600	406
Average load on plant—kw........	116.4	75.5
Load factor........	15.45	15.25
Prices charged, lighting—cts. per K. W. H........	8	8
Discount, power—cts. per K. W. H........	5–3	5–3
FINANCIAL RESULT.		
Capital expenditure to date:		
Land and buildings........	81,050	75,650
Plant, engines, machinery........	198,000	179,600
Total expenditure........	546,100	367,000
Revenue, total........	63,000	48,380
Costs, total........	21,640	16,910
Profit, total........	41,360	31,470
Profit—per cent to average capital........	9.05	10.87
Sinking Fund—per cent to average capital........	2.66	3.20
Average price obtained—cts. per K. W. H........	7.14	8.40
Per cent working costs to revenue from current........	38.46	40.9

OPERATING COSTS........	Cts. per Kw-h. Sold.	Gen.	Cts. per Kw-h. Sold.	Gen.
Coal* and other fuel, delivered........	0.932	0.745	0.84	0.69
Oil, waste, water** and general supplies........	0.383	0.306	0.46	0.37
Wages of workmen........	0.738	0.590	0.82	0.67
Repairs and maintenance†, total........	0.081	0.065	0.24	0.19
Total works cost........	2.134	1.706	2.36	1.925
Distribution, public lamps, rent, management, taxes, insurance, etc........	0.649	0.519	1.11	0.929
Total general costs........	0.649	0.519	1.11	0.929
Total costs........	2.783	2.225	3.47	2.854

* Cost of coal averaged $6.50 per ton in 1902-3; $6.75 in 1903-4. ** Artesian well not yet in service; water purchased. † Including buildings, mechanical and electrical equipments, storage batteries and distribution system.

A very important point, however, is the personal attitude which engineers take toward gas machinery. The best plant will quickly depreciate in the hands of operators who have taken a personal dislike to the innovation. The inevitable result of such attitude cannot be truthfully laid to the door of gas power. But it is almost always the case that personal prejudice may be overcome by systematic educational methods. In many of our plants the old steam engineers and oilers have been retained and placed in charge of gas equipment, after a thorough coaching by competent erecting engineers. After this is done properly the invariable result is highly successful operation.*

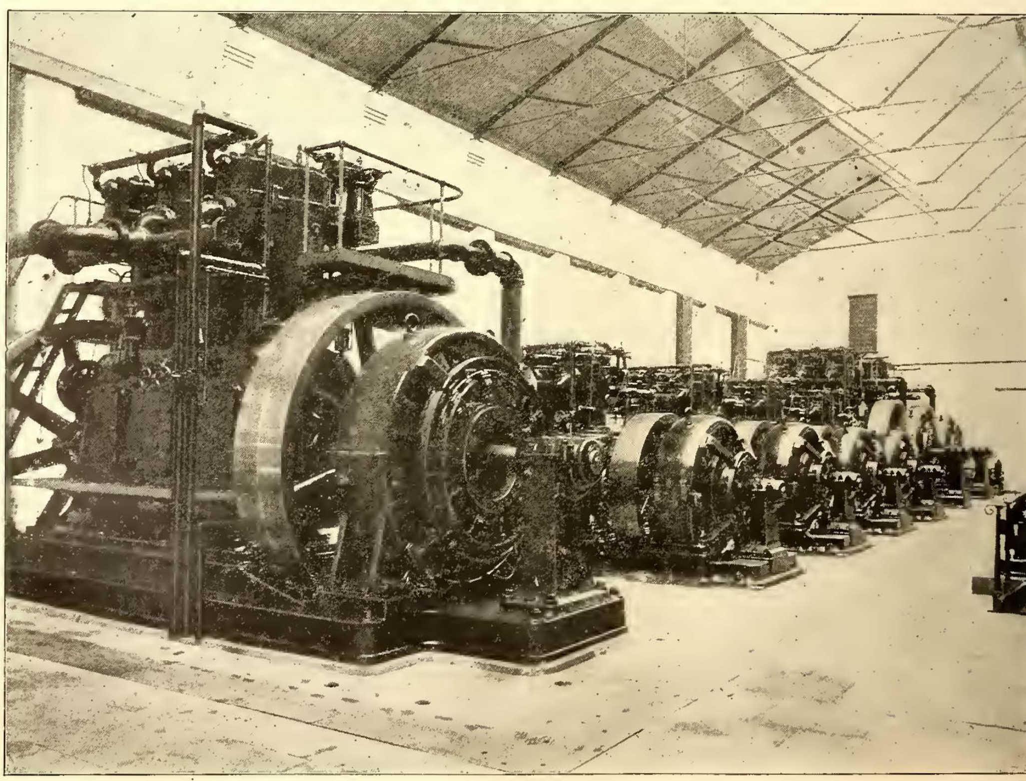


FIG. 13.—800-HP GAS POWER RAILWAY AND LIGHTING STATION, BOROUGH OF WALTHAMSTOW, LONDON

OIL

In well regulated plants, equipped with a continuous return system, the oil consumption should not much exceed, if any, that of a steam plant. Two 500-kw gas plants at Franklin and Bradford, Pa. (each consisting of five Westinghouse vertical enclosed type engine units), average through the year less than ½ gal. per unit day, at a total cost of under 7 cents (.0032 gal. per hp-day). At another station, near Warren, Pa., using three ver-

* As the chief engineer operating a plant in Northern Pennsylvania stated to the author recently, "I would rather throw up my job than go back to steam." He freely acknowledged his initial prejudice, which disappeared as he became acquainted with the gas engines.

tical open type engines of 275-hp capacity each, the oil consumption averages under .9 gal. per unit day. This is certainly not excessive; in fact, we know of a large steam station in the Pittsburg district, equipped with several 1600-hp cross-compound engines, in which the oil consumption averages .0025 gal. per engine hp-day, and has reached double this amount for weeks at a time. This plant has a return oiling system; the others have not.

MAINTENANCE

Maintenance expense is frequently thought to be excessive in a gas station. When this is so we may look for faulty operation or design of the plant. Recent data from the station at Bradford, Pa., show what may be accomplished when the equipment is properly operated. The plant is in its seventh year of service; yet the average cost of repairs on the engines for the past two years was $92.70 per year, 11.6 cents per horsepower-year, or .0125 cents per kilowatt-hour generated. Returns for the past two years are shown in Table 5 (page 598). As an example of the results secured, we may mention the following: After six years' service, averaging 18 hours per day, it is found necessary to inspect the engines only once in twelve months. This was formerly done in three months and later in six months. At each inspection a set of piston rings is replaced by new ones, whether worn out or not. Up to the present time no extensive repairs have been made on any of the engines, except a voluntary change, on the builders' part, from dry to water cooled exhaust valves. The present exhaust valves average one year's working without regrinding, and even then are not in bad condition. Some valves have run fifteen months. Admission valves require no attention. Igniters average about nine months without repointing. By reversing the current each day electro deposition is entirely avoided, so that the points wear evenly.

In Table 4 the repair costs at Walthamstow are much lower than the steam plants cited. In a 300-kw manufacturing plant at Birmingham, using Westinghouse vertical engines and Mond gas, the typical year's expense for repairs and renewals was but 0.174 cent per kilowatt-hour generated, incurred in the proportion of 65 per cent to the gas and 35 per cent to the engine plant.

A notable run was recently reported by the superintendent of a gas compressing station in central Ohio, where a 650-hp Westinghouse vertical engine is at work.* This engine was under maximum gas load continuously night and day for forty days, without a misfire or mishap of any kind, and without incurring extra expense for repairs.

COST OF POWER

Comparative plant economy is best brought out in figures expressing the total operating cost of power. The complete returns from Walthamstow are shown in Table 6 (page 598). With a load factor of only 15½ per cent and coal at $6.75 per ton, delivered, the total cost of generating current was 1.7 cents per kw-hour; or, based upon current delivered to consumer, 2.13 cents per kw-hour, the average price obtained being 7.14 cents, and the net profit 9 per cent. Referring again to Table 4, the summary shows that in the average borough steam plant of over three times the capacity and of higher load factor, the generation cost is 2.2 cents. It is presumable that the steam plants used cheaper coal; yet with gas coal at $6.75 a ton, the saving of coal alone was over 38 per cent in favor of the gas station. At this price the Walthamstow plant required throughout the year's run but slightly over 2 lbs. of coal per kw-hour generated. Of the total operating cost, fuel represented 43 per cent; in the steam plant, 55 per cent; repairs, 5 per cent for gas, and 20 per cent for steam. At the Birmingham plant, mentioned above, the total operating cost was 1¼ cents per kw-hour, of which fuel represented 26½ per cent, and repairs 14 per cent; this on a load factor of 43 per cent average, and bituminous coal having 31 per cent volatile. The total coal consumption averaged 2.9 lbs. per kw-hour through the year.

TABLE No. VII.—CAPITAL COST GAS AND STEAM PLANT PER KW. CAPACITY.

	Gas Plant.		Generating Plant.		Total.
	$	%	$	%	$
Average tender	35.00	31.2	77.00	68.8	112.00
Accepted tenders	24.00	24.5	74.00	75.5	98.00
Steam Plant.					
Lowest tender					75.00
Highest tender					106.00
Mean tender					90.00
Recommended					92.00

TABLE No. VIII.—SUMMARY OF GUARANTEES.

GUARANTEE.	Producer Plant.		Generating Plant. ⅔ Rated Load.			Power Station.	
	B. T. U. in Gas Per Lb. Coal.	Efficiency with 12,000 B. T. U. Coal.	B. T. U. per Kw-hr.	B. T. U. per B. H. P. Hour.	Kinetic Efficiency, Per Cent.	Kinetic Efficiency 12,000 B. T. U. Coal.	*Duty Lb. Coal per Kw-hr.
Highest	9,500	79.2	12,300	10,440	27.7	21.9	1.29
Lowest	7,000	58.3	18,000	15,290	19.0	11.1	2.57
Average	8,729	72.7	13 876	11,775	24.6	17.85	1.59
Accepted	8,500	71.0	13,700	11,630	24.9	18.1	1.61

* Estimated.

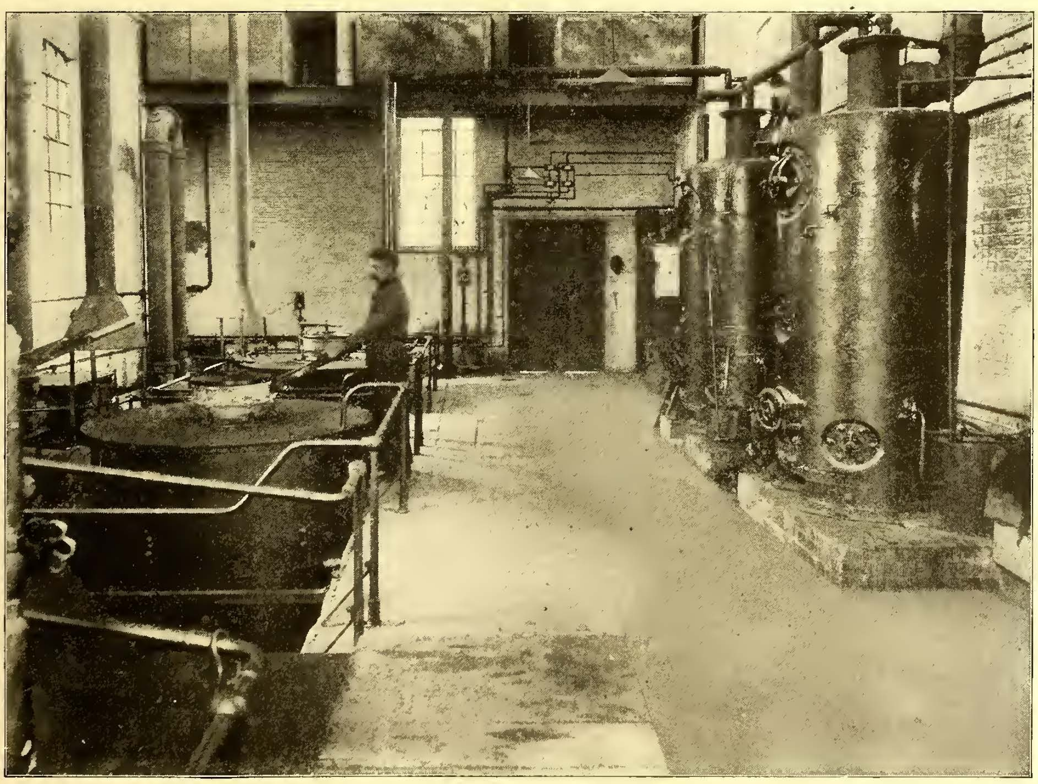


FIG. 14.—WALTHAMSTOW STATION PRODUCER HOUSE, CHARGING FLOOR

At the Bradford, Pa., station (see Table 5, page 598), although handicapped with old type belted machinery, the average yearly gas consumption is less than 25 cu. ft. of gas per kw-hour on a 19½ per cent load factor, and a total operating cost of power of about 0.8 cent per kw-hour.

The station at Franklin, Pa., operating on natural gas of exceptionally high calorific value, gives experience of similar character. The engines regularly operate 30 hours to a run. With a

* After running practically day and night for nearly three and a half years, the total repairs on the plant have been:
One set of igniters.
Two sets of exhaust valves (one spare).
One admission valve (jammed accidentally).
One cylinder head (cracked from mud deposits).
One intermediate gear.

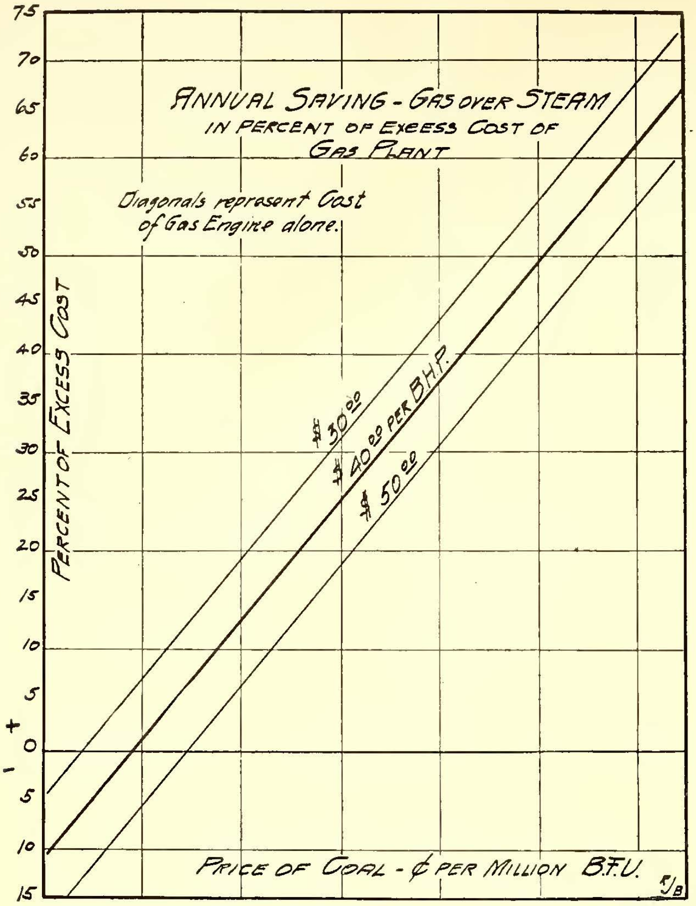


FIG. 18.—SHOWING ANNUAL SAVING OF GAS OVER STEAM

load factor of 15 per cent to 20 per cent, as low as 17 cu. ft. of gas per kw-hour was recorded for the year 1904, at a total operating cost of under 1 cent per kw-hour. In the cases of both the Bradford and Franklin plants building heating by natural gas is included in the gas charge for the engines.

CAPITAL COST

Much of the prejudice against gas power is due to exaggerated statements regarding the comparative capital cost of steam and gas equipments. In some instances it has been stated that for the same character of equipment the gas plant costs double. This is not the case; in fact, in larger plants the two may be brought nearly to a parity, and the higher economy of the former will soon wipe out the difference in actual cost.

We cannot do better than cite the returns* of tenders for one of the largest gas power stations in Europe, over 8000-kw in capacity and designed for both railway and lighting service. Tenders were invited for both steam and gas equipment complete, in every respect the best obtainable and with considerable spare plant. An approximate summary of the tenders received from over thirty of the most prominent European manufacturers is as follows, including erection, but not including transportation charges. (See Table 7.)

The engineer's report on the accepted tenders shows a total excess cost of gas plant of 7.4 per cent actual, or 14 per cent with certain extras charged to the gas plant for additional ground and building requirements; yet the annual saving in operation is esti-

COMPARATIVE ESTIMATES—GAS vs. STEAM PLANT.

Assumption for Diagrams, Figs. 15 and 18.

GENERAL.	GAS PLANT.	STEAM PLANT
Rated capacity	5,000 kw.	
Character of load	Street Railway	
Load curve	Figure 1-B.	
Load factor, average	66%.	
Maximum mean load	3,750 kw.	
Load fluctuation	10%—normal, 15%—light loads.	
Number of units (one spare)	Five 1,000 kw.	
Type	Horiz. tandem double acting, heavy duty.	Horiz. compound, Corliss, condensing.
Overload capacity	10%	
Average load	2,611 kw.	
Daily output	62,688 K.W.H.	
Daily engine hours	75¼.	
Average load on units	83% rating.	
HEAT CONSUMPTION.	10,000 B. T. U. per B. H P. Hr.	14 lbs. steam per I. H. P Hr.
Overall efficiency unit	80.9%.	83.7%
Auxiliaries	5%.	10%.
Producer—efficiency	75%.	
Boiler—efficiency (13,000 B. T. U. coal)		60%.
Plant duty. B. T. U	23,275 per K. W H.	42,900 per K. W. H.
Coal consumption	1.8 lbs. per K. W. H.	3.3 lbs. per K. W. H.
CAPITAL COST		
Generating plant	$77.20 per kw.	$43.60 per kw.
Boiler—producer plant	25.06	27.50
Buildings, coal storage and switchboards	16.50	18.00
Total	$118.76	$89.10
Excess cost of gas plant	$29.66—30%.	
WORKS OR OPERATING COST OF POWER.	CHARGED.	
Fuel for all purposes	Pro rata	
Labor	Equal for gas or steam.	
Supplies, including oil, waste, water, etc.		
Repairs (working repairs only, not betterments)	0.5 cts. per K. W. H.	

FIXED OR CAPITAL COSTS
Interest (6%).
Insurance and taxes (2%).
Depreciation (physical depreciation only).
Engine plant 6⅔%, boiler plant 7½%, producer plant 5%, buildings and switchboard 3%
Average for complete plants—gas 5.8%—steam 6.2%.
Total cost of power comprises works and fixed costs.

*Steam pressure 125 pounds, feed temperature 180° F., evaporation 8.1 pounds from and at 212°—7.5 pounds actual.

mated sufficient to annul the excess cost of gas plant in less than two years. Capitalized at 5 per cent interest, this annual saving represents a capital of $1,485,000, or considerably more than the original cost of the entire gas power station. In other words, the gas plant might have cost twice the actual amount and still realize a definite annual saving over steam power. Incidentally, the efficiency guarantees are of interest. These are shown in Table 8. The heat conversion efficiency of the generating equipment at two-thirds load is as high as 25 per cent, giving an over-all plant efficiency of

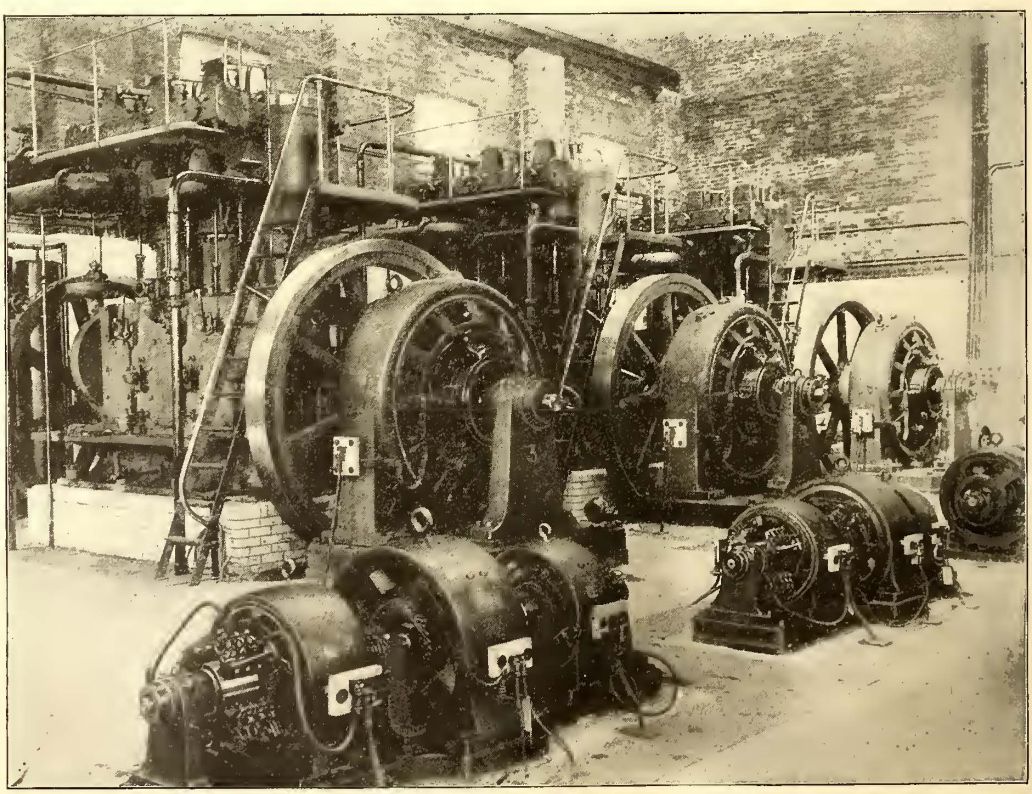


FIG. 16.—GENERAL VIEW OF ENGINE ROOM, MIDLAND RAILWAYS, DOCK TERMINAL POWER PLANT, HEYSHAM HARBOR, ENGLAND

* For obvious reasons, the names of the customer and manufacturers are withheld.

about 18 per cent. The average well-equipped steam plant rarely exceeds 10 per cent.

The problem of gas vs. steam power thus partakes of the nature of economies, rather than mechanics. In order to demonstrate

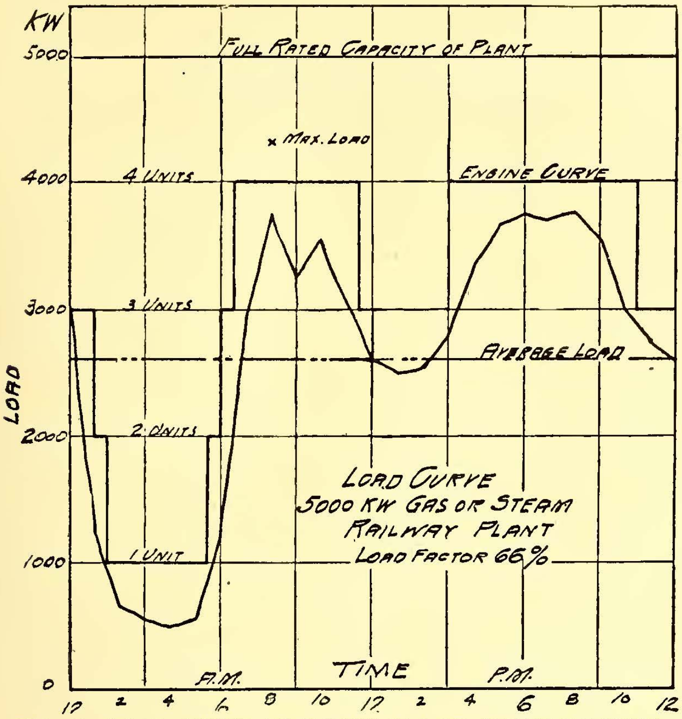


FIG. 17.—LOAD CURVE OF 5000-KW GAS OR STEAM RAILWAY PLANT

more clearly, the diagram, Fig. 15, was prepared, which shows the relative cost of steam and gas power for different grades of coal. By expressing the cost* of the latter in terms of million thermal units, the differentials in transportation are avoided. This diagram is based upon an actual load curve, Fig. 17, and the present approximate cost of power plant equipment, f. o. b. factory, but including erection. From the assumptions (page 600), you will observe that if we have erred it is upon the conservative side, favoring, if anything, the steam plant, especially in the matter of cost.

* In estimating the cost of labor, supplies and repairs, these three items are assumed to be the same for either steam or gas plants, as it is reasonable assumption that any possible excess cost of upkeep on the gas engine equipment would be balanced by the smaller expense of maintaining the producer equipment.

In Fig. 15 the shaded area represents reasonable range for capital cost of gas engine. You will observe that the diagonals for steam and gas intersect at the left of the diagram. The interpretation of this is that at this point, with coal costing 3.5 cents per million B. T. U., or about 90 cents per ton, both plants can deliver power at the same cost, or, in other words, we cannot afford to use gas plant with cheaper coal. Fig. 18 expresses this saving in per cent of excess capital cost of gas over steam plant. Thus, with coal at $3.50, the annual saving is 30 per cent of the original excess.

Upon the assumption of equal labor, supplies and repair costs, it is quite evident that any excess fixed charges on the gas plant will fix a definite economic limit of saving over steam, and it thus occurs that gas will be more effective where fuel is not dirt cheap. If, however, a gas plant can effect a saving in the cost of labor, supplies and repairs, as is the case at Walthamstow, then it may be operated to advantage on still lower grades of coal.

FIELD PRACTICE

This subject may be well concluded by a brief perspective, as it were, of the work that has already been accomplished in the American gas power field. To be sure, the application to railway service has in this country been limited; yet we find abroad many evidences of successful working. A prominent European engineer reported in 1903: "Nineteen stations on tramway work, totaling 6000-hp capacity. These include Barcelona, Tunis, Lausanne, St. Gallen, Poictiers, Orleans and Zurich, from 400 to 600 hp, each working on either producer or town gas." As a result of the excellent experience with Walthamstow electricity station, 650 hp has been added to the plant for operating the new tramway system* recently constructed. At Buenos-Aires, South America, two plants, aggregating 2240 hp, are at work for the Buenos-Aires Great Western and Great Southern Railways. Both used Mond gas.

But eclipsing in interest probably all former gas power railway undertakings is that of the Warren & Jamestown Railway system† now under construction. As the details may not be entirely familiar to you, a brief review is given on page 604. This plant will practically inaugurate the use of the heavy-duty type engine, in connection with single phase railway systems in America.

The new engine equipment, now nearing completion, consists of two 500-hp Westinghouse double-acting engines of the horizontal tandem type,§ each direct connected to a 260-kw a. c. engine type generator. These engines are both of the single crank type, but

* Length of line 9½ miles, 100-lb. girder rails, thirty-two double-deck single-truck cars, double trolley.

† Following the precedent established by the Warren plant, the Union Traction Company, of Independence, Kan., has adopted double-acting engines of the same size, type and design for railway service, using Kansas natural gas as fuel. The initial equipment will comprise single-crank and double-crank units of 500 hp and 1000 hp each (sea level rating).

§ Dimensions of engines: Cylinder diameter, 21 ins.; stroke, 30 ins.; speed, 150 r. p. m.

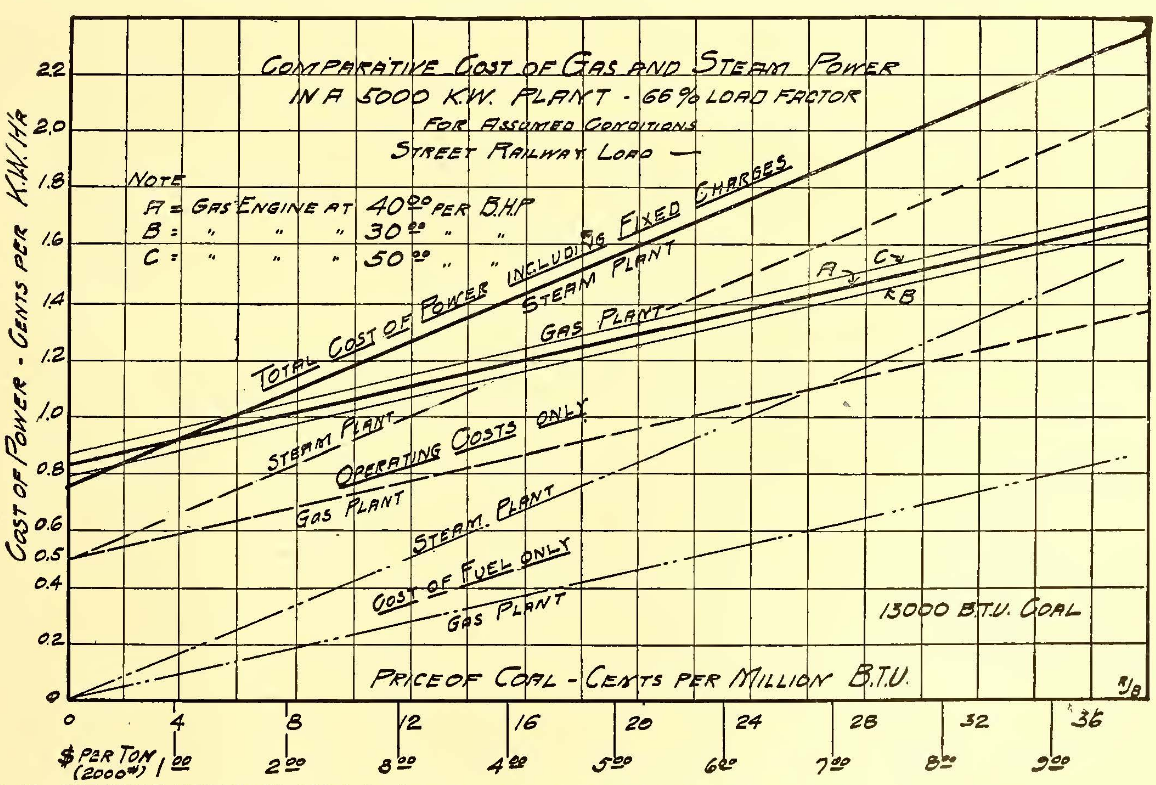


FIG. 15.—SHOWING RELATIVE COST OF STEAM AND GAS POWER FOR DIFFERENT GRADES OF COAL

with the tandem arrangement, a power stroke is developed at each half revolution, as in the double-acting steam engine. The gas

FIG. 20.—PRODUCER PLANT AT HEYSHAM HARBOR, SHOWING COAL-HANDLING APPARATUS

units will operate in parallel on the electrical end, without the necessity of synchronizing the cranks.† Owing to the absence of a battery and the small number of cars, the plant will be subjected to the most severe test possible. It is estimated that one generating unit will take care of the present maximum demand with two cars starting and two running.

Natural gas fuel is entirely used in this territory, and at the present price and heat value will correspond with producer gas delivered at a cost of about 2 cents per thousand cubic feet. The economy in operating with natural gas is striking. In the old gas plant it is estimated that the cost of power averages 75 cents per kw-hour, including all items chargeable to operation, except repairs on buildings and battery; the corresponding gas consumption being 20 cu. ft. per kw-hour.

Among gas power stations in American and British territory we find a large number up to 2600-hp capacity operating on producer, natural and oil gas, and many with the a. c. system with generators running in electrical parallel. In fact, parallel operation by gas engines on a large scale was first accomplished in this country at East Pittsburg, with three cylinder engines of the vertical single-acting type. In view of the success with this type of engine, it is evident that the tandem and twin-tandem double-acting type should be even more suitable. In Great Britain twenty central stations, from 40 kw to 2000 kw in capacity, are in operation, mostly with producer gas.

In the field of electric lighting much has been accomplished. Outside of the Walthamstow station, already mentioned, an interesting plant is the 1150-hp station of the Rockland Electric Company, at Hillburn, N. Y., equipped with Westinghouse horizontal double-acting engines, operating on Loomis-Pettibone producer gas. As in several other industrial plants using this type of producer, most of the water gas generated is used for furnace heating, while the "air" or "blow" gas, too lean for other purposes, is used entirely in the engine plant. In many respects this system is unique, in that it makes possible the commercial use of otherwise expensive water gas, while the cheap "air" gas is rendered useful for generating power.

The utilization of waste products of manufacture has within recent years made great progress. Gaseous by-products have already been put to use on a large scale, but the near future may readily witness the use of the producer in its present or in modified form for utilizing all combustible wastes recoverable in manufacturing processes. Blast furnace gas applications are now more or less familiar; coke oven gas from by-product coke ovens has many notable applications in Europe (a small plant is in use at Camden, N. J.); and oil gas (obtained by fractional distillation of petroleum—a by-product in the refining process) has lately been successfully applied in America.

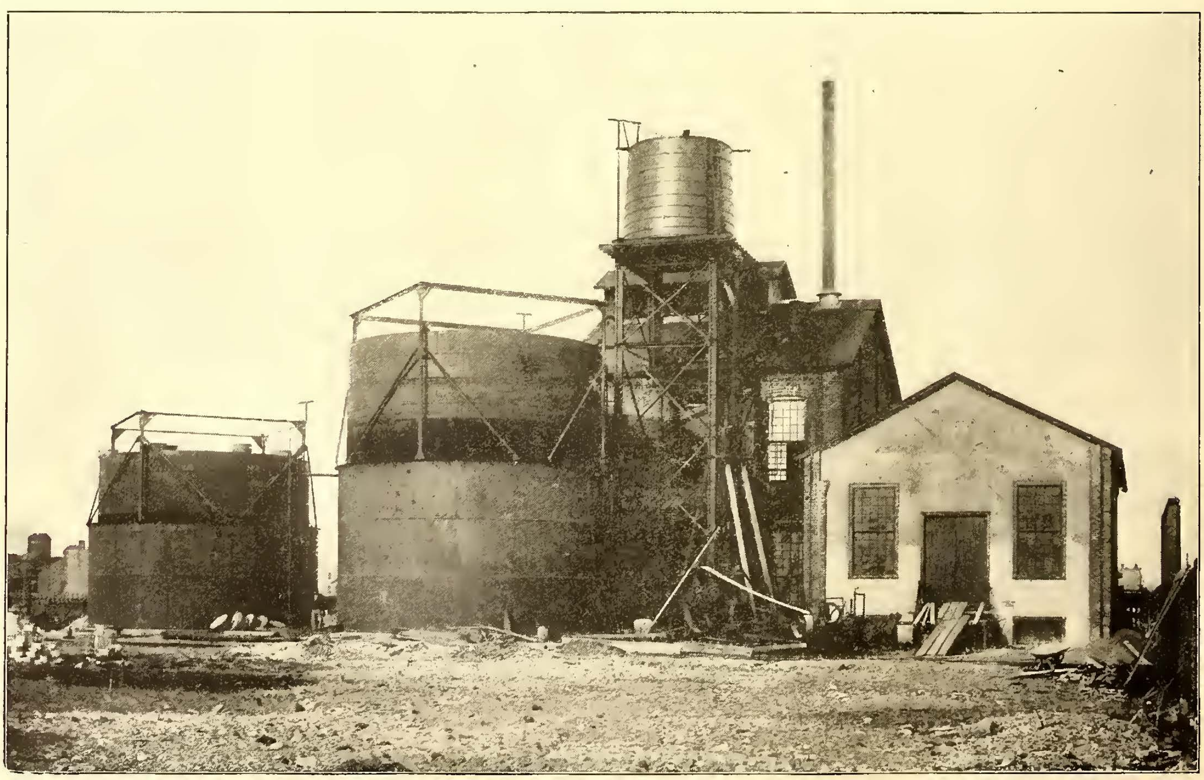


FIG. 19.—TYPICAL GAS POWER PLANT FOR COMBINED POWER AND METALLURGICAL SERVICE, ATLAS TOOL COMPANY, NEWARK, N. J.

SUMMARY

The large number of small plants that has come within our range of experience has not prevented us from obtaining similar ex-

† The cylindrical speed variation and the governor regulation is sufficient to meet present a. c. generator specifications.

perience from larger ones. The operation of close to 100 plants, from 200 to 2600-hp capacity, would seem to indicate that some measure of success has been attained. That one-half of the aggregate capacity operates on natural gas and but one-third on producer gas, simply emphasizes the value of this country's natural resources, rather than reflects upon the producer gas system, especially when one considers the comparatively short time that producer gas has been seriously taken up. About 10 per cent of the larger plants (above 200 hp) operate city and suburban railway systems. The remainder are devoted to many classes of service, such as light and power for city and suburban territory, power for the electrical driving of industrial works, power for operating railroad terminals, gas compressing stations, water pumping plants and high-service fire systems. A notable example of the latter is the 2200-hp station in Race Street, Philadelphia. Most of the prominent types of producers are represented, including the Mond, Loomis - Pettibone, Dowson, Taylor and the more recent Westinghouse system. A few small plants are working on suction gas. This indicates that successful operation is not confined to any particular type of producer.

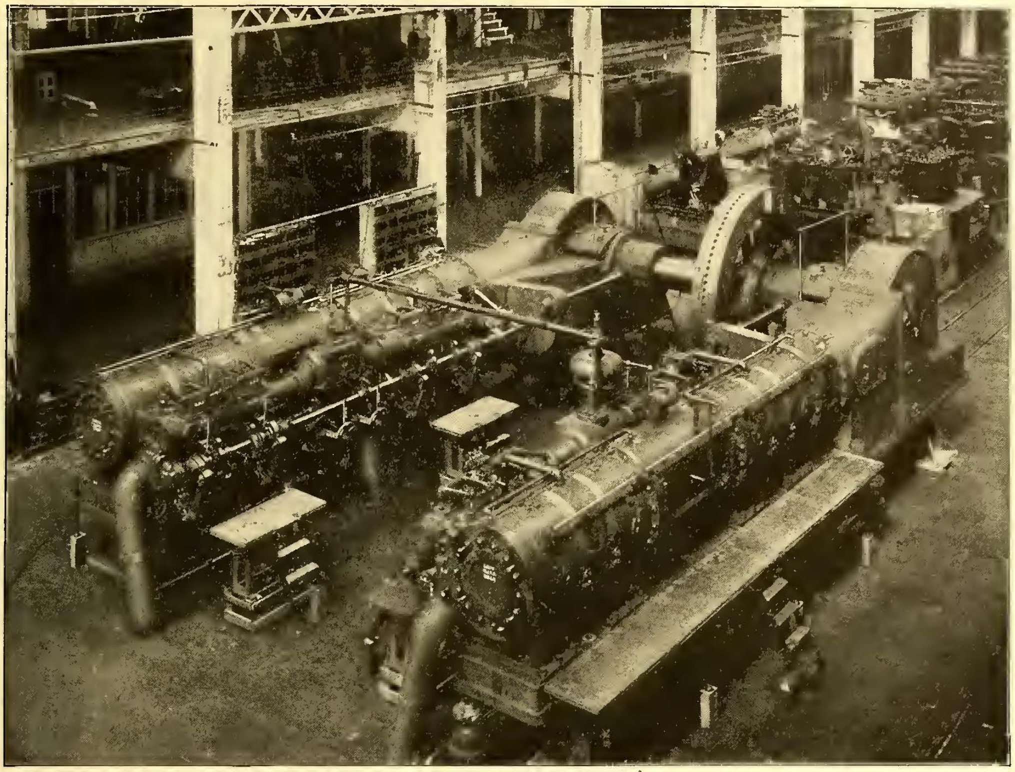


FIG. 21.—1000-HP WESTINGHOUSE DOUBLE-ACTING GAS ENGINE FOR INDUSTRIAL WORKS SERVICE AT WINCHESTER REPEATING ARMS COMPANY, NEW HAVEN, CONN.

In conclusion we can but reiterate our premises:

1. That the gas engine has been brought to a state of development where it is capable of doing the same work as the steam engine, with far greater efficiency, and usually at reduced cost.

2. That the producer has been so far perfected as to be a reliable and more efficient generator than the steam boiler.

3. That the gas power plant "in toto" is entirely suitable for even the severe service incident to electric railway operation.

4. That its component parts, engine and producer, are possessed of characteristics leading to harmonious co-operation.

5. That practical difficulties incident to gas power working have been so far overcome as to warrant commercial confidence.

6. That experience with gas power in almost every known line of modern industry has proven its general sufficiency for any power service.

Such data as has been obtainable is presented in the light of a record of past performance rather than in the nature of prophecies regarding the future. The future is believed to be already assured.

CHARACTERISTICS OF RAILWAY LOADS

The various systems may be classified as follows:

Metropolitan.—Light cars, many in number, small headway (1 to 5 minutes), small load fluctuation—yielding a station load that may be readily predicted and closely followed up by the requisite engine capacity.

Urban.—Light cars, few in number, medium headway (10 to 15 minutes), station load fluctuating considerably.

Interurban.—Heavy cars, few in number, large headway (30 to 60 minutes), high speed, moderate acceleration, heavy grades, load violently fluctuating, cannot be closely predicted.

Rapid Transit.—Heavy cars, multiple-unit trains, small headway at rush hours, rapid acceleration, load fluctuating at sub-stations.

Specific examples may be found in the curves, Figs. 1 to 6, which are explained in Table No. 1. In all the city systems the morning and evening peaks are strongly accentuated and the daily average is high. Owing to the superposition of loads from various distribution centers or sub-stations, the fluctuations at power stations are not necessarily severe. With heavy service, however, sub-stations are subjected to severe fluctuations; *e. g.*, Manhattan

FIG. 22.—2200-HP HIGH-PRESSURE FIRE PUMPING STATION, CITY OF PHILADELPHIA

sub-station No. 2, shown in Fig. 4, where the fluctuation is 40 per cent above and below the average load.

The interurban load presents less distinct peaks, but, although the average is high, the station is subjected to violent fluctuations. This may be appreciated from the recording meter chart, Fig. 7, corresponding to the load curve shown. Although the inertia of the instrument pointer has probably exaggerated the indications, it is safe to say that fluctuations of 30 per cent from the mean load are ordinarily encountered, and with a reduced number of cars as high as 60 per cent.

The characteristics of electric lighting service, on the other hand, are quite different. Except in the case of occasional storms, the load may be closely predicted and followed up with necessary generating capacity, and rapid fluctuations are practically absent.

WARREN & JAMESTOWN RAILWAY SYSTEM

The Warren & Jamestown Railway is a high-speed interurban road, approximately 21 miles in length, operating over a comparatively level and straight right of way between Warren, Pa., and Jamestown, N. Y., at the southern end of Lake Chautauqua. The population of the territory traversed is estimated at 50,000, with 11,000 tributary, not including a large summer population at the various lake resorts. Heavy high-speed cars will be used, approximately 52 ft. over all, and with a normal seating capacity of fifty-four persons, each car being equipped with four alternating-current, 50-hp motors on 33-in. wheels. Four cars will be operated at present, with two additional cars later on.

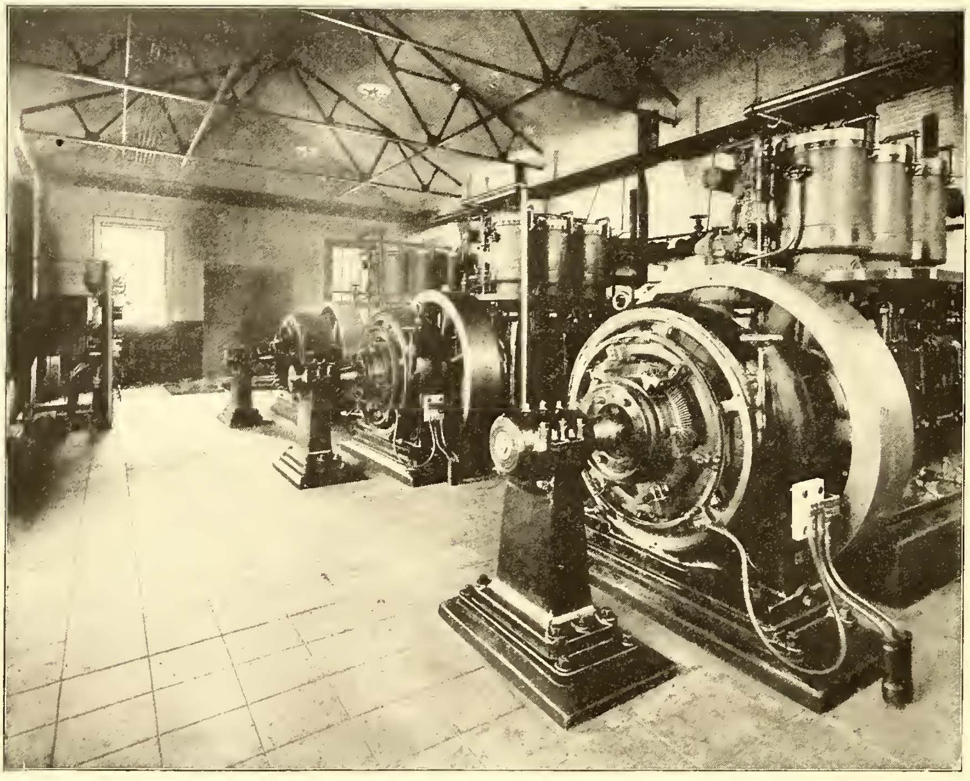


FIG. 23.—ENGINE ROOM OF ATLAS TOOL COMPANY, SHOWING GENERATOR SOLE-PLATE CONSTRUCTION

Power will be generated at the power house now operated by the Warren Street Railway, at Stoneham, 4 miles south of the city. For some time gas engines of the vertical single-acting type have been used for operating the present city railway system, and it is due to the general successful experience from gas power that gas engines will be used for operating the interurban road.

A noteworthy feature of the new interurban system is that Westinghouse single-phase apparatus is used throughout, with 22,000 volts transmission and 3300 volts on the trolley, which is of the Westinghouse catenary construction. A step-up transformer station is located at the power house, and two step-down sub-stations about 1 mile distant from both Warren and Jamestown. These equipments contain transforming, switching and protective apparatus alone. As no direct-current is used upon the system it is impracticable to employ storage batteries, so that the generating equipment will thus be required to sustain at all times the entire demand. In the present city system a 150-amp.-hour (1 hour rating) storage battery is in use, which is kept floating on the line throughout the load fluctuations, to the relief of the gas engine equipment. In the new plant the gas engines must sustain both load and fluctuations without assistance. Each unit complete of the new equipment occupies a floor space of 20 ft. x 47½ ft., allowing 4-ft. to 5-ft. passageways, which is equivalent to 3.65 sq. ft. per kilowatt, or 1.9 sq. ft. per horse-power capacity.

THE SINGLE-PHASE RAILWAY SYSTEM

BY CHARLES F. SCOTT,
Consulting Engineer, Westinghouse Electric & Manufacturing Company

It is the purpose of this paper to present some of the salient features of the single-phase railway system, and the results of the work which has been accomplished in the development of apparatus to meet the increasing demands in electric traction.

The questions which a railway manager is apt to raise with regard to the single-phase railway concern is its suitability for his particular conditions, its present practical status and its cost. The answers which apply in one case may be misleading in others, so that the discussion of the subject must be general rather than particular.

There are two other questions which have been asked so often that they deserve a passing comment: Will the motor start with good torque and accelerate rapidly? Will it commutate? Suffice it to say that the single-phase motor of the variety which I am considering does start and accelerate and commutate.

It is not the motor itself, but the single-phase system which the motor makes possible that is of prime importance. And the system is of commercial value only as it is able to operate electric railway service more effectively and economically than is practicable by other means.

SINGLE-PHASE AND DIRECT-CURRENT SYSTEMS COMPARED

The single-phase system accomplishes the same results in car movement that may be obtained by direct-current equipments, but in many cases with less first cost, less operating expense, increased flexibility and greater simplicity.

The radical difference between railway systems using direct-current motors and those using single-phase motors is not so much in the car or the power house as it is in the circuits connecting them. In the first place, the high voltage used on the trolley wire does away with expensive feeders, and it also enables the current to be carried to a greater distance from the power house or from the sub-station. Second, the sub-station employed in the single-phase system requires simply a lowering transformer. The sub-station for supplying a direct-current railway requires the rotary converter and a set of lowering transformers. Third, the number of sub-stations for a single-phase road is less than is required for direct current, and these do not require the attendance which is necessary for the operation of rotary converters. It is these characteristics that peculiarly adapt the single-phase system to interurban and long-distance railways.

CONSTITUENT PARTS OF SINGLE-PHASE SYSTEM

The motor is the feature which has received particular interest and comment, for it has been conceded that if a single-phase motor be available the other elements would follow as a matter of course. No one has questioned the adaptability of control apparatus, transformers and high-tension line construction to the requirements of the single-phase railway system. This simply involves the application of well-known apparatus and methods to the particular requirements of railway operation. But a perfected motor does not mark the completion of development work. Control apparatus for handling alternating current must be devised and constructed. It must be suitable for hand control for small cars and it must be adapted for the multiple-unit operation of heavier equipments. Still other forms must be suitable for operation interchangeably on either direct or alternating current. Transformers, line switches and other auxiliaries must all be combined into a workable equipment. Forms of trolley and overhead construction must be developed suitable for the new conditions of current and voltage. The announcement of a commercial single-phase motor, made in the paper of Mr. Lamme before the American Institute of Electrical Engineers three years ago this month, was necessarily the beginning rather than the end of the development of the system as a whole in all its details.

ADVANTAGES PROVED BY SERVICE

In how far have the advantages claimed for the single-phase system been realized? Among the important features are the following:

A high-voltage trolley construction has been developed and has proved to be simple, strong and thoroughly practicable. Thirty-three hundred volts has been used and has proved to be safe and reliable.

A sliding contact device which does not require reversing when the direction of the car is changed is found more satisfactory, especially for high-speed operation, than the trolley wheel. Its wearing surface lasts longer than trolley wheels operating lighter cars on direct current.

Transformer sub-stations supply current satisfactorily without feeders and without station attendants.

The car equipments show simplicity and effectiveness in the control apparatus. Less than half the controller notches required for direct current give equally smooth and as rapid acceleration with alternating current. Platform controllers are simpler, as no magnetic blow-out is required. The multiple-unit control system is readily adapted for the operation of single-phase motors, and is in some points simpler than the control of direct-current motors.

The operation interchangeably by alternating current and by direct current is a feature of an important road which operates large equipments on direct current in the city and on alternating current across country.

Motors of four or five sizes have been built and show excellent commutating features. The commutators take a good polish. The motor windings are such that there is a practically balanced magnetic pull, even if the armature be slightly out of center. Although the armature speed is higher than in corresponding direct-current motors, the advance criticism has proved ill founded, as there have been no bearing troubles. The oil lubrication has proved highly satisfactory.

The foregoing features, which are the important elements upon which the claims of the single-phase system are based, have been shown by actual operation to be entirely feasible and practicable and such as to inspire confidence.

Difficulties have been met which have been annoying and vexatious. The difficulties, however, have usually been due to some error in the general engineering features or to some specific point of weakness in the insulation or construction of some part of the apparatus. In other words, the troubles have not been fundamental and inherent in the single-phase system, but have been incidental and capable of ready remedy. Some particular difficulties will be taken up further on in this paper.

LEADING FEATURES OF SINGLE-PHASE SYSTEM

As a guide to determine the conditions under which the adoption of the single-phase system is advantageous it will be useful to review briefly some of its features which are particularly concerned in its installation and operation.

The Motor.—A motor which is protected from the trolley voltage and lightning disturbances by an intervening transformer winding, which has only 200 to 250 volts across its terminals, which may have its brushes grounded or short circuited without "flashing" or "bucking," and which may have full voltage thrown on its terminals without disaster to itself, is essentially a safe motor. The armature has a bar winding on sizes of 30 hp and upward. The increased current required at low voltage necessitates brush capacity equivalent to that on a direct-current motor of twice the output.

The Control.—One usually thinks of the direct-current street railway motor as a variable-speed motor. Yet it is, in a sense, fundamentally a one-speed motor, for with definite trolley voltage, weight of car and grade, the motor soon attains a definite speed, at which it continues to run until there is a change either in the voltage applied or in the load. If two motors be operated in series there is a second definite speed, which is about half of the speed when they are in parallel. Other speeds are obtained by lowering the voltage on the motor by means of resistance, but this is inefficient and is admissible only in starting.

Certain results follow. The speed of the car depends upon the trolley voltage. If the voltage be low, the speed is low. The efficient speeds are fixed by the trolley pressure and not by the motorman. The relation between speed on level and the speed on grade is fixed by the inherent characteristics of the motor. A given motor with definite gear ratio has its one definite speed depending upon train resistance and electromotive-force. There is no range of adjustment like the throttling of an engine without the introduction of the wasteful rheostat. In a series motor the current determines the torque, and the electromotive-force determines the speed. Hence, for speed control there must be voltage control. In the direct-current system efficient voltage control is not attainable, but with alternating current it is easily secured. The simplest method of variable voltage is by means of taps from the transformer winding. The low voltage required for starting is obtained from a low tap, and the successively higher voltages for increasing speeds are secured from successively higher taps from the winding. As there is no rheostat, the motor may run efficiently from any tap, thereby giving the motorman a control over his car movement which is not possible with direct current. If there be a tap giving a voltage higher than that required for normal running, it is available for giving a higher speed for making up lost time, or for supplying normal voltage to the motor when the line pressure is low. The car can run at any time at the pressure needed.

The number of points required on the controller for smooth acceleration is much less with alternating than with direct current. The whole control system, in fact, is simply half a dozen taps from the transformer to the controller, by means of which any one of them may be connected to the motor. An intervening preventive coil enables the controller to pass from one point to the next without opening the circuit or short circuiting the two taps. The controller may consist of a drum of ordinary form on the car platform or of unit switches placed under the car and operated by a master controller. The latter type used in heavy equipments and also when several cars are to be operated in the multiple unit system. An effective form of switch with magnetic blow-out has been developed for heavy currents. The switches are assembled in a compact group, thoroughly protected and easily accessible.

Trolley Voltage.—Twenty years ago the electric railways of the United States, as measured either in miles, in cars or in kilowatts, comprised less than 1 per cent of what they do to-day. In this enormously rapid growth two features of the electric railway have remained unchanged, although other elements have been greatly modified. These two features are: First, the series motor; second, the use of direct current at approximately 500 volts. During this time the generating plant has changed from small belt-driven to large direct-connected units, and then from direct current to alternating current. High tension transmission circuits with rotary converter sub-stations have been common. Motors have increased in size and have been improved in design and in reliability and the multiple unit system of control has been introduced for larger equipments. The trolley voltage, however, has been limited to approximately 500 volts on account of the limitations of the direct-current motor and the inability to transform direct current on the car from a high voltage to a low voltage. The general trend of electrical engineering has been toward alternating current at high voltage. Many can remember the time when the use of 1000 or 2000 volts was decried as impracticable or unsafe, and when 5000 or 10,000 volts was the limit to laboratory experiments. Progress has been made in design, in construction and in materials until voltages, which not long since were impracticable, are now operated with greater reliability and safety than were the lower pressures a few years ago. Safety is very largely a question of mechanical excellence. In railway motors and control apparatus, in the mechanical equipment of heavy and high-speed cars, in overhead construction and in power house equipment, reliability is primarily dependent upon mechanical excellence.

While any considerable increase in voltage may not be safe on existing trolley lines, it is practicable by an increase in mechanical strength to offset the higher pressure and produce a high-voltage trolley system of greater reliability and safety than the present construction for low voltage affords. Such a construction has been developed into a commercial form in the catenary suspension of the trolley wire. An auxiliary steel cable with a moderate sag at the center of spans supports at frequent intervals the trolley wire which is thereby maintained at a uniform height. It is adapted for high-speed running and it possesses a greatly increased strength. The excess cost of the catenary construction over the cost of poles and overhead construction of the ordinary type is moderate, and, in a large measure, is justified by the gain in mechanical reliability quite aside from the question of voltage.

The Sub-Station.—To one familiar with an ordinary rotary converter sub-station interest will center chiefly in the negative characteristics of the single-phase sub-station. There is no rotary converter—a most essential link in the old system, one which behaves remarkably well when all is favorable, but is inclined to be fussy and obstreperous when the conditions are not to its liking. There is no synchronizing, no sparking, no flashing, no dropping out of step. The transformers are not arranged in banks of two or three little ones, with polyphase switches and auxiliaries in primary and secondary, and the direct-current switchboard has disappeared entirely.

So much for what it is not. In its simplest form the sub-station is a single transformer with its primary and secondary connections. Additional transformers, switches, lightning protection and instruments are added as circumstances require.

Short circuits have lost much of their terror. The alternating current on short circuit is limited by the self-induction of the circuit, and a transformer is not disturbed by a "short" as is the commutator and the speed of a rotary converter.

The difference in the effect of a short circuit on direct current and on alternating current is well illustrated in the underground circuits in New York City. In an 11,000-volt cable system a fault in the cable causing a short circuit is usually confined within the cable and merely burns out a few inches of the conductor before the circuit-breaker opens. On a low-tension system, however, the currents are very large and considerable lengths of the conductor may be melted before the current is interrupted. In an alternating-current system the normal current in a circuit delivering a given amount of power is less in proportion as the voltage is increased, and, as the increase of current above normal is not as great on account of the self-induction of the circuits and apparatus, accidents are less liable to be destructive.

OPERATION ON DIRECT CURRENT

If the single-phase road is to be an extension of an existing road, it may be desirable to run the single-phase cars over the tracks which have a direct-current trolley wire. While single-phase cars can be arranged to operate from a direct-current trolley wire, it handicaps in some measure the single-phase equipment. The addition of resistance to the car equipment and the extra switches and the like for enabling the change to be made in the current supply are obviously objectionable. It is best, therefore, to keep single-phase equipments free from operation on direct current if it be practicable to do so. When it is found necessary for them to operate from an existing direct-current trolley wire, the motors are connected two in series for 500 volts, and if there be four motors the two pairs may be connected first in series and then in parallel as in ordinary series parallel control. The transformer is cut out, and the control apparatus and motors operate in substantially the same way as those on an ordinary car.

SOURCE OF POWER

The standard frequency for the single-phase motor is 25 cycles, (3000 alternations). Generators may be wound for single-phase, or current may be taken from one phase of a two-phase or a three-phase generator. Current from the several phases of a polyphase generator may be used for operating different divisions of the railway.

If power is to be taken from a power house which generates a higher frequency it cannot be applied directly, but must be changed to 25 cycles. This may be effected by a motor-generator set. A polyphase motor taking power equally from each phase of the high frequency circuit may drive an alternator, either single-phase or polyphase, for furnishing current to the single-phase railway. The converting outfit may be located in the main power house or in a sub-station as may be found most convenient.

THE FIELD FOR SINGLE-PHASE RAILWAYS

The development of a new and more efficient method for accomplishing a given result often leads on and opens new fields which had not been commercially practicable before. Such is the case with the single-phase railway. The direct current interurban railway has its limitations. If a region be sparsely settled the available traffic will not show a profit on the cost of circuits and rotary converter sub-stations. There is a material reduction in the investment and operating expense incident to the single-phase railway that will enable it to be built and operated with a profit in cases where the traffic would not support a rotary converter system.

On the other hand, in heavy service the direct current has not made much headway, being handicapped by the heavy cost of sub-stations and of conductors. Heavy and relatively infrequent trains are the hardest loads for sub-stations. For example, if sub-stations be 8 miles apart, each will supply 8 miles of track. A train running 40 miles per hour will receive current from a given sub-station for 12 minutes. In order that a sub-station may be continuously supplying current to trains in one direction they must have a headway of 12 minutes. If they be an hour apart the current from each sub-station is used but one-fifth of the time. Trains in two directions will double the sub-station output, but as the peak load is considerable when two trains pass near a sub-station the load factor is extremely low. Therefore as the aggregate capacity of the sub-stations must be large in proportion to the actual power taken by the cars, it follows that the sub-stations will involve a relatively large expense if they are equipped with expensive rotary converters and require constant attendance, whereas the cost will be relatively small if they require simply lowering transformers having an efficiency very much higher than the rotary converter sub-station and not requiring attendance. The reduction in the sub-station is therefore of especial value when the service is infrequent. Moreover, the single-phase equipment by reducing the size of conductors frequently enables the sub-stations to be more widely separated. This possibility in the reduction in the number of sub-stations and in the aggregate capacity of sub-station equipment, as well as the elimination of rotary converters with their energy losses and their attendants makes practicable the operation of long-distance roads which could be operated by direct current only at an excessive cost.

The single-phase system therefore decreases the cost of installation and operation for the kind of interurban service which has been successfully developed by the direct current, and it extends the field of commercial operation to include, on the one hand, rural roads with relatively light traffic, and on the other, a heavy, infrequent, multiple unit or locomotive service for passengers or for freight approximating steam railway conditions.

SINGLE-PHASE RAILWAYS IN OPERATION

The single-phase railway which shows the most extensive operation as measured in car-miles, is the Indianapolis & Cincinnati Traction Company. Operation was begun over a short length of track Jan. 1, and on April 1, 37 miles were covered. Since July 1 a regular schedule has been maintained over 41 miles, 37 miles of which is under alternating-current trolley and the remaining 4 miles is under direct-current trolley in the city of Indianapolis. The company has 10 cars, each equipped with four 75-hp motors. A maximum speed of 60 to 65 miles per hour is secured, and the cars are not only the heaviest, but they operate upon the fastest schedule of any of the numerous suburban roads radiating from Indianapolis. Some defects have developed in the equipment, which, however, have been incidental in character, and not in those new features where trouble might reasonably have been anticipated. It was found that the natural ventilation under the car was insufficient for the transformer and a ventilating motor was added. A weak point developed in the armature insulation when the cars, which had been running for some time by alternating current, were first run regularly over the direct-current lines into Indianapolis. One feature of the new condition was the opening of the circuit with four motors in series, the motors having laminated fields which give greater field discharge than solid poles. The remedy was obviously the strengthening of the insulation. This brings out the interesting fact that operation on alternating current at 3300 volts with an intervening transformer is less severe upon the motor than operation on direct current at 500 volts. Experience showed wherein the control apparatus, suitable for both alternating and direct current, could be simplified and the apparatus reduced in quantity. The result is a control system which is relatively simple and compact, although suitable for operation interchangeably between alternating current and direct current.

The best verdict upon the working of the single-phase system on this road at Indianapolis has been given by the operating company. It is found in the contracts which have been placed for extending the present line a distance of 16 miles; also in extending the single-phase operation to the Shelbyville line, both to the 29 miles which have been operated by direct current and for a 20-mile extension. The length of track is therefore to be increased from about 40 to 100 miles; the number of cars will be double the present number and all equipments will be similar. It is significant that a company which has been operating two substantially similar suburban lines, one by single-phase current and the other by direct current, should see fit to throw out the direct current and substitute single-phase alternating current. It may be noted that this course was taken, although the reverse was easily possible, as provision was made in the original contract for the single-phase apparatus by which it would be exchanged for direct-current equipments if its operation proved unsatisfactory.

Other single-phase roads which are operating Westinghouse equipments show a variety of conditions, some having exceptionally sharp curves and steep grades. On the road between Derry and Latrobe, in Pennsylvania, 30-ton cars are started on a 10 per cent grade. The cars have platform controllers and are equipped with four 50-hp motors. In some cases the initial operation has been handicapped on account of incompleteness, or through the use of temporary apparatus either in the power house or on the car. In its fundamental elements, however, the operation is proving perfectly satisfactory.

SOME NEW ROADS

The extension to long distances will soon be shown in the carrying out of the contract which has been closed by the Spokane & Inland Railway Company for 150 miles of railway running south from Spokane, Washington. The equipment will consist of fifteen motor passenger cars, each with four 100-hp motors, six motor freight cars, each with four 150-hp motors and six 40-ton freight locomotives which may be in pairs for heavy trains. The engineer of this road has been intimately connected with the installation and operation of the single-phase road at Indianapolis.

The most notable recent event in electric traction is the purchase of Westinghouse single-phase locomotives by the New York, New Haven & Hartford Railway Company. The passenger trains on this road which enter Grand Central Station in New York run over the tracks of the New York Central Railroad for about 12 miles. As steam locomotives cannot enter the new terminal station, and as the New York Central is equipping its track for direct current, it is imperative that the New Haven trains be handled over 12 miles by direct-current power. Instead of changing from electric to steam locomotives for all local and through trains at the end of 12 miles it was decided to extend the electrification and to do it, not by extending the direct current, but by changing to alternating current. The single-phase locomotives will be designed so that they may operate interchangeably from direct current or from single-phase alternating current.

The adoption of the single-phase system by one of the leading railroads of the country for its heavy and important passenger service is all the more noticeable; first, because its officials are already familiar with electric traction matters through the operation of many important city and interurban railways in New England, and second, because the obvious thing to have done would have been to follow the example of the New York Central by adopting direct current locomotives. Probably this is the turning point, and the coming electrification of heavy railways will follow the conspicuous example set by the New York, New Haven & Hartford Railroad Company in adopting the single-phase system.

ELECTRIC RAILWAY EQUIPMENT

BY W. B. POTTER

The annual meetings of the American Street Railway Association are not only occasions for the exchange of ideas between the operating companies, but they also afford an excellent opportunity for engineers concerned in the selection or development of the various appliances to study the present and future requirements in their broader aspect.

Recent years have witnessed such radical changes in many details of electric railway equipment, that it is advantageous to occasionally review the modifications made to meet the requirements of modern railway practice. Numerous changes are made each year, and while the general trend is toward improvement, the ultimate degree of perfection is only attained through the experience resulting from a thorough trial of the new ideas under operating conditions. In this respect the designing engineer and manufacturer owe much to the operating company, an obligation which should be, and I believe is, fully recognized.

The limits of this paper will permit only a reference to a few of the features relating to the development of the past few years.

STEAM TURBINES

No more prominent example can be found to demonstrate the rapid march of progress, than the introduction and successful operation of the steam turbine, of which there are several types now on the market. The extent to which the reciprocating engine is being superseded is indicated by the sales during the past three and one-half years of one type of turbine alone, which amount to over one-half million kilowatts, of which about one-third are for electric railway service. These figures are mentioned for the purpose of emphasizing the recognized importance of the steam turbine as a prime mover.

As compared to the reciprocating engine there are several important advantages generally known, but perhaps not appreciated at their true value. The steam economy of a turbine at full load is at least equal and frequently higher than that of an engineer of similar capacity, and at fractional loads the degree of economy is decidedly in favor of the turbine. This is owing to the relatively more efficient utilization of the steam at partial load and also the lower frictional losses. As the load factor of a prime mover is commonly less than full load, the resultant relative economy of the turbine is considerably higher than if it were judged only by a comparison of the steam consumption of both the turbine and engine at full load—a comparison at one-half load would more nearly represent the average operating performance of a railway power station. The turbine has also the advantage of a better maintained operating economy, as it is not dependent upon the setting and fit of admission and exhaust valves, the derangement and leakage of which may reduce the initial economy of the engine 15 per cent, or even more, depending upon the degree of attention which the engine receives. The attendance and maintenance, as would be expected from a comparison of the mechanism, of the turbine and engine is in favor of the former. The reliability has also been proven by extended runs and further by the accidental admission of water, which although harmless to the turbine, would have caused serious injury to an engine.

The curves shown in Fig. 1 illustrate the performance of a 2000-kw Curtis turbine at different loads and under various steam conditions, and show the characteristically high economy at the fractional loads. The higher economy secured by superheating does not altogether represent an equivalent reduction in fuel, as a certain additional amount of coal is required to produce the superheating. The net result, however, shows a saving in favor of superheating. While the larger sizes of turbines have been more generally applied to driving alternators, they are adapted for direct-current railway generators, and turbine sets of this character have been built up to 2000 kw. The turbine certainly gives great promise of being the only steam-driven prime mover of the future for producing electric power, and its usefulness is by no means limited to that particular field.

MOTORS

Each year bears evidence of the growing popularity of electric traction, and the increase in traffic has naturally affected both the size and weight of the cars and the schedule speeds. The more onerous conditions imposed on the electric apparatus to meet the ever increasing demand for larger and heavier equipments, and the demand for greater seating capacity on systems already operating at 500 to 550 volts, has led to an increase in the generated voltage. We have been accustomed to consider 500 to 550 as the standard direct-current voltage, but 600 volts is now being used to such an extent that it has really become the standard for the power station. The rôle of the manufacturer is to design and construct such apparatus as will best meet the conditions of the operating companies, and it is, therefore, the requirements of the operator that should be studied rather than the development of any particularly idea.

The direct-current railway motor has been greatly improved, and has undergone more changes in detail than is perhaps generally appreciated. The old troubles of sparking and flashing at the commutator have been practically eliminated. Previously it was considered advantageous to short circuit a turn on the field winding to reduce the sparking at the brushes and in the controller, the idea being to restrain the rapidity with which the magnetism of the motor changed, but several years ago it was found that while this provision decreased whatever troubles occurred, due to opening the circuit, it was a positive cause of flashing in case the current was interrupted and suddenly applied. For example this trouble would occur on passing a section insulator with the controller on, and more especially when operating with sleet on the trolley wire or running over a third rail with an uneven surface.

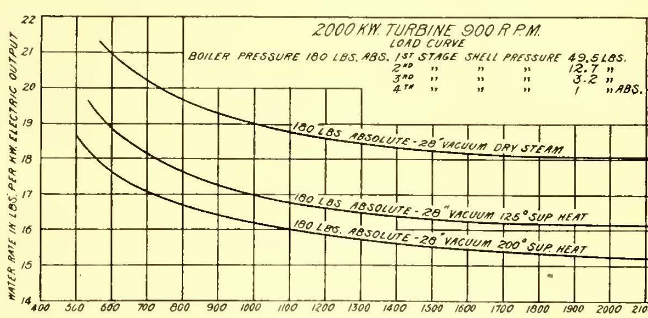


FIG. 1.—PERFORMANCES OF A 2000-KW CURTIS TURBINE AT DIFFERENT LOADS AND UNDER VARIOUS STEAM CONDITIONS

The field coils as now made not only have no short circuiting turns, but where metal spools are used, it is customary to split the spool and introduce an insulation into the shell to eliminate every feature of a short circuited turn.

The armature revolutions of a motor as affecting the peripheral speed of the commutator have also an effect on the sparking and wear of the commutator. The armature revolutions further affect the performance of the bearings, and while it would be possible to build a lighter and cheaper motor at higher armature speeds, a maximum of 1500 r. p. m. appears to be the highest desirable limit as indicated by experience.

To meet the requirements of the higher voltage now more commonly used, and to further insure the stability of the motor as regards flashing, it is now the practice to provide a greater number of commutator segments; that is, the voltage difference per commutator bar has been reduced to a lower figure.

The commutator being a revolving switch, it is important if sparking and flashing are to be avoided that the brushes should maintain good electrical contact with the copper segments. The commutator being built up of alternate sections of copper and mica, it sometimes happens that the mica does not wear evenly with the copper. In such cases the sparking becomes more pronounced, and there may even be serious trouble from flashing; the most effectual remedy in such a case is to groove out the mica between the commutator segments to a depth of about 1-32 of an inch below the surface of the commutator. Many cases of troublesome commutation may be wholly cured by this expedient.

The performance of a motor for any service may be limited by its commutation, or, as is more commonly the case, by its heating. The heating of a motor is affected by the losses in both the copper and iron, but the relative heating effect of these two elements is quite different. The copper losses predominate during acceleration and the iron losses when running at the higher speeds; the effect of the iron losses is, therefore, to limit the capacity of the motor for

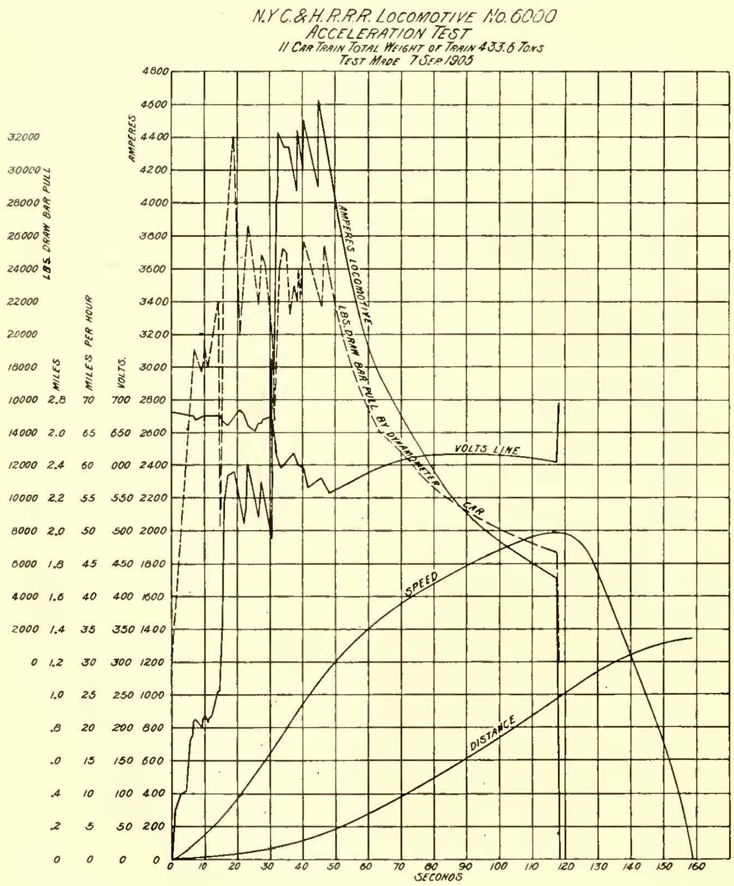


FIG. 2.—ACCELERATION TEST ON NEW YORK CENTRAL LOCOMOTIVE

continuous running. Although the service in which motors are now commonly used does not call for a continuous run of many hours at full speed, without occasional acceleration, the iron losses are, nevertheless, of importance, and more care than formerly is now exercised in the selection of the iron for armature. The principal cause of these iron losses are the eddy currents in the iron, and to eliminate these a special study has been made of annealing and japanning the laminations.

While the temperature of a motor under given conditions is proportional to its internal losses the actual temperature rise may be greatly influenced by ventilation to assist in dissipating the accumulated heat. Forced ventilation by means of a blower, similar to those used with air-blast transformers, may be employed. By this means the temperature of the motors in any particular service may be very much reduced, but the complication is such that it does not seem well adapted to the ordinary electric car. Forced ventilation is, however, well suited to locomotive work where the blower may be carried in the cab. As the motor commonly used depends upon its own rotation for ventilation, the arrangement of the ventilating passages must be carefully studied, not only to secure the best cooling effect, but also to prevent depositing brake-shoe and carbon dust or other injurious material upon conducting surfaces of the motor which cannot be conveniently cleaned.

For this reason it is inadvisable to provide ventilating ducts just at the back of the commutator ears, for any accumulation of conducting dust at this point is sure to produce burn-outs. It has also been found advisable wherever ventilating ducts are provided through the core head to extend the slot insulation of the armature coils for some distance beyond the end of the core.

The use of oil in preference to grease for the lubrication of motor bearings seems now to be universally favored. Of the various methods which have been tried, a waste-packed journal with an oil well, similar to the journal box of a car truck, has given the most satisfactory results. Nearly all the larger motors at the present time are designed for this method of lubrication.

The mechanical injury to motor armatures usually results either from the armature striking the pole pieces or the mechanical weakness of the armature binding. The former, where resulting from the wear of the armature bearing linings or loose cap bolts, can be avoided by a proper system of inspection, but the latter is a question of motor design.

The strains to which the armature bindings are subjected, particularly if the car is speeded above the normal by driving it with power down grade, are not ordinarily appreciated. As an illustration, the weight of the armature coils in a 125-hp motor is less than 200 lbs., yet the radial centrifugal strain of all the coils at 1500 r. p. m. is about 48 tons, giving a resultant strain of over 15 tons on the binding wires. Even if these wires are strong enough to hold the coils without breaking, they may stretch enough to permit a considerable movement of the coils in the armature slot, resulting in an abrasion of the insulation. An armature should be so bound that there will be no evidences of weakness at 50 per cent above the maximum normal speed, and the ultimate strength of the binding or bursting speed of the armature should be at least double the maximum normal speed to insure the proper margin of safety.

The field coils of a motor, although subject to less potential than the armature, by reason of their location in the motor, are more subject to injury from occasional water. A distinct improvement has been made in the construction of the field coils by immersing them in a bath of hot compound under vacuum. The effect of this process is to thoroughly fill all air spaces with compound. This not only renders the coil more waterproof, but also makes it more solid and less liable to injury from mechanical vibration.

More attention is being paid to the fit of commutator and oil well covers, which, being frequently opened, are now provided with machined seats in order to insure a better fit for the exclusion of dirt and water.

With the increased capacity of the motors the strains on the gearing have very much increased, particularly on the pinion teeth, which are of weaker section than the gear teeth. To meet these more severe conditions a very high grade of steel is required, both with respect to ultimate strength and elastic limit. The grades of steel commonly used five or six years ago would by no means answer for the pinions of the larger motors built to-day. Not only are the strains severe, but owing to the overhang of the pinion, the face of both the gear and pinion teeth, when new and doing heavy work, are not in contact across their full width. The strain is borne principally by the end of the teeth nearest the motor, with the result that a shearing action takes place, which will sometimes break out a part if not the whole of a pinion tooth. As a pinion wears the teeth become thinner on the side toward the motor, so that a pinion which has been in service until its teeth match with the gear across the full face, may prove stronger under stress than a new pinion.

The solid axle gear is to be preferred to the split gear, and, were it not for the inconvenience of removing the car wheel, would doubtless be more generally used. The objection to removing the car wheel for the reason that its fit on the axle is impaired, may be overcome by the use of a wheel with an extended hub, on which the gear is shrunk, as proposed by Messrs. Doyle and Brinkerhoff, and in use on the Interborough Rapid Transit Railway in New York.

The more severe demands of present service have also necessitated changes in the older type of controllers, as well as the development of new types of control and control appliances. The cylinder controllers have been improved by making the arc deflectors of a more vitreous material, less affected by the arc and productive of a much smaller quantity of conducting gas when opening the circuit under abnormal conditions.

CONTROLLING SYSTEMS

For the control of equipments aggregating 200-hp and over, the type-M control, consisting of electrically-operated contactors or switches, is recommended and is being very generally used. It is not only possible to handle heavier currents and a higher voltage by contactor switches, but a further advantage lies in the fact that the master controller occupies considerably less space than a cylinder controller handling the full motor current.

Whether the cars are operated singly or in trains, as the Sprague-General Electric multiple-unit system, the control may be either hand-operated or automatic in its action. In the former case the handling of the master controller is similar to the ordinary cylinder control, and there are controller notches corresponding to each rheostatic step and the series and parallel running points. In the automatic control there are only three positions of the handle, the first one giving slow movements to the car for switching; the other two points are the series and parallel running positions. The intermediate rheostatic points are actuated automatically by a series relay on each car of the train. The automatic form of control is well adapted for services where the rate of acceleration may be predetermined, and need not be dependent upon the judgment of the motorman.

FUSES

For automatically protecting the equipments from the results of accidental short-circuits, it was the early practice to provide fuses consisting of a composition of lead and tin, and, although magnetic fuse boxes were used, their action with this type of fuse was not always satisfactory. It was partly for this reason and because of the time required to replace fuses, which with the older types of equipment were more frequently blown, that the automatic circuit breaker came into quite general use. On the larger equipments, however, where the circuit breakers had to be set for 1000 amps. or more, it was found difficult to provide space for them in a position where the arc resulting from a short circuit would be free from danger of grounding to some part of the car. As a substitute for the circuit breaker in this heavier class of work, many different forms of fuses have been tried, but none has proved thoroughly reliable, with the exception of a fuse composed of thin copper ribbon enclosed in an insulating chute and surrounded with enough iron to provide a magnetic field. This copper ribbon fuse has been quite generally used on the larger equipments for the past few years, and has given excellent satisfaction. The same type of fuse is applicable to smaller equipments, and in many cases it may be found superior to the circuit breaker, as its reliability is a strong point in its favor. A circuit breaker should have frequent inspection, and in case of several repeated short circuits it may be so injured as not to finally extinguish the arc without an amount of flame that may alarm the passengers.

CAR WIRING

It is a matter of favorable comment that the car wiring is now receiving much more attention than formerly. Those familiar with the character of work formerly done will readily testify to the advantages secured by eliminating the dangerous practice of attaching the wires by staples or other means to any convenient place on the under side of the car, and often without regard to the movement of the brake levers and compression of the springs of the loaded car. The best recognized practice is now to install all wiring in iron conduit. If properly done, with the ends of the pipes fitted with bell mouths or other provision to avoid abrasion of the wire, the car wiring should prove the most safe and permanent part of the electrical installation.

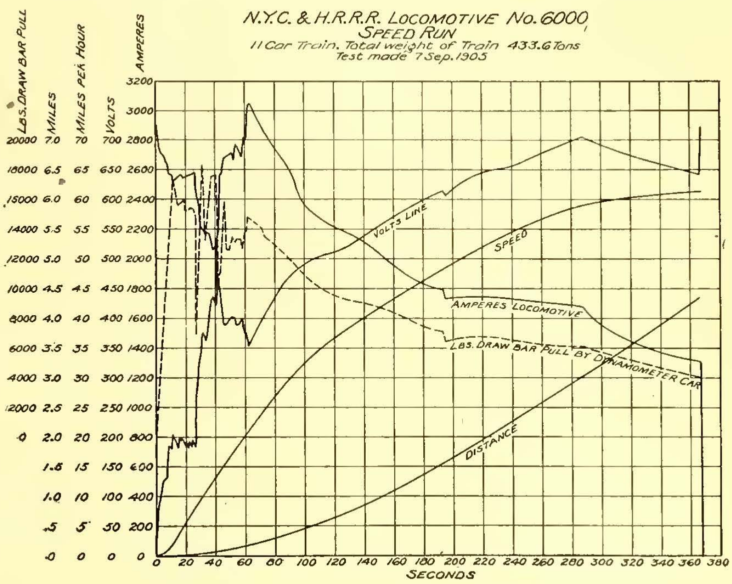


FIG. 3.—SPEED RUN CURVES OF NEW YORK CENTRAL LOCOMOTIVE

The suggested improvements in wiring apply with even greater force to the lighting and heating circuits, as these circuits have generally been given less attention than the motor circuits. As a source of fire, the lighting and heating wires are dangerous on account of their location in the roof or sides of the car, their inaccessibility for inspection and the fact that current is often left on these circuits when the cars are in the car house.

While many of the preceding remarks have been based more particularly on the experience with direct-current apparatus, the essential principles apply equally to the alternating railway equipment.

FIG. 4.—ELEVEN-CAR TRAIN USED IN NEW YORK CENTRAL ELECTRIC LOCOMOTIVE TESTS

ALTERNATING-CURRENT APPARATUS

During the past year there have been several installations of alternating railway equipments, and the outlook is very promising for this class of equipment under conditions advantageous to its use. Considered wholly from a technical standpoint, there is no question but that alternating-current motors can perform any service now done by direct-current apparatus, but the choice as between alternating and direct current should not be made without a full consideration of the direct and indirect expense incident to either type of equipment.

NEW YORK CENTRAL ELECTRIC LOCOMOTIVE

As the street railways and the steam railroads are now becoming so closely identified, a reference to some of the recent tests of the New York Central electric locomotive will not be out of place. This locomotive has now run over 21,000 miles with trains of varying weights. The maximum speed attained with a train weighing 278 tons, including the locomotive, was 71 miles per hour in a distance of about 4 miles. With the locomotive alone, the maximum speed was 85 miles per hour, with the probability that the speed would have been 100 miles per hour had the run been twice the length.

The accompanying curves show tests made with an eleven-car train, including the New York Central dynamometer car, which were made for the purpose of checking the results obtained from the speed-torque characteristics of the motor.

Fig. 2 shows an acceleration test, all the records of which were taken with automatic recording instruments. The draw-bar curve was taken by the dynamometer car, with no damping device or dash-pot to control the fluctuations on the recording pointer. The comparative steadiness of the pull of the electric locomotive will appeal to those who have seen a dynamometer record, without the damping device, taken from a steam locomotive.

Fig. 3 shows the curves of a speed run over the test track with the same train. The notch in the curve at about 190 seconds is caused at that point by the locomotive leaving an additional strip of third rail which was fed from some distance away.

The total weight of this locomotive is 97 tons, of which about 70 tons is on the drivers. The nominal rated power is 2200 hp, although the output during acceleration has often exceeded 3000 hp. The accompanying Fig. 4 shows this locomotive with the eleven-car train attached. The weight of the train, including the locomotive, was 433 tons.

RECORD DATA

In conclusion, I would call attention to the benefits that may be derived, both from an operating and manufacturing standpoint, from a record system covering the mileage of parts and detail cost of maintenance of the car equipment. The records of the power and sub-stations, which are more easily kept, seem to be fairly complete, but of the car equipment, the records do not seem to be generally available in such form as to permit a comparison of the relative merits of any particular method of operation or quality of material. If a uniform system could be standardized and the records submitted at each association meeting, they would be a valuable source of information and a further incentive to improvements in the design of apparatus and the methods of operation.

CONSTITUTION AND BY-LAWS OF THE AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION

The following is the final form of the constitution and by-laws adopted Sept. 27. The changes from the form published in the STREET RAILWAY JOURNAL for Sept. 2 are indicated by printing the new words introduced in italics and the words stricken out in brackets []:

CONSTITUTION

NAME AND LOCATION

I. a. The name of the association shall be the "American Street and Interurban Railway Association."

b. The headquarters of the association shall be located in the city of New York.

OBJECTS

II. The objects of the association shall be as follows:

a. The discussion and recommendation of methods of construction, management and operation of street and interurban railways, and of safeguarding the interests of the same.

b. The establishment and maintenance of a spirit of co-operation among the members, and the encouragement of friendly relations between the companies and the public:

c. The acquisition of experimental, statistical and scientific knowledge relating to the construction, equipment and operation of street and interurban railways and the diffusion of this knowledge among the members.

MEMBERS

III. The membership of this association shall consist of two classes, as follows:

a. Active members, consisting of American street and interurban railway companies, or lessees, or individual owners of street and interurban railways. Each member shall be entitled to one vote, which shall be cast by the properly-accredited delegate.

b. Associate members, consisting of individuals, *co-partnerships and corporations*, who are [or have been at some time] actively identified with street and interurban railway interests, and other persons who in the opinion of the executive committee have had experience of such a nature as to render desirable their connection with the association. The privileges of the associate members shall be similar to those of the active members, excepting that they shall not be entitled to vote or hold office, nor shall they have the privileges of the floor unless permitted by the association.

AMENDMENT

IV. This constitution may be amended by a two-thirds vote of the members present at a regular meeting, provided the proposed amendment shall have the approval of *two-thirds of* the executive committee, and provided that a copy shall have been sent to each of the active members at least thirty days prior to the date of the meeting at which the proposed amendment is to be acted upon.

BY-LAWS

ELECTION OF MEMBERS

I. Every applicant shall signify his desire to the secretary, enclosing the requisite fee. All applications for membership shall be referred to the executive committee, a two-thirds vote of the members of the executive committee by ballot being necessary to election. In case of rejection, the membership fee shall be returned. The executive committee shall report at each meeting the names of new members elected.

OFFICERS

II. a. The officers shall consist of a president, vice-presidents equal in number to the number of affiliated associations, a treasurer and a secretary. The officers shall assume their duties immediately after the meeting at which they are elected.

b. The president *and* vice-presidents [and treasurer] of the association shall be elected at the annual meeting of the association. All such elections shall be by ballot, and a majority of the votes of all members present shall be necessary to an election. The secretary *and treasurer* shall be appointed by the executive committee, *and both offices may be filled by the same person.*

PRESIDENT AND VICE-PRESIDENTS

III. The president shall be the chief executive officer of the association. He shall preside at the meetings of the association and of the executive committee. In the absence of the president, any duties devolving upon him may be performed by one of the vice-presidents.

TREASURER

IV. The duties of the treasurer shall be to receive, safely keep and account for all moneys of the association; to keep correct accounts of the same, and to pay all bills approved by the president. He shall make an annual report to be submitted to the association. He shall give a bond to the president in such sum, and with such sureties, as shall be approved by the executive committee. He shall be paid a salary fixed by the executive committee.

SECRETARY

V. The duties of the secretary shall be as follows:

a. To take minutes of all proceedings of the association and of the executive committee, and to enter them in books proper for the purpose.

b. To conduct the correspondence of the association.

c. To read minutes and notices at all meetings, and to present papers and communications if the authors wish it.

d. To collect and file for the benefit of the members information and statistics regarding matters relating to the purposes of the association.

e. To receive applications for membership, and to lay such before the executive committee.

f. To attend to the publication of the proceedings of this association; and, in conjunction with the secretaries of the affiliated associations, to the publication of the proceedings of such affiliated associations.

g. To send notices to all members of the association at least thirty days before each meeting, mentioning papers to be read and any special business to be brought before the meeting.

h. To perform such other duties as may be required of him by the constitution and by-laws, and such duties as may be assigned him by the executive committee.

The office of the secretary shall be maintained at the headquarters of the association. He shall be paid a salary fixed by the executive committee. [He may or may not be in the employ of an active member of the association.]

THE EXECUTIVE COMMITTEE

VI. a. The entire charge and management of the affairs of the association shall be in the hands of an executive committee, which shall consist of the president, the vice-presidents, and one member appointed by each of the affiliated associations. The executive committee shall make arrangements for carrying out the objects of the association.

b. The executive committee shall hold a regular meeting before each regular annual meeting of the association, and shall hold such special meetings as may be necessary. Such special meetings may be called by the president or any five members of the executive committee. *A majority of the members* [five members] of the executive committee shall constitute a quorum at all meetings.

The secretary shall give such reasonable notice of all meetings as the committee shall by vote prescribe, and all such notices shall, *as far as practicable*, specify the business to be brought to the attention of the committee at such meetings.

c. The executive committee may assign to its allied association, the American Street Railway Manufacturers' Association, the management of the exhibit features of the annual conventions, and it may arrange with the said Manufacturers' Association the details of such entertainments as may be given in connection with the annual conventions of this association.

d. The executive committee shall present a report to each regular annual meeting of the association, and shall include in such report the names of members elected during the year, and its recommendations for the future work of the association.

MEETINGS

VII. a. Regular annual meetings of the association shall be held at such time between the 15th day of September and the 15th day of December, in each year, as the executive committee may decide to be best suited to the locality in which the meeting is to be held; the time to be decided upon and each member notified of the selection by the 1st day of May in the year in which the meeting is to be held. Special meetings may be held upon the order of the executive committee. Notice of every meeting shall be given by the secretary, in a circular addressed to each member, at least thirty days before the time of the meeting. Fifteen members shall constitute a quorum at any meeting.

b. At all meetings of the association discussion shall be limited to active members, provided, however, that special privileges may be accorded others at the will of the meeting.

c. At any regular or special meeting, executive sessions may be held. Such sessions shall be open to active members only.

ORDER OF BUSINESS

VIII. The regular order of business shall be:

1. Reading of minutes of last meeting.
2. Report of the executive committee.
3. Address of the president.
4. Report of the treasurer.
5. Reports of standing committees.
6. Reports of special committees.
7. Reports from affiliated associations.
8. Reading and discussion of papers.
9. General business.
10. Election of officers.

COMMITTEE ON SUBJECTS

IX. In order to secure continuity of work and uniformity of general purpose, a committee on subjects shall be appointed each year by the executive committee. The function of this committee shall be to suggest topics for the work of the American Street and Interurban Railway Association and its affiliated associations for each year in advance.

The committee shall consist of one member from each of the affiliated associations and a number from the American Street and Interurban Railway Association equal to the total number from the affiliated associations. The committee, at each annual meeting, shall present its plans for the coming year.

VOTING

X. All votes except as herein otherwise provided shall be viva voce, and in case of a tie, the presiding afficer *shall* [may] vote.

READING OF PAPERS

XI. All papers read at the meetings of the association must relate to matters connected with the objects of the association, and must have been previously approved by the executive committee.

AFFILIATED ASSOCIATIONS

XII. This association shall do all in its power to promote the welfare of other associations organized with its approval to investigate technical matters connected with street and interurban railway construction and operation. To this end it will, in the following way, and in others which may be determined by the executive committee, assist in the work of such affiliated associations:

a. By *authorizing the formation of* [granting charters to] and approving the constitutions of such associations.

b. By admitting to the executive committee a member from each of such associations.

c. By granting financial assistance to such associations [for specific purposes.]

d. By editing, printing and binding the reports of the proceedings of such associations.

e. Through its secretary and committee it will assist in arranging for conventions, suggesting suitable subjects for investigation; it will file information for reference and distribution, and in every way endeavor to stimulate interest in all of the affiliated associations.

PAPERS, DRAWINGS, ETC.

XIII. All papers, drawings and models submitted to the meetings of the association shall remain the property of the owners, subject, however, to retention by the executive committee for examination and use, but at the owner's risk.

FEES

XIV. Active members shall pay an admission fee of $10 and annual dues payable in advance based on gross earnings from railway operation during the preceding fiscal years [ending June 30th], *of the respective companies*, as follows:

Gross Receipts.				Annual Fee.	Originally Proposed.
Under	50,000			$15.00	$25.00
Between	$50,000	and	$100,000	25.00	
"	100,000	"	250,000	50.00	50.00
"	250,000	"	500,000	75.00	100.00
"	500,000	"	1,000,000	100.00	150.00
"	1,000,000	"	2,000,000	150.00	
"	2,000,000	"	3,000,000	200 00	250.00
"	3,000,000	"	4,000,000	250.00	
"	4,000,000	"	5,000,000	300.00	350.00
	5,000,000	"	6,000,000	350.00	
"	6,000,000	"	7,000,000	400.00	
"	7 000,000	"	8,000,000	450.00	500.00
	8,000,000	"	9,000,000	500.00	
"	9,000,000	"	10,000,000	550.00	
"	10,000,000	"	over	600 00	600.00

Associate members shall pay in advance an annual fee of $5.

ARREARS

XV. No member whose annual payment shall be in arrears shall be entitled to vote.

WITHDRAWAL

XVI. Any member may retire from membership by giving written notice to that effect to the secretary and the payment of all annual dues to that date, but shall remain a member, and liable to the payment of annual dues until such payments are made, except as hereinafter provided.

EXPULSION

XVII. A member may be expelled from the association by the vote of two-thirds of the members present at any regular meeting of the association, upon the written recommendation of the executive committee.

RULES OF ORDER

XVIII. All rules not provided for in these by-laws shall be those found in Roberts' Rules of Order.

AMENDMENT

XIX. All propositions for adding to or altering any of these by-laws shall be laid before the executive committee, which shall bring them before the next regular meeting of the association, if it shall consider such course desirable; and it shall be the duty of the committee to do so, on the request, in writing, of any five members of the association.

[The form of charter to be granted by the American Street and Interurban Railway Association was omitted entirely.]

MEETING OF THE CLAIM AGENTS' ASSOCIATION

The meeting of the Claim Agents' Association was held at Room 1032, Land and Title Building, the private office of Mr. Rhoads, claim agent of the Philadelphia Rapid Transit Company. The meeting was originally scheduled for Tuesday morning, but as that was the time selected for the meeting of the executive committees for discussing the question of reorganization, it was decided better to adjourn the meeting of the Claim Agents until Wednesday morning. In consequence, James R. Pratt, of Baltimore, was appointed representative of the association at the meeting of the executive committees, and the Claim Agents adjourned to inspect the offices and methods of the company at the main office at Eighth and Dauphin Streets.

The convention reassembled in Mr. Rhoads' office Wednesday morning. In the absence of Mr. Dibbs, president of the association, who has left street railway work, E. W. O'Connor, of Savannah, was elected temporary chairman. The roll call was then taken and it was shown that fifty companies were represented at the meeting. Mr. Renaud, of the New Orleans Railway Company, presented a report on the meeting of the executive committee in Philadelphia on June 12, and Mr. Pratt, of Baltimore, rendered a report of the meeting on Sept. 26. Upon motion made and seconded, it was agreed to accept the proposition of the parent association to unite in the new organization. As this will involve certain changes in the by-laws of the Claim Agents' Association, it was decided to appoint a committee on by-laws to draw up such changes and provisions as will be required by the new plan. It was also decided to increase the number of officers so that the executive committee should be seven, to correspond with the other associations.

The regular business of the association was then taken up. Mr. Feeney, claim agent of the Public Service Corporation of New Jersey, spoke about the interesting articles on the subject of street railway fakirs which had appeared in recent numbers of "Pearson's Magazine." He said that these articles had been of considerable assistance to all street railway companies in enlightening the public as to the corrupt methods of this class of swindlers. He believed that it would be most appropriate if the association as a body should extend a vote of thanks to the publishers of the magazine for this service, and also to the author, Theodore Waters. This motion was seconded and carried.

Chauncey S. S. Miller, secretary and treasurer of the Casualty Company of America, then addressed the meeting. He referred to a movement which had been initiated last summer in New York to secure co-operative action on the part of all companies which had been swindled by fraudulent accident claims, and stated that a meeting was to be held next month in New York to consider the advisability of taking further steps to advance this cause. He invited the assistance and co-operation of the Claim Agents' Association. The subject was referred to the executive committee.

Two papers were then presented to the association upon accident claims, one by E. W. O'Connor, claim agent of the Savannah Electric Company, the other by James R. Pratt, claim agent of the United Railways & Electric Company, of Baltimore. These will be published next week.

The following officers were then elected: President, S. L. Rhoads, of Philadelphia; first vice-president, E. W. O'Connor, of Savannah; second vice-president, Henry G. Bradley, of Chicago; third vice-president, Andrew J. Farrell, of Buffalo; secretary and treasurer, B. B. Davis, of Columbus. Executive committee: the officers and William H. Renaud, Jr., of New Orleans; H. V. Drown, of Providence, and James R. Pratt, of Baltimore.

A vote of thanks was then extended to the Philadelphia Rapid Transit Company for courtesies extended during the convention, and the meeting then adjourned.

After the meeting the members were entertained at a banquet at the Bellevue-Stratford Hotel by the newly-elected president, Mr. Rhoads, of Philadelphia.

PROCEEDINGS AT THE PHILADELPHIA CONVENTIONS—I

PROCEEDINGS OF THE AMERICAN RAILWAY MECHANICAL & ELECTRICAL ASSOCIATION

MONDAY MORNING SESSION

The first meeting of the American Railway Mechanical & Electrical Association was called to order at 11 a. m. by President C. F. Baker, who introduced Hon. John Weaver, Mayor of Philadelphia.

Mayor Weaver.—It gives me very great pleasure as Mayor of Philadelphia to welcome you here to this convention. It seems to me that a convention of manufacturers and others who are interested in the carrying of the public must be of great interest and importance, and the results must be beneficial to the traveling public. We all know that you get some benefit from it from an economical standpoint, because the very best cars and the very best equipment of every kind is probably synonymous with the greatest economy. But what you and I suppose what every citizen in the United States is interested in is in having their welfare looked after, and I am quite sure that your meetings and the resulting exchange of views must result in great benefit to the traveling public. I do not know of any other organization that represents more closely the public of the United States. I suppose at some time or another the majority of all the men, women and children get into a trolley car, so that we can see that the majority of the American citizens are interested in electric cars and electric roads. The electric railway system is rapidly extending. Formerly we had the old horse cars on the streets. We now have electric cars, but they are not confined to the city; they go out from the city streets into the suburbs, and are even extending beyond the suburbs, because you have the great interurban roads that have been developed in the Middle West so successfully, and are now being developed so successfully here in the East. I have been told recently that a great many of the trunk steam railroads are thinking of putting in electrical equipment for carrying their local trade, and just what "local" means is a question, because the steam roads carry local trade for hundreds of miles.

I am very glad as executive of this city to welcome you, gentlemen, here to this convention. I trust you will have an exceedingly profitable time and a pleasant time, and if there is anything that the city of Philadelphia can do to make your stay more pleasant, I shall be very glad, as chief executive of this city, to do it. I welcome you in behalf of the citizens of Philadelphia. I give to you the freedom of the city—the keys are yours. Use them as you like, and after you are through with your convention I trust that when you leave here, wherever you go you will carry away with you some very pleasant recollections of this good old city of Philadelphia. (Applause.)

President Baker.—President Ely, of the American Street Railway Association, has kindly offered to give us a few remarks.

Hon. W. Caryl Ely.—I am sure we are all deeply indebted to Mayor Weaver for taking his time to come here this morning, and in behalf of the great city which he represents extending so beautifully as he has done its welcome and its freedom. About the key, of course, Mr. Mayor, we all understand that the key does not open up as much as it did awhile ago. (Laughter.) That is from what we read in the outside newspapers.

Mayor Weaver.—It opens the hearts of the citizens. (Applause.)

President Ely.—That is sufficient if it opened no more. Mayor Weaver is going to stay here, probably out of courtesy, while I deliver my remarks. I must, therefore, make them very short. In the first place, I wish to say, as president of the parent organization, that there has been a great deal of work done during the past year looking toward the closer affiliation and organization with the parent association, and the methods of work to be pursued by not only the parent association, but your organization and the others affiliated with the parent organization. What I wish to particularly impress upon your attention to-day is that there should be no misapprehension of the purpose of this move toward organization. It comes simply from the desire that there should be no unnecessary multiplication of organizations and to secure action by the existing organizations harmoniously and along well thought out and well developed lines. So the idea is that in some way, and in the way mapped and laid down, to get things together so that the lines of work to be pursued by the different organizations should be carefully thought out a year in advance, and that the investigation and the work devoted to the most important things that are involved in the street railway industry, should proceed in each organization so that it will supplement the work of the other. Particularly do I desire to impress upon you this fact, and it is a fact that may be absolutely relied upon, that there is not one in the parent organization, not one among these who desires in any way to do anything that will detract from the dignity of this organization of yours. You cannot be prouder of this organization than are the presidents of the companies and those who worked in the ranks of the parent organization. I could not more clearly illustrate my ideas upon the subject than to refer to the remarks of Mr. Beggs last year at St. Louis, when he was addressing your convention. His remarks present absolutely the ideas that animate the minds of those in the parent organization. Your work is of vast importance. As the Mayor said, probably at some time or another almost every man, woman and child in the country gets into and out of a trolley car, and the safety of that apparatus and the proper working of that apparatus and its adaptability for convenience and comfort are dependent upon the departments which you represent. Nothing could be more important than the apparatus which carries the people to collect the coin that makes the business go. Therefore, that method of work and that dignity of that organization, that autonomus organization which you have had up to now, no one intends to interfere with. The only thing is that we shall work together, and that the expenses attendant upon the running of the different organizations shall be paid at one time, to the end that the work does not fall into confusion, and that there may be no misunderstanding as to the value of the work and how much it costs. Upon that is determined what we may be able to do in these lines of work. So much has been said on this subject that probably nothing more is desirable from me at this time, but especially do I desire to emphasize the fact that no one wishes to interfere with the autonomy of your organization nor put a halter or bridle on it or curb it or ride it to death, or compel it to do anything which it does not desire of its own free will and volition to do. This matter will come up for action at these meetings that are to be held, and, therefore, it is greatly to be desired that each one here, each delegate, gives a careful reading to the proposed form of constitution and by-laws, and if there are any objections now is the time that they are to be heard. It is to be a square deal and a fair showdown all the way around. Nobody to be subdued, nobody is to be silenced, muffled or gagged, and we want everybody to talk, and out of that should come that which will be of immense benefit to these organizations, all of which are engaged in one work, although in different branches of it. I am glad to meet you all here again. Each convention is larger than the other; each convention brings some new faces, and I am happy to say many, many old ones. This work that has been done here by the Manufacturers' Association is simply superb. This exhibit, as one walks through it, reminds one of the finest departments of the largest expositions that have been held in this country. Nothing could be more beautiful, well arranged and adapted to inspection than the exhibits as they are arranged below. Where everyone pulls so true, to mention the names of individuals is invidious. All the members of the Manufacturers' Association, from the president down, have worked unremittingly for months, and to some of them has fallen a greater part of the work than to others. I have seen no evidence of shirking, but on the contrary everyone has stood forward to bear his full share. Not only is the Manufacturers' Association to be congratulated by us on the result that has been attained, but it seems to me that as it is one of the first accomplished results of the movement toward organization in our lines of work, it speaks well for the success and the desirability of the plan. I thank you, Mr. President, for the opportunity of saying these words, and I, in your behalf, extend to the Mayor your thanks and our thanks for his hearty welcome. (Applause.)

Daniel M. Brady, chairman of the Manufacturers' Association, spoke of his early association with mechanics and mechanical men and of his warm feeling for them. He welcomed the visiting members and spoke of the efforts to run the Manufacturers' Association on an equitable basis.

President Baker then read his address.

PRESIDENT'S ADDRESS

It affords me great pleasure at this, the third annual convention of our association, to extend to you all a hearty greeting. I note with keen satisfaction the goodly number of our members present; it certainly augurs well for the enthusiasm and success attendant upon our meetings. Since it seems desirable to dispense with the reading of the papers in order to give us an opportunity for a thorough discussion of the same, it hardly behooves me to take up much of your time with a long address.

We have found a cordial welcome extended to us here, and there is an atmosphere surrounding this historical "City of Brotherly Love," which should be conducive to a full attendance and effective work. It is my hope that this meeting will surpass the excellent record of the past, and that at its close we can congratulate ourselves upon its having been our best and most valuable convention. Although as an organization we are young, it has become a recognized fact, that our society has done and is doing much to increase the world's stock of useful knowledge in matters pertaining to electric railway operation and maintenance. The improvement shown each year may well indeed be a source of pride and pleasure to us, and it is to be hoped that our excellent progress may be continued. This can assuredly be brought about by earnest attention and free participation in the discussion of such subjects as may come before us.

The question of the reorganization of the parent association and its relations with our association has received considerable attention from the committee appointed for that purpose, and their proposed plans have been favorably commented upon by the technical press and the public at large. While the details of this change are as yet to be fully decided upon, the general plan will surely appeal to all of us as being for the best interests of all concerned.

The extension of the bounds of our association to admit of the inclusion of the members of the maintenance of way departments has greatly broadened the scope of this association, and will, I am sure, be of benefit not only to the association, but also to the individual members, whether they be of the mechanical, electrical, or maintenance of way department.

If I may digress for a few moments I would like to say a few words relative to my feelings when elected president of the association. In a society having a so widely extended membership as this it is impossible for the president to know, personally, very many of the members who may be in attendance at our meetings. This is a source of much embarrassment to the presiding officer, but is one which can be greatly lessened if each member, as the opportunity may offer, will present himself to the president, make his acquaintance and let him make his. This would apply with equal force to our secretary, whose very efficient work as the only permanent officer of our society and the one on whom the president has to depend in a great many ways, will be greatly enhanced by a large personal acquaintance of our members. It is the duty of each member to do all in his power to make such meeting a success socially, as well as an occasion of making and renewing acquaintances, for promoting good fellowship and for bringing out and distributing useful knowledge in their various departments.

One of the principal efforts of an executive officer of our railways and through him and his subordinates is to increase the difference between the cost of operation and revenue received. In this effort the departments represented by this association can, above all others, materially assist. There are numerous channels through which this may be accomplished; one of the most important, to my mind, is system and organization properly laid out and applied. Desired results may often be obtained and success in small matters made possible without the necessity of inaugurating anything that might be dignified with the term "system," as in such matters an officer would be able so to divide his time as to come in personal contact with much of the detail; but this can only be done where the organization is small, and where dependence must be placed on but few. In large companies covering considerable territory and employing many men, an executive officer is unable to go into much of the detail or have frequent personal contact with his men. In this case success in the management of property is absolutely dependent upon good organization and system. The larger the company the greater is the necessity for a proper and adequate organization, since the executive officer must depend to a greater extent upon his subordinates. Any system to be successful must clearly define the duties and measure of responsibility of each individual, so that if a failure occurs there will be no doubt as to who is to be looked to for an explanation and no difficulty in placing the responsibility. Lack of good system or absence of a good and reliable organization has caused many an executive officer to carry burdens and worries which might easily have been avoided, were the organization such that his subordinates could relieve him and thus enable the chief to devote more time to planning and systematizing his work. The details could then be more readily and satisfactorily carried out by his assistants, as scattered efforts are more often futile, and concentration is necessary for success in large matters. An organization and system of this kind is not brought about at a single stroke, but can only be the result of long and patient study of the conditions surrounding the department, the personnel of the men in the department, and the hearty cooperation of the subordinates upon whom the head of the department must depend for attention to the details. We have already taken a step in this direction in the report of the joint committee of the accountants' and our associations upon the standardizing of the blanks and forms used in these departments. That this can be continued to good advantage there is no doubt, but as local conditions vary so much it is extremely difficult, if not impossible, for any general system to be devised which will be applicable to all. We can only strive by earnest study and hard work to improve our organization and system of records and accounts in every conceivable way in order that we may approach as closely as possible the ideal. A quotation from "System" occurs to me as being particularly pertinent to this subject:

"No good system ever just happened; it was wrought out by the hammer of concentrated thought on the anvil of hard work."

This to my mind gives us the key note—concentration—and to admit of concentration it is necessary that the organization must be such as to permit of the details being taken care of by the subordinates, leaving the head of the department free for greater and more important matters I bespeak your careful thought and consideration of this matter, as I believe it well deserves the attention of each and every one of us, and to my mind can be easily made the means of a vast stride toward our goal

It is with a feeling of deep and sincere sorrow that I have to announce the heavy loss sustained by our association during the past year by the death of one of our most active and able members and officials, W. O. Mundy. Mr. Mundy was one of the original members of the organization, and, by his strenuous efforts, contributed very largely to the success of this society.

The high character of the papers and reports previously presented has been fully upheld in those to be presented this year. They are a credit to the association and also to the writers, and I sincerely trust that the discussion will be free and ample, that the greatest possible benefit may be derived from our convention.

E. W. Olds and Alfred Green made some remarks on the decease of W. O. Mundy, and deplored the loss to the association resulting from his death.

President Baker appointed a committee to draft suitable resolutions on the subject of Mr. Mundy's decease. The committee was composed of Mr. Olds and Mr. Green and one other to be selected by them.

Mr. Mower, secretary of the association, read the report of the executive committee, containing details of the management of the association during the past year. He also presented the report of the secretary and treasurer, in which was set forth that during the past year there has been added to the membership of the association 10 company members, 59 active members and 1 junior member, making at present 38 company members, 134 active members and 31 junior members. The New Orleans Railways, on account of passing into the hands of a receiver, lost its membership.

The financial report showed cash on hand Oct. 9, 1904, $403.55; dues received from company members, $760; from active members, $635; from junior members, $18, and miscellaneous resources, $30.98, making a total of $1,847.53. Expenditures: printing and stationery, $454; postage, $68; salaries, $500; annual convention, $109.25; expenses executive committee, $191; miscellaneous, $29.48, a total of $1,351.73; leaving a balance in bank of $495.80. There is outstanding on the books quite an amount from active members and junior members, and there is one company member owing the association at the present time. The bills payable amount to $100.04.

On motion, seconded and carried, the reports were accepted as read.

Mr. Adams, chairman of the committee on organization, said that Mr. Ely had outlined the principal thought in connection with that subject. In the plan submitted, the points that will affect this association are in relation to financial assisance. This organization is going to look to the parent association for support. This financial assistance, in the opinion of Mr. Adams, is one of the principal reasons for organizing. He also referred to the question of the printing of the reports of proceedings, which the parent association will take care of, and set forth the desirability of closer relations between the associations.

In answer to a question by Mr. Green as to whether this association will elect its members as usual, President Baker said that is for this association to determine. It would make its own constitution and by-laws, and this would be left largely the same as now, with possibly a change in the name. He further said it had been suggested to call it the American Street Railway Engineering Association.

Mr. Green expressed the opinion that the constitution of this association as it now stands should not be changed, in reply to which Mr. Adams said he thought the constitution could be kept virtually on the same lines.

Mr. Olds, of Milwaukee, said that under the proposed plan the membership of this association would not be restricted to the companies who may belong to the parent association, but that the individuality of this association would be retained. He expressed the idea that the wish was to work absolutely in harmony with the parent association.

Mr. McCulloch, of St. Louis, said it was not the intention in the plans suggested to diminish the authority or standing or prestige of the subsidiary organization. In regard to the membership, he said that the members were to be the railway companies themselves, and also such associate members as should be elected, and that there was no reason why anyone interested, or who had formerly been interested, in street railway business should not become a member of the association and have all the privileges of membership, except voting and holding office.

Mr. Simmons commented upon the remarks of the Hon. W. Caryl Ely, expressing the thought that they should wipe out all feeling of any desire to curb these associations in their power to do good. Mr. Simmons also spoke of the amount to be subscribed for the partial support of this organization by the main association, which can only be determined as events proceed. He said that the scheme of raising funds is to have each company pay in proportion to its gross receipts, as the larger companies are going to derive far greater benefit than the smaller ones, the large company having at present a dozen different men representing different departments, while the small company will have but one man present.

W. E. Harrington moved that the subject matter under discussion be placed in the hands of the executive committee. This was seconded and carried.

A recess was then declared.

MONDAY AFTERNOON SESSION

President Baker called the convention to order at 1 o'clock.

Charles Hewitt, engineer of the Philadelphia Rapid Transit Company, extended an invitation to the delegates to visit the power houses and stations of the company, and mentioned that perhaps the most interesting station, on account of the newness of the installation of turbines and the high-tension alternating current, would be the Second and Wyoming Streets stations in the lower part of the city.

C. H. Hile, superintendent of wires, Boston Elevated Railway Company, presented his paper on "Power Distribution." (This paper will be found on page 560.)

L. P. Crecelius, of St. Louis, asked Mr. Hile about his experience with lightning trouble at terminal points, where the overhead feeders joined on to the underground feeders, and what scheme, if any, he had for protection at such points. He said that was one of the weak points in connection with the cable overhead construction. He asked particularly whether Mr. Hile used lightning arresters to avoid electrolysis in the cable.

Mr. Hile replied that they had installed on every cable two lightning arresters, one at the station end and one at the terminal end, wherever there is a terminal. Where the current comes in on the overhead wire they install a lightning arrester, and their experience had been that they had very little trouble. He could only recall three instances in which it was believed that the underground cable was injured due to lightning; whether it was owing to the good fortune of having the lightning arresters in use or not he could not say. Some extra lightning arresters were also installed on the terminal poles. On iron poles it was the practice to make the ground connection by running an insulated wire to the track system down the iron pole.

Mr. Crecelius thought that there would be some trouble from induction in this practice. He also inquired how Mr. Hile connected his equalizers, and whether the circuit breakers acted automatically in case of trouble on any particular section.

Mr. Hile replied that the circuit breakers acted automatically at the power station only, that the feeder system or section might include one feeder or a half dozen feeders, depending on the size of the section, and if it happens to be a feeder section, fed from more than one station, it meant more cables in that section, and the company depended on circuit breakers to cut-out at the station to protect that section. They do not always do it, however. In that case, if the section is badly disabled, the first thing to do is to clear the section, which can quickly be cut dead at the power station, and get the crew on the ground, jump in with the other section and throw out the feeders which were disabled.

Mr. Crecelius remarked that in order to accomplish that, it would be necessary to have a good system of communication and a good record of locations so that the repair crew could know where to cut-out.

Mr. Hile answered that the company had complete plans which showed every detail of location. Copies of these plans are kept at the power station, at the headquarters of the operating department, and at the headquarters of the department having charge of wires and conduits. An attendant is also kept constantly at the telephone. In case of trouble the crews are directed to go to the point of trouble and cut out the injured cable. The cables are identified by numbers so that the company does not depend wholly on the knowledge of the crew, although the crew is supposed to know. The records which are kept show that the crew was called to throw such a switch and cut out such a cable; it reports back so that a complete record is kept of everything that it does.

H. H. Adams, of Baltimore, asked Mr. Hile what he considered was a good distance for the installation of lightning arresters on overhead construction.

Mr. Hile replied that he could not answer the question off-hand, as much depended on local conditions. In hilly districts he would advocate a lightning arrester about every mile, or three-quarters of a mile. In certain districts of the country, especially in the West, where lightning is a pretty serious consideration, he considered the use of lightning arresters as very important. He considered that the character of the country and the location had a great deal to do with the question, and that no definite rule could be laid down.

Mr. Adams agreed with the previous speaker, that the desirable location of lightning arresters was largely a question of local study. He said that for the past three years he had kept a record of his equipment that had been injured by lightning, and had inserted a pin on a map of the system at such points. He had found that crossings and at corners there is more likelihood of trouble from lightning than at other places.

Mr. Crecelius stated that he had serious doubts about the performance of lightning arresters without a well-grounded wire. He believed that it would be desirable to use wooden poles at terminals, to avoid the inductive resistance introduced by iron poles.

Mr. Hile replied that he thought this suggestion was a good one, where there was much trouble with lightning. He believed good results would also follow from a good earth ground independent of the system.

Mr. Adams referred to a particular case bearing on this question, from his experience during the past spring. He said his company had a line which ran out into the country, and on which there was considerable trouble from lightning. They went over the grounds, and where they had track grounds they put in a good ground plate and doubled the number of arresters and very materially reduced the trouble. In other words, it seemed to be a question of more arresters, but that line was equipped with wooden poles.

E. A. Sturgis, of Worcester, said that his company had had a good deal of trouble with lightning, and had overcome it by forming underground connections and putting in more arresters. He asked Mr. Hile for particulars in regard to the changing load at the Boston power stations. As he understood it, the load swings from one station to another by a variation in voltage.

Mr. Hile replied that technically that was so. A heavy load on one station tends to lower the voltage of that station, and the other stations get all the benefit of the high voltage and ease up the pull on that station, even though having the heavier load.

Mr. Hanna asked Mr. Hile his experience in regard to cement-lined conduits, in which he said he was much interested.

Mr. Hile replied that his company had some 76 miles of cement-lined iron pipe ducts, although it had not laid any cement-lined iron pipe conduits since 1895, and is not contemplating laying any more. He could not say that these pipes have ever injured the cables. The main objection he always felt to them was the fact in the case of any cable trouble, the cement-lined conduit seemed to distribute the trouble widely on account of the iron rings and the iron casing of the pipe.

Mr. Hanna replied that for some time he had tried to discover some way of using cement-lined conduits so as to avoid the burning of the cables. They found that the cement-lined conduit undoubtedly damaged the cable. They had requested some chemists to examine the pipes and cable about two years ago. These chemists had not yet made a report, but they had found enough to know that not only does a cement-lined pipe greatly increase electrolytic troubles but there is also an actual chemical action on the lead, due to the cement, which is strongly alkaline. He had hoped that some way had been found of putting a covering on the lead sheath, or something of that nature to keep the cables from coming in contact with the cement. Their principal trouble had been in parts of the city where the drainage had not been very good.

Mr. Charles Hewitt said that in Philadelphia practically the lines are tied together with heavy copper cables, which connect one-half of the stations without any reference to the feeder sections. If the tie lines are connected into the bus-bars on two stations which are near together, one station will cut out inside of 5 minutes. Stations 10 miles apart will work perfectly on a tie line, as the point of greatest drop will travel up and down the cable, depending on the load created by the cars, but with stations near together, say a mile or 2 miles distant from each other, a tie line connecting the bus-bars together would probably be impossible.

Mr. Hile remarked that his company had stations tied together, but that the ties connect into the feeder sections. This keeps the voltage adjusted, and no trouble has been experienced from bucking, except in cases where there was a bad ground in one station, which would throw the other station out.

Hugh Hazelton asked if Mr. Hile could give any information in regard to the amount of amperes carried on a cable of any given size.

Mr. Hile replied that ordinarily he would expect a 500,000-circ. mil cable to carry continuously about 500 amps. or 600 amps.; a 1,000,000-circ. mil cable about 900 amps. or 1000 amps., and a 2,000,000-circ. mil cable about 1600 amps. or 170 amps. The average load on his company's copper would perhaps not equal 200 amps. for 500,000 circ. mil, and while the momentary loads would run pretty high, they were not sufficient to give any serious trouble. The copper was laid out more with respect to the voltage drop than to the current-carrying capacity.

In reply to another inquiry in regard to iron pipe conduits and the precautions taken to prevent electrolysis and arcing from the lead sheath to the iron pipe, Mr. Hile said that his company had considerable 3-in. iron pipe, which was used as connections to the poles, and that iron pipe was also used to cross bridges and at certain places in the street. In those cases where there was trouble on the cable creating electrolytic conditions, it was customary to cut the lead and insulate it. He described in detail the company's practice of dividing the lead sheath into insulated sections, and said that he could not recall an instance where a cable breakdown had resulted from this cutting.

Hartley Le H. Smith then referred to the point brought out earlier in the discussion with reference to tying stations together. He thought that the success of this practice depended upon the extent of the compounding used. If the series winding was strong enough, the station would not operate that way. If, however, the series winding helps to hold the electromotive force up, but is not strong enough actually to raise it, as the load becomes heavier the station will operate smoothly. For this reason he did not recommend considerable compounding.

Paul Winsor, of Boston, said that their machine characteristics are practically flat, the machines being compounded for a rise of potential. With a large distance between installations there was no trouble. He thought it possible to over-compound when the distance between stations was considerable, so that the drop in voltage from the stations was large. His company is running two stations within 200 ft. of each other, all one station, but with the machinery in different buildings, and he did not know of any case where the machines are as close to each other running that way, and he did not have any trouble.

H. Le H. Smith thought that if machines are so adjusted that they will simply hold their electromotive-force without raising it or lowering it with the alteration of the load, and if the stations are near each other they are in a state of unstable equilibrium, or near it. On the other hand, if the distance between the stations is reasonably large, then it amounts to about the same thing as if the machines had a drooping characteristic.

Mr. Hewitt inquired if the machines referred to by Mr. Winsor were not practically shunt machines with the compound wiring practically cut out.

Mr. Winsor answered that they were not; that one station had direct-current machines, and that all are compounded and running practically flat. The other station contains 1000 to 1200-kw direct-connected to 15 units, and they are all compounded the same way.

Mr. Hewitt remarked that the machines in use by his company are compounded by about 50 to 75 volts, and they maintain practically a flat voltage line. He thought the question of these tie-lines without taps was simply a question of drop. If two stations are tied together with sufficiently large copper, and these stations are compounded, no matter whether they maintain the flat line or not, the stations will buck. He did not see how it is possible to prevent it, unless the drop in the tie-line is sufficiently great so that the point of greatest drop will never reach the bus-bar, but run along the line.

After some further discussion on this point President Baker announced that the next paper to be discussed was on "Power Station Load Factors."

L. P. Crecelius, chief electrician, The United Railways Company, St. Louis, then read his paper on "The Power Station Load Factor as a Factor in the Cost of Operation." This paper will be found on page 563 of this issue.

H. Le H. Smith said he thought the subject of the load factor at stations had not received sufficient consideration, that it was to a considerable extent neglected absolutely, and yet it was one that was most intimately concerned in the efficiency of the station operation. The load factor before the meeting was the ratio of the average load to the maximum load; he did not think that to be the ratio most significant in showing the efficiency of the station. In his opinion the ratio between the actual load which the machines have had to the load they would have had if they operated at the rated load has the greater influence in the station operation. It is not realized, either, to what an extent that ratio alters. This ratio shows the average steam consumption of the engine, a thing that is usually neglected very largely; it also shows the electrical losses in the machine, although these are rather insignificant.

Mr. Crecelius remarked that the establishment of a new definition for load factor was a subject that he could not say much about. In his paper he had considered the load factor as the ratio between the average and the maximum load.

Charles Hewitt stated that in Philadelphia they had six storage batteries, five of them being located in sub-stations and used for facilitating the distribution of the load and for steadying the load, that is, for obtaining regulation. The sixth battery is connected directly with one of the stations. He could not give in percentage the load factor of the stations in Philadelphia, but thought it was about 70 to 75 per cent, that is the average of the various stations. They had a practice in Philadelphia of maintaining a full load on every engine throughout the day, by means of the tie-lines which have been referred to, but they transpose the load from one station to another during the day. In that way, no matter what time of day it may be, or what the load may be, the engines which are running are running at practically their most economical load. The storage batteries no doubt assist very greatly in accomplishing that, and the effect of the batteries is very strongly noticeable in the operation of the station. He thought the merits of the storage battery lay more in assisting to maintain a good load factor, and in making it possible to transpose the load from one station to another, than in reducing directly the cost of production per kw-hour.

Richard McCulloch, of St. Louis, called attention to a difference in the two papers. In Mr. Hile's paper the load factor is based on a period of operation of 18 hours, while in Mr. Crecelius' paper the load factor is figured over a period of 24 hours.

Mr. Smith referred again to the relation between the two load factors which had been mentioned. He said that the ratio of the average load to the maximum is a measure of extent to which the machines are standing idle in the stations. It also has a relation to the labor item and is really an index of how often the engines are run. The other load factor is a measure of how economically the engines are working when they are running.

G. S. Lawler, superintendent of the power distribution of the Boston Elevated Company, in a written communication, said that the load factor of a system varies with the system and depends to a great extent upon the habits of the people served by it. The cost of operation is greatly affected by the load factor, and when a comparison is made of the cost of operation of two railway systems, it is essential that the load factor on which each is run should be known; also whether this load factor was obtained by the use of a storage battery. If so, the efficiencies of the battery should be taken into consideration. However, knowing the load factor does not always tell the whole story, as the momentary fluctuations may also have considerable effect. Therefore, unless the characteristics of the system are known they cannot fairly be compared. The methods of raising the load factor in the larger stations as used by Mr. Crecelius is the one used by Mr. Lawler. He had not been fortunate enough to be able to obtain corresponding figures for his system which show results as clearly as do those given by Mr. Crecelius, although his figures tend the same way. That was due to the fact that the load factor varies with the time of the year, and they make most of their repairs not when the wear and tear is the greatest, but when the load is light, that is, during the summer. Therefore, the maintenance account is light when the load is heavy and heavy when the loads are light. On this account their total expenses may not vary with the load factor, and the results of the various methods of operation are somewhat concealed. Of course when one station out of a number is shut down, the transmission losses of the district fed by this station are increased, and unless there is considerable difference in the economy of that station over the remainder, they must be careful that the increased transmission losses are not greater than this difference. Again, these transmission losses are not the only ones to be considered, because there are also the stand-by losses and the losses due to cooling down and starting up fires again for the station taken out of service. Where it is necessary to use the auxiliary stations for morning and evening, the losses may be considerable, but if the station is only operated during the evening peak, these stand-by losses may become of less account. These stand-by losses plus the increased transmission losses may amount to considerable, and the real saving by this method of operation may not be as great as would be apparent at first sight. One thing that would favor the keeping in service at reduced load of the auxiliary station, would be its value in an emergency, for it would be immediately available to carry an increased load. This applies to fairly modern machinery, and not to antiquated machinery, which is very frequently found in systems which are the results of gradual growth. The old machinery should be run as little as possible, and therefore only during the peak loads. In this case, as it may be considered very cheap machinery, the fixed charges are small, and as it only runs for a few hours, its efficiency while running would not be very important. Again, where there are a number of units in a station, and a number of stations are used on the system, the cost of operation is not so dependent on the load factor as where only a few units are in use, for it is fairly easy to keep all machines in service during light hours loaded up economically by shutting down as occasion requires, and banking unrequired boilers. The machinery remaining in service will be running just or almost as economically as during the heavier loads. In this case the thing that varies most with the load factor is the cost of labor, and as the amount of labor during the day shifts is fixed by the peak loads, this amount would be nearly a constant no matter what the choice between the two methods. While it was important in order to keep down the cost of operation to watch closely each piece of apparatus, that it may operate efficiently, he believed that the method of operation of the stations is equally as important and may mean considerable to the yearly operation expense account.

After further discussion on this subject and also upon the different methods of employing storage batteries, the president announced that the association would now consider the report on controlling apparatus.

CONTROLLING APPARATUS

J. S. Doyle, superintendent of equipment, Interborough Rapid Transit Company, New York, chairman of the committee on "Controlling Apparatus," then presented his report on this subject. This report will be found beginning on page 565 in this issue.

Paul Winsor stated that the Boston Elevated Railway Company had put on 40 surface cars with multiple control, but that was done temporarily because the company found that the platform controller was not large enough to handle the cars.

E. W. Olds, of Milwaukee, said that his company was having constructed at the present time 50 controller equipments which were especially designed to take care of the large amount of current required in a four-motor equipment. It was proposed to use one of the K-types of controllers with two contactors in the circuit, the idea being that the controller contacts will be made before the closing of the main contactor system. By this method the main circuit is opened and closed underneath the car so that no case of short circuit can occur in the controller. He had found that most of the so-called controller accidents are caused not by the failure of the controller, but by some short circuit in the other apparatus which causes so great a flow of current that the ordinary cylinder controller will not break the arc. The wiring of this new Milwaukee controller is such that one side of the armature will be always positive, and the reversing is done in the fields. By this method it is possible to protect each motor with its own individual fuse, so that should a short circuit occur in the motor or in the wiring the individual fuse of that motor would blow, cutting out the motor.

Mr. Olds referred to the fact that Mr. Case, of the General Electric Company, was familiar with the new type of controller.

F. E. Case said that practically the only thing he could add was that it is merely a partial step in the right direction, as he believed that full contactor control, with the apparatus all located under the car, is the proper method. In the process of getting at it gradually the placing of the principal contactors under the car is the right thing to do, and that ultimately the railway men would look at it in that light. He thought it a proper thing, perhaps, to get at it gradually, as this plan would be more convincing than to go at it hurriedly. In the event of a mistake having been made, which he considered improbable, it would be easy to dissociate the two parts and go back to the plain cylinder control by merely omitting the additional contact.

W. D. Wright thought that they were all agreed that the removal of the controller from the front platform was a desirable step. Last summer his road had considerable controller trouble on the open cars. This year there had not been as much, and as an experiment they had two open cars running, on which the controllers had been swung around outside the dash. That gave more clearance on the platform. The motorman handled the apparatus in the new position about as well as in the old position. Putting the controller outside the dash necessitated building the bumpers out a little. He asked Mr. Olds if the fuses he spoke of are in a position where it can be readily ascertained if they blow, and what type of fuse he used.

Mr. Olds remarked that they had decided to adopt the enclosed fuse, which is on the no-arc principle, and that they are placed underneath the center of the car in a box by themselves. He anticipated very little trouble in locating a blown fuse. The fuses they are using are of sufficient capacity so that they will not blow on an ordinary overload; it would take a short circuit to blow them, and the circuit breaker or main fuse will take care of the overload.

Mr. Pevear, of the General Electric Company, in reply to a question, said that the controllers described by Mr. Olds will be exactly like the ordinary K-type controller, except in the fact of its altered position.

Mr. Olds remarked that the method they are putting in is to be used only on the city equipment with four 40-hp motors. On their interurban equipment they use the type M controller. On the city equipment they use the K-28 type of controlled, modified to meet the changed conditions.

George H. Hill, of the General Electric Company, said that the difficulty with a cylinder controller was not due to its improper design for the duty which it has heretofore been called upon to perform, but to an increase in the severity of the conditions. These conditions have approached gradually, and to them has been added the further objection of lack of space under the car which has made it difficult to produce a satisfactory small multiple control equipment. The size of cars on city lines is gradually increasing and that will help matters out. The problem of furnishing full multiple unit equipment for double-truck cars in city service is feasible.

Mr. Doyle, of New York, remarked that the maintenance cost was in favor of the multiple unit system.

R. C. Taylor, of Brooklyn, thought that in the discussion of the controller question one of the principal factors was overlooked—the multiple unit control was being mixed up with the drum control. The multiple unit controller, however, could be a drum control, or contactor, or any other form, provided it is big enough to do the work. All that was the matter with the controller at the present time is that it is not big enough for the work. He thought the operating men who are in charge of the equipment should create a demand for a good controller, and it would be supplied. He believed the controller should be put under the car.

Edward Taylor, of Brooklyn, stated that his company had built and was operating in Brooklyn a new form of multiple-unit control. The main thing in designing this controller was to make it simple and yet effective. The main principle of the apparatus was a simple solenoid which is operated by a rapid switch, which notched the controller up a step at a time. The rapidity of this movement was effected by a throttling device or limit set at any predetermined point. In connection with the controller the circuit breaker was operated automatically, as was also the air-brake equipment, thus making an automatic air out of the straight-air system. The point borne in mind in designing this control system was to have the normal position safety, so that in case any connections were broken, or any of the circuits interrupted the apparatus would go to the stop position. All parts were released by springs or by gravity, not depending on electric circuits. For instance, if the car should be running along with the controller on and the brakes off, and the pole came off, the controller would be turned off, the circuit breaker would open, and brakes would be applied. An original device was also used in connection with the operation of the magnets. Heavy currents were used at the start to insure a strong pull on them. Later, when the magnets were in operation, high resistance was automatically put in circuit, which reduced the running current to as low as one-tenth of an ampere on the entire apparatus. A special feature of a controller of this sort was that cars could be run singly in the city or in congested districts and could be operated together over the suburban lines. By placing a control apparatus on the trailers it was possible to operate the train from the trailer or motor car. This avoided the necessity of shifting the motor car to the head of the train at the end of the line. The experimental apparatus had cost considerable to construct, nevertheless the company estimates that if it was building a large quantity, this controller could be built with the money that would be realized by taking off the other apparatus and the less amount of wiring which would be used.

Mr. Olds stated that as he understood it, this K-11 controller was placed under the car, on a two-motor equipment. He thought that the work was along the right lines. Such a controller must necessarily reduce the number of parts and consequently reduce the expense, and he believed that the apparatus as described had considerable merit.

On motion of Mr. Olds a vote of thanks was passed to the authors of the papers presented, after which the meeting adjourned.

TUESDAY MORNING SESSION

On Tuesday morning F. G. Simmons, of Milwaukee, chairman of the committee on way matters, read a brief synopsis of his report, with conclusions. W. Boardman Reed, of New York, opened the discussion. He reviewed the troubles that have been experienced with all types of joints since the first tramway days. He thought enlarging the surface of contact under the head of the rail and under the base of the rail would, if it were practicable, in a large measure overcome the difficulty, but to get this increased surface, as is shown in one of the papers, is not practicable unless both the joint-plates and the rails are machined to a perfect fit. The day of the ordinary joint-plates, therefore, it seemed to him, was about past.

A peculiar trouble had been experienced with the joints and the rails on surface lines in the borough of Manhattan. The rails on these lines were laid on cast-iron yokes, perfectly rigid, in lieu of ties, the yokes being spaced 5 ft. between centers, and the ends of the rails or joints supported on the yokes. Nine-inch girder rails, 107 lbs. per yard, with 36-in., 12-hole angle-bar joint-plates, were used. At joints which were hardly loose enough to be noticeable, there was a fracture of the head of the rail, the break beginning about 2 ins. from the joint, at the gage line, and extending diagonally across the head for a distance of from 12 ins. to 18 ins. One theory of the cause of this trouble is that the joint became slightly loosened and the hammer blow of the wheel pounding upon the head of the rail finally causes a fatigue of the metal, so that it gives way at the point of least resistance. It was first thought that this was due to extreme brittleness of rails. That this contributed in a large measure, he had no doubt, but, at the same time, analyses of the sections broken off did not show any great amount of segregation of elements or any great excess in either manganese or carbon.

Joint-plates that support the rail by the base as well as the head, overcome, in a large measure, many of our troubles, and could these plates be made to fit the rail accurately there would, he believed, be no further trouble with joints.

But, in his opinion, success cannot be obtained as long as dependence is placed on the supporting of the rail by contact of surfaces which resemble sandpaper. There is always sufficient motion to finally wear off the sand.

Rail manufacturers have done much to lessen our troubles by increasing the length of rails from 30 ft. to 55 ft. or 60 ft., but they can do little more in this direction. The limit of length has been about reached, not only on account of the difficulty of handling in the mills, but also on account of the difficulty in handling on the street. He believed, therefore, that it behooved the construction engineer to follow on along the same lines as the rail mill, and if the rail cannot be made longer before it is in place, lengthen it by welding the ends of the rails together.

Good results have been obtained in the welding of rails, or the making of continuous rails, by electric welding and by the so-called cast-iron weld. The most serious objection to either of these processes is the amount of machinery required. Though either process is practicable on large jobs, neither of them would be practicable on small jobs, for the expense of getting the plant in operation would be prohibitive.

Thermit welding has been recently introduced into this country, and would seem to offer many advantages. The process is so simple that any track gang can do the work, and, as stated in one of the papers, all the necessary tools and even the material for several joints could be carried in one wheelbarrow. The expense is rather high, but any road that could afford to use a solid roadbed and 107-lb. rail could afford, he believed, to pay $5 or $6 a piece for perfect joints.

The objection is made to welded-joints that in case of changes in the track layout the joints can only be cut out. Of course, this means the loss of the joints, but he could not see that it meant anything else, for rarely, in the case of a new layout, are we able to make the new work fit to the existing joints. This objection, therefore, would not appear to be very material.

He was not familiar with Nichols joint, but it would appear, from what he had seen of it, to have some very excellent points. The sand surface mentioned before is covered over and a greater bearing surface is given both under the head, on the top of the base and under the base of the rail. The riveting should hold the plates in place. We know, however, that there is a certain amount of shrinkage in spelter. Would this not tend to leave some space, and consequent looseness, between the joint-plate and the rail? Would the spelter resist the hammering pressure, especially when not confined? Spelter is used with success for the bedding of wearing plates, but in this case it is confined by caulking where exposed, and even then the wearing plates do get loose. It is considered good practice, when using spelter between two surfaces, to bring these surfaces together, either by bolts or wedges, immediately after the cooling of the spelter. The machinery necessary for the Nichols joint, for sand blasting, reaming, riveting and pouring of the spelter, is almost as formidable as that used for either the cast-iron or electric weld, and this, it would seem, would militate against its general adoption, except, possibly, again, on large jobs.

Cast-welding has been used longer than either of the other methods. If the rail is properly treated, previous to the pouring of the metal, and the welding is done with the atmosphere at the proper temperature and when there is not too much humidity, and if the cast metal is of the proper mixture and poured at the proper temperature, good results are obtained, but it seems quite difficult to have all of these conditions favorable. As a result, there is a considerable proportion, oftentimes, of failures of cast-welded joints.

Electric welding has certainly given magnificent results in many places where it has been tried. Buffalo offers one of the best examples of this method of rail fastening, and were it not for the cumbersomeness of the machinery necessary, he knew of no better method for the treatment of joints.

He was one of the first to weld joints commercially with thermit in this country, but, unfortunately, in neither of the places where thermit welding was done was the construction such as to give it a fair trial. In the first place, the yoke spacing is about 5 ft. centers. On one line, where 7-in. rail, 107 lbs. per yard, is used, the joints are suspended, so that had it not been for the fact that a line of ducts was laid underneath the end of the yokes and extending to within about 4 ins. of the base of the rail, there would have been an excellent opportunity for a fair trial of the thermit weld, but this small space between the base of the rail and the top of the duct line prevented proper access to the molds, and in a large proportion of cases the molds were evidently not properly applied or properly luted, so that there was a loss of more or less metal when the joint was poured. Something like fifty portions of thermit were used. In some four or five cases there was a failure owing to the inexperience of the workmen and proper care not having been taken in the luting, and, in one or two of these instances, in consequence of the molds not having been properly made. These failed joints were repoured, and at the end of the work forty-five joints were left in what was supposed to be good condition. This work was done in about July, 1904. All of the forty-five joints held until some time early in the spring of 1905, when there seemed to be several failures. With the coming of warm weather more failures developed, so that out of the forty-five joints there were about thirty-six good ones. Pieces were cut out where the joints had failed and examination made of the failed joints. It was found in each case that the defective joint had been caused by improper handling of the material or tools. In some instances the metal had been lost, so that the thermit only came an inch or two above the base of the rail. In other cases there was no adhesion between the thermit and the rail, showing that the rail had been improperly cleaned or not properly dried. Of the thirty-six joints that were intact in April, 1905, all are at date of writing in good condition. The result, though somewhat discouraging, was still sufficiently satisfactory to warrant him in recommending that thermit welding be used on about 5 miles of track that is now being constructed in the borough of Manhattan. This being new construction, the rail is exposed and there is every opportunity to properly apply the molds.

The second experiment made by him in 1904 was made under such conditions that he had little confidence that it would be a success, and yet the thermit people were anxious to make a trial. In this case the rail was 9-in. girder rail, 107 lbs. per yard, laid on yokes, with the joints supported. It was therefore impossible to get any metal whatever underneath the base of the rail. The mold was so made as to cover the top of the base of the rail and the web up to the head. This did not leave sufficient metal of the rail itself connected to withstand the strain, and as a result the rails broke on the web.

Mr. Winsor, of Boston, asked Mr. Reed whether there had been any bad effects from the heat on the head of the rail.

Mr. Reed replied that there had not. It gets to a very low cherry heat. Cars had been operating on one minute and a half to two-minute headway, a little over a year, and it would be difficult to find some of the joints.

Mr. Clark asked Mr. Simmons what the percentage of poor joints was in cast-welding.

Mr. Simmons said they had one company, now out of existence, that did very poor work. They had a loss probably of 3 per cent on their work. Another company, which they considered the best cast-welding company in the market, did the major portion of their joints, and on these they have had a loss approximating 1½ per cent to 2 per cent. For the past three years they have owned their own apparatus, and welded all their own joints, possibly 10,000 in the three years. They have not lost one joint nor had one bad joint out of these 10,000.

Charles H. Clark, of Cleveland, said they had a company cast-weld for them on a 6-in. rail, and out of about 350 joints, the next spring they knocked off fifty-two of them and welded them with electricity.

Mr. Simmons said possibly there were adverse conditions—a poor foreman or poor workmen. He had never had such experience.

H. M. Sloan, of Chicago, said he was a great advocate of a cast-weld. He thought he had cast for less than 2 cents a pound on a 6-in. rail with 85 lbs. of metal. He had cast at a cost of $1.17 per joint, but could not always do this. In estimating the cost of a cast-joint they always figured $2, but it rarely cost over $1.60 for a 7-in. rail with 100 lbs. of metal.

Mr. Voynow, of Philadelphia, called attention to the fact that if you take the weight of the rail, multiply it by two, and add 10 per cent, you get the weight of the cast iron that it is necessary to use in order to get a cast-welded joint.

Mr. Simmons, in making a cast-weld joint, figures 75 per cent of good pig iron and 25 per cent of soft scrap.

Mr. Sloan said there was one thing he possibly omitted in the cost of a cast-welding. His road being a small proposition, he was able to make temporary cross-overs and work in day time. He had cast with twenty men 185 joints a day. As to going along at night with a wagon and casting a few joints, that was impracticable. With this first weld he spoke of, where they poured the metal on either side and depended on a union of the metal to hold the joint, he discovered no amalgamation above the joint holes. When they changed to the next method he designed the mold to extend over a space only 4 ins. long at the top, or just sufficient to take in the bolt holes that were put there to help hold the joint.

Mr. Clark, of Cleveland, said there were 2000 joints in Cleveland welded with a cast-joint. He did not believe there was one good one left now.

Mr. Reed said there was in the borough of Manhattan a considerable amount of 7-in. 108-lb. rail welded with cast iron. They had some 9-in. 107-lb. to 109-lb. rail welded with cast iron. Generally speaking, they have had good results. The work was done, part of it, in 1899 to 1901. A 7-in. rail on Third Avenue under the elevated structure, where the work was evidently done under good atmospheric conditions, gave excellent results. The 9-in. rail on the so-called Boulevard on the Amsterdam Avenue line they have not had as good results with, but he should say far better than the average results. He did not believe there were now 5 per cent of the joints that were welded at that time but that were in good condition. A lot of old 7-in. rails, very nearly worn out in 1899 and 1900, welded with cast iron went to pieces. Regarding the price, they made a contract to do that work. He did not recollect the exact figures, but somewhere between $4.50 and $5 a joint. Perhaps in Cleveland, they welded an old rail instead of new. He thought it would make a great deal of difference.

A. W. Pratt said, in reference to cast-weld joints, in the city of Newark some 15,000 or 20,000 joints have been welded on that system. Out of that number he did not think there were very many that were bad. Some of that work was done on new track and some on old rail. They cast-welded some old 4½-in. rail some thirteen years ago, and it was taken up this last summer. On Market Street, in the center of the city, from the Pennsylvania Depot to the foot of the Court House hill, they cast-welded Trilby rail that they put down new, and one could not see where the joints were. In reference to the cost of the joints when they cast about three years ago, the cost ran from $3.23 to $3.48, not allowing anything for maintenance. That is the mere cost of labor and material on a 7-in. joint. In reference to the shrinkage of the spelter in a zinc joint, and also the flowing of the metal, he would like to ask if any experiments have been made to determine whether anything of that nature existed. It appealed to him as being the most perfect joint in railway practice.

Mr. Voynow said there was quite a dispute among not only practical engineers, but many scientists, whether zinc shrinks or expands after cooling. Some experiments on the zinc castings seemed to show sometimes a casting would shrink and sometimes it would slightly expand. That experiment is a delicate and complicated one. It is not as easy as it looks. As to the flowing out under hammering, the hammering can occur only between the rail and the metal when there is a space left. When there is no space left between the metal and the rail, hammering cannot occur. These joints have been in some streets in the ground for the last four and a half years, and he had not noticed any difference from their condition when they were put in. There were two breaks in the rail, and these occurred on account of a flaw. He thought the impression should be corrected with reference to the cost of closing and opening of the street. It had been mentioned in the paper that it costs $1 to open and close a street. That is not so. Opening and closing some streets may cost that, but it depends on how the street is paved and how the ties are placed. Sometimes the cost will run up to $10 or $12. In Philadelphia they had cast-welded joints and were making new cast-welded joints for rails that were past repair. Where they cannot repair the joints, they are cast-welding them, and it seems that for such a condition cast-welding is almost the ideal process. The cost per joint is approximately what Mr. Simmons had stated in his paper. Of course, under some conditions it runs higher.

J. M. Larned, of Pittsburg, reported 5000 cast-welded joints in Pittsburg that have been cast-welded for two or three years. It cost $4 a joint. It was a 9-in. rail that was cast-welded. The total cost of the joint ran up in asphalted streets to about $10. The average cost was about $7. They had as many as 100 men at work, and thought eighty joints was a pretty good day's work.

Mr. Sloan thought paving ought not to enter into the cost of any joint, because pavements differ so.

E. Stütz, of the Goldschmidt Thermit Company, pointed out that welding portions for a 5-in. rail would cost considerably less than for a 9-in. rail. In the report the conclusion was based on a comparison between a 9-in. rail, in Mr. Pellissier's paper, and the price for the cast-welding as he understood it of a 5-in. rail. On a 5-in. steel rail it would cost about $3.30 for the thermit part. The outfit is extremely simple and inexpensive.

Mr. Clark, of Cleveland, told of the thermit welding of from 2000 to 2500 joints on his track this year, and gave interesting particulars of the methods used there in doing this work on a large scale.

H. F. A. Kleinschmidt, superintendent of electric welding for the Lorain Steel Company, upon invitation spoke a little on that process, saying in part: "There are a few things in connection with our process which I would like to call your attention to. One thing is the elimination of the holes in the old rail. We have found that the old bolt holes cause a great deal of trouble, and in our process we can lengthen the bars to any extent to get beyond the bolt holes. Another advantage is that we do not go below the bottom of the rail. It is not necessary to excavate below the rail. It is just as easy to weld a joint that comes on top of a yoke as it is to weld a joint that is suspended. Another advantage is that we stand behind our joints and guarantee them. Any poor workmanship which is due to our men we make good. We are welding in the neighborhood of 1200 joints a week at the present time. Our equipment, as you see by these cuts, is pretty good sized, and it looks as though it might be cumbersome. The machines have their own motors. Those who have used the process find, as far as the equipment is concerned, that it does not give them as much trouble as they might think. I am ready to answer any questions you might ask. I think if there is any one who would like to know any particular point I would be glad to enlighten him as far as I can. We have one of our welding equipments at work in Camden, N. J., and if there are any interested I would like to meet them and have them go over and see the process."

MAINTENANCE AND EQUIPMENT OF ELECTRICAL EQUIPMENT

The committee on maintenance and inspection of electrical equipment, of which William Pestell, of New York, is chairman, was then called upon to report. Mr. Pestell reported in substance as follows:

In considering the above subject we have tried to take into account all the factors that enter into the operation of equipment working under different conditions. We have therefore written to all of the railway companies in the United States asking for information regarding details of their operating conditions and the methods pursued in caring for their equipment. From the information thus obtained we shall be able to deduce conclusions as to the best manner of handling equipment under the various conditions of urban, suburban and interurban service. We have been fairly successful in obtaining this information, and when it is complete it will furnish a means of determining how the different conditions affect the maintenance account. The committee ask for further time to carry on this work, as they believe the information when once obtained and properly tabulated will enable us to not only draw conclusions as to the best of the various systems now in use, but to segregate the best points of each of the systems and to devise therefrom a system complete and of economical value to us all. In this connection the accountants would be of incalculable value, as, after we were able to outline the salient points of the best apparent system, they would be able to put it in concise form so that it could be handled with the minimum amount of labor. We would call your attention to the fact that the list of questions as submitted appeals to many as being entirely too much in detail, and in many respects irrelevant to the subject. On careful examination, however, you will note that none of the points included is such as can be lost sight of in a careful consideration of the subject. The comparison of the cost of maintenance of the equipment of one road with that of another is only fair when all the elements entering into its operation, the track over which it operates, character of service and the equipment itself are known. The fact that we do not all of us have this information at hand indicates that we are not careful enough to consider all of the elements necessary to obtain the most economical results in the maintenance of our equipment. When we consider the vast amount of money invested in our equipment, the depreciation and cost of maintenance, we realize the importance of an adequate system for following up and caring for the various details in connection with it.

One point that shows up more clearly than any other in tabulating the answers to questions submitted is the utter lack of standardization of materials. It seems to me that a permanent committee should be appointed by this association to consider and suggest ways and means of standardizing various parts of our equipment. This has been attempted before, but results can only be obtained by working continuously at it, and we trust that this convention will take some steps toward starting the work of standardizing equipment.

After some discussion on standardization by R. C. Taylor, of Brooklyn, and others, Mr. Pestell explained that his idea was not standard equipment itself so much as standardization of the parts —the brake-shoes and things of that kind. He thought we should very soon be getting to work on that sort of thing. We have now thirty or fifty different types of brake-shoes. In the big consolidations of roads to-day the storeroom is filled with different kind of brake-shoes, and hardly any one knows just what to send out for any part of the line to take care of the equipment. It takes a long while to get any one standard kind in service. The association should take the matter up with a view to getting some standard that we can all use, similar to the Master Car Builders.

Mr. Doyle mentioned some of the great economies made possible on the Interborough lines in New York by virtue of the standardization of equipment there.

W. H. McAloney, of Denver, agreed with Mr. Pestell in his suggestion. He thought it one of the most important offices of this association that the standardization of the parts be taken up and carried out to the limit. Such standardizing would not mean that everybody use a 40-hp motor, or any particular size or style of motor, but it would mean that, for example, for a given horsepower motor the association would recommend a certain gear seat and width, so that the equipment carried in the storeroom even for different types of motors would be the same, consequently the stock would not be so large. That same plan could be extended to the journal boxes with the different types of trucks.

R. B. Stearns, of Chicago, thought this a movement in the right direction. On the elevated lines in Chicago there has been a good deal of standardization, but in the possible event of a cooperation or interchange of all the lines there would be a disastrous condition of affairs in the storeroom. As far as his particular locality is concerned, he was heartily in favor of some move tending now to start this thing going so as to get on a standardization basis.

In regard to the suburban roads of Chicago, one road has already entered the city over the elevated lines, and it is not any question but that in a short time there will be absolute necessity for further interchange, and those companies certainly feel that they ought to get the benefit of a consensus of the opinions of all the intelligent men who are interested in this subject in other parts of the country. If it does not come sooner or later in some substantial manner, similar to the way the thing was brought around by the Master Car Builders, there will be a local standardization in Chicago similar to what is going on in New York. He would very much favor some more radical move in this direction.

Mr. Olds told how the standardization of journal boxes and brake-shoes had been going on in Milwaukee for nine years, and told the dimensions of the present standards.

Mr. Pestell referred to Mr. Olds' remark, and said that he doubted if many others are doing the same thing. If this matter had been taken up in the same comprehensive way by an order of men like this nine years ago, instead of having Mr. Olds' standard in Milwaukee and some other standard in Chicago, another in Boston and another in New York, he thought there would have been uniform basis. For that reason he believed this association should appoint a standing committee on standardization, appointing one member for a year or two years, another for three or four, and so on, to make recommendations at the annual meetings.

Mr. Olds said that was in his mind when he got up. Standardization is a matter of great importance. We realize that we are advancing and that methods that are used to-day will no doubt be obsolete to a very great extent in some parts, but there are parts that can be standardized, and there is no reason why we should not do it. He said that he was in full accord with Mr. Pestell's suggestions.

A motion was carried to appoint such a standing committee.

Mr. Winsor, of Boston, wanted to find out if any of the members were working on a mileage basis of inspection. The Boston Elevated has always inspected its cars once in so many days. He is trying to work out a mileage basis of inspection.

Mr. O'Brien, of St. Louis, described his system. He gets the mileage from the auditor's office and he sends out reports to the different foremen on the different equipments when it is time to watch for low bearings. One type of equipment will run a longer mileage than another. They find it very satisfactory and not very expensive. They have one girl in the shop office who keeps track of the mileage and sends out these reports.

A very interesting discussion between Mr. O'Brien, Mr. Winsor, Mr. Doyle and Mr. Stearns on the plan of inspecting and overhauling by mileage then took place.

President Baker then announced that the president of the Philadelphia Rapid Transit Company had extended the courtesies of its power stations and shops, and had invited an inspection of the subway.

He then appointed as a nominating committee Mr. Olds, Mr. Pestell, Mr. Green and Mr. Hile, with the privilege of choosing themselves a fifth member.

The morning session adjourned.

TUESDAY AFTERNOON SESSION

President Baker called the meeting to order at 2:10 o'clock, and announced that the paper on "The Power Station," by Fred. N. Bushnell, chief engineer of the Rhode Island Company, of Providence, R. I., was before the meeting for discussion. This paper will be found on page 583 of this issue.

L. LeH. Smith remarked that Mr. Bushnell had a good deal to say in his paper concerning superheated steam, both for reciprocating engines and for the later style of mover. Mr. Smith supposed that few of the members knew as much about superheated steam as they would like to know, and he was rather astonished to hear in connection with some of the latest stations that had installed the newer apparatus which was expected to operate only at its highest efficiency with superheated steam, that in some instances they were operating without the superheaters; it was extremely interesting to have the heat efficiency of a modern station, as stated in the paper, in which the greatest apparatus is used with the steam heated, but in his opinion the efficiency stated is something which is not at all extremely high; for instance, he knew of an old station, which has been operating for a dozen years, that has a heat efficiency that is extremely near the one which is stated in the paper, and what made it more significant is that in the station referred to they are using a fuel which is high in heat units, and hence expensive. The older station, to which he referred, which has an over-all efficiency almost as high, uses inexpensive fuel with low heating values; so that in the case of operating the old station with old engines, and without any superheating, the expense would be less than in the new station. Another thing which he thought well worth studying, which was referred to in the paper, were the remarks on the heat losses through the stack. In most stations, as stated in the paper, there is a temperature at the base of the stack of over 400 degs., and in certain known instances it was as high as 800 degs., although that is extreme. The author, the speaker said, stated that it is usually considered that you have a high efficiency when you have temperature that is lowest, and states that that is often a mistake. The speaker said that he thought the author of the paper was correct in that statement. He had just recently had an experience of that in a station where the variation of the load on the station makes an alteration of steaming wide enough to have a temperature variation at the stack of perhaps 150 degs. or 200 degs., but they found they were operating most economically at the rush hours, when they had the highest temperature in the stack. The reason was that under these circumstances the excess of air was notably lower than when the station was working on lighter loads.

Some discussion followed by Messrs. Green and Smith, on superheated steam and cylinder lubrication.

L. P. Crecelius remarked that he thought that the experience with superheated steam was confined more to men operating steam turbine stations. In that case, the question of cylinder lubrication does not enter to the same extent as in the reciprocating engines, and a great deal higher temperature can therefore be maintained in the steam. He would like to hear from someone operating a steam turbine on that question. There was no question about the economy of superheated steam, and the limitations imposed upon it, for reciprocating engines, were the troubles one gets into in regard to the lubrication of valve movements and different parts exposed to this increased heat. He said that by referring to the tests of steam-generating apparatus, one can see that the efficiency curve will continue upward with the superheat.

William Pestell offered a few words in connection with the regulation of auxiliaries used in power plants. He entered a turbine plant a short time ago where auxiliaries were driven by steam engines as well as by motor drive, and what struck him particularly was the circulating pump for the condenser running at over 400 revolutions in the case of the electric-driven unit, and in the case of the steam-driven unit at about 175 revolutions, the same vacuum being maintained in both cases. These were surface condensers; there was very little difference in the temperature, and the vacuum was something over 28 ins., and it struck him there must be a great deal of power lost all the time in taking care of so much water. The pumps were designed to take care of 50 per cent or 75 per cent overload, and worked all the time at that rate, whereas in the case of the engine-driven unit, the pump could be regulated in accordance with the load factor on the turbine as the load changed from hour to hour.

Paul Winsor asked if any of the members had experience with centrifugal pumps for boiler feed water. He thought that the station could be cut down somewhat if they could get rid of the ordinary reciprocating pump. These latter pumps require much attention in the way of new valves, etc., in the course of a year, and the expense of maintenance is considerable.

C. O. Mailloux remarked that he had seen in Europe last summer a 40-hp centrifugal pump of the multi-stage type used for water feed, against a pressure of something like 140 lbs. The manufacturers of the pump were ready to undertake to furnish the pumps to feed against any desired pressure for any purpose whatever. He understood that similar outfits would be obtainable in this country before long. The idea of using such pumps has been brought to the attention of American engineers, and it was not unlikely that they would be in use here. He called attention to the use of graphite for cylinder lubrication, especially at high temperatures.

Mr. Green thought that as the graphite went into the cylinders, it would deposit itself in the cylinder, and practically all of it stay there; he did not think the graphite would be carried away with the condensed steam. The question of operating steam plants with economy in the matter of lubrication was an important one, and it is a question upon which engineers are devoting a great deal of study at the present time. Some engineers can take a plant and operate it for just one-half the cost for lubricants per 1000 kw-hours that others can.

Mr. Mailloux replied that in gas engines the use of graphite has eliminated the difficulty Mr. Green referred to, where the deposits of carbon choked up the cylinders so as to necessitate frequent removal and cleaning of the pistons; as a matter of fact, the graphite enabled the same engine to work for a longer period without any attention whatever. It was natural to expect that graphite would stand higher temperatures. One might consider that the lubricating properties of graphite might increase, rather than decrease, with increasing temperatures, and it was for that reason, combined with the good reports he had heard of graphite when used in connection with gas engines, that he thought it was worth the while of station managers and operators to experiment with it. It was conceded by all that in all ordinary lubrication graphite is at an advantage. He had used graphite many years ago in lubricating street car axles with considerable success.

L. R. Nash, of Savannah, thought he could throw a little light on the question of the use of graphite compounds for cylinder lubrication in reciprocating engines. Something more than two years ago a plant in which he is interested made a trial of a graphite compound; he thought it was called "Perfecto." The trouble with most graphite is that it does not remain in suspension, but in the case he referred to, the suspension of the compound was perfect and there was very little deposit to it. The results had been extremely satisfactory up to two months ago, when he last heard from the plant. The cylinders very shortly after the use of the graphite compound began to take on a high polish. Further than that, the cost of lubrication was very much reduced. The compound cost something more than twice as much as a good grade of cylinder oil, but the quantity used was something like 25 per cent, so that the cost of lubrication was not more than 50 per cent of the cost with cylinder oil. He said it was the opinion of some engineers that sooner or later this process of lubrication will result in the accumulation of graphite on the cylinder walls so that a cutting will begin. He had watched the plant in question with particular interest to learn if anything of that kind had happened, and there had been no evidence of this up to two months ago. He thought that in the case of cylinders running with that compound for two years, that if there was any trouble to be feared there would be some indication of it in that length of time.

A. H. Warren, of Brockton, said he could confirm what Mr. Nash had said. They had been running for eighteen months their engines with the graphite compound, and had found a very material saving in the cost of lubrication, and the cylinders are the best looking cylinders he had ever seen. There has been no cutting; there is a slight deposit on the cylinder head, but that has not bothered them in any way.

President Baker remarked that the experience in Boston for the last two years had been the same as described by Mr. Nash. Their cylinders are more highly polished; the cost of maintenance reduced materially, and the cost of packing rings, bull rings, etc., has been materially reduced since they started the use of this compound. They have about 1.5 per cent to 2 per cent of graphite in a high-grade cylinder oil. They had not had so much success with it in connection with superheated steam, and he did not know whether the fault lay in the condensation of the cylinder oil with which the graphite is compounded. The consistency of the lubricant is like a thick grease, with the graphite floating in it.

President Baker then stated that the paper on "The Track Brake," by F. F. Bodler, master mechanic of the United Railroads of San Francisco, was before the meeting. This paper is published on page 590 of this issue.

Paul Winsor remarked that he was much interested in reading the paper on "Track Brakes" until he came to the last sentence, which read: "It ought not to be used on curves, switches or crossings, but should it be used, about the only damage resulting would be a split shoe." He stated that a large portion of his road is made of curves, switches and crossings (laughter), and he did not see how it would be possible to use such a brake.

Edward H. Dewson said, as to applying the brake on curves, so far as the magnetic brake was concerned, there was no difficulty if it was given lateral motion enough so that it followed the track. The effect of the magnetic pull is to hold the brake-shoe to the rail, and it naturally would follow the track. In the case of a wooden shoe pressed down there would be no such tendency, nothing to cause it to follow the rail, and possibly it would slip off on the pavement and be destroyed.

H. V. Schrieber said he was in Pittsburg a couple of weeks ago, and understood they were meeting with success in the use of the magnetic track brake. He referred to the fact that they used the brake on the West Penn road, having taken off the air brakes on the interurban cars and put on the magnetic track brakes.

J. W. Bridge said that he could verify what had just been said in connection with the magnetic brake used on the West Penn road, with which he was connected. They had removed quite a number of air brake equipments and replaced them with the magnetic brake on account of the large number of dangerous curves which they have. They have a hand brake, used in connection with the magnetic brake, which operates on the same levers, and they secured very good results from the brake. The use of the magnetic brake had almost entirely overcome the difficulties from flat wheels.

Mr. McAloney asked for further information regarding the trouble with air brakes.

Mr. Bridge replied that the air brakes had been removed on account of the extremely dangerous grades. At Connellsville they go down a grade 14 per cent, right in the heart of the town, and they had two or three runaways, when the car slid down the hill, narrowly averting several bad accidents. The cars were examined, and the brakes found in good condition. The grade was so severe that when the car got the least start it was almost impossible to control it. Another condition which made the track a little more dangerous was the proximity to the coke ovens, the smoke from the ovens making a sooty deposit on the rail, and it is almost impossible to stop the car on the track. They found they needed something to grip the rail in addition to the pressure on the wheels.

The president then announced that the Question Box would be discussed. The Question Box will appear in the Oct. 7 issue of this paper.

In connection with question No. 14, "Do You Use Felt Wicking or Waste Packing with Oil in Your Car Journal Boxes?" Mr. Alfred Green said that in his opinion in order to get the best results in journal boxes it is necessary to use a good quality of waste. In packing journal boxes everything depends on the way the waste is taken care of or soaked before it is put in the journal box, and the manner in which it is put in the journal box, and in order to get the best results out of the journal box strict attention must also be paid to the brass. The brass should be made so that the outer edges of the brass do not touch the axle from the time it goes in until it is taken out, so that one should practically carry the bevel back about three-quarters of an inch, so that when the brass is worn out the edge is still away from the axle. The reason for this is that the edge forms a regular scraper, and takes the oil off the axle, and does not allow it to go up under the brass. Therefore, one gets a hot brass.

Another thing is that the waste should not go above the center of the axle; in packing a journal box, especially of the old type, where a change had been made from felt to waste for journal packing, he would recommend cutting out the two little shoulders in the bottom of the box, put there to support the felt, which gives an opportunity to put the waste in the proper form. Another difficulty in regard to the felt wick is that it cannot be changed on the road; one must wait until the car comes into the house or jack up the body of the car enough to release the brass, and drop the box back to get the felt out. One thing which is very essential to keep in mind in connection with the waste is that it should be thoroughly soaked before it goes into the journal box.

C. O. Mailloux said grease was an excellent thing where power costs nothing, but where power costs something it should not be thought of. Those who used it would be deterred from so doing if they made dynamometer experiments and measured the current required to perform a certain schedule time. He found that in ordinary street car work the portion of train resistance which is due to journal friction is, after all, a very small quantity. It is less than 4 lbs. per ton in almost all cases, and consequently the improvement which would be effected by varying the viscosity of the lubrication could not be very great, but the moment one departs from the fluid lubrication to one which is semi-solid, like grease, a marked difference will be found; the train resistance increases very greatly.

In connection with question No. 16, "What is an Economical Figure for Lubrication (per 1000 car miles) of a 20-ton Car Equipped with Four 40-hp Motors?" Mr. Green said that it was a question entirely dependent on the men who are operating the road, on which factor the cost depended almost entirely. J. S. Doyle, of New York, remarked that they operated at 19 or 20 cents, and he would like to hear from the men who operated at a cost as low as 8 cents and 11 cents per thousand car miles.

W. J. McAloney, of Denver, said that it appeared that he was the highest priced man in the costs for lubrication. A short time ago he made a special accurate test on five different cars, the results of which in pints and cost were given.

Three years ago, when they used grease, the entire cost for lubrication, including the motor bearings, journal bearings, gear cases, air compressors, etc., cost 40 cents per 1000 car miles, which is a pretty steep figure, but 28 cents, the present cost, is also a steep figure. Even if oil should cost 40 cents and grease a less figure, it would be still more advantageous to use oil, from the fact that so many armatures were saved that were formerly lost by the use of grease. The cars are kept in service. They do not lose one armature now where they lost ten before with the old grease lubricant.

J. W. Bridge remarked that the cost would depend entirely on whether the motor in use was a modern type or old type motor. The old type is arranged for grease lubrication, and certainly could not be run as economically as some of the modern type motors, arranged solely for oil lubrication. He could not see how the figures could get down to 11 or 12 cents with that type of motor.

Mr. McAloney suggested that time would be saved if it was understood, as he thought it was, that the discussion emanated from the fact that they wished to lubricate the old types of motor with oil that were formerly lubricated with grease.

W. Wallerstedt remarked that he knew that they run mixed trains on some of the roads which had given the figures of cost, using both trailer cars and motor cars, and probably in giving these figures they had not separated the cost of motor car service from the trailer car service, and in that way they would get lower figures.

C. O. Mailloux remarked that the direction in which engineers must look for the increased cost of lubrication presents two principal points, namely, they must seek to maintain the quality of the lubricant and maintain the quantity. Lubrication costs money, because the lubricant deteriorates in quality and diminishes in quantity. The deterioration in quality is due to the presence of dust and cinders and other impurities. The deterioration in quantity is due to leakage.

Mr. Green replied that a high cost of lubrication per 1000 miles does not come from any dust or dirt, but from the losses of oil in the car house and the imperfect method of using it.

Mr. Wright remarked that when it was attempted to cut down the amount of oil to the minimum it was very necessary that each drop of oil should reach the journal. He gave figures obtained from a lubricator so designed that each drop would reach the journal. There was no waste when the car was standing. The amount of oil to which he referred was used only for lubrication of the journal bearings.

J. R. Cravath said that the road which reported 8 cents per 1000 miles was the Metropolitan Elevated Railroad in Chicago. If the members would look a little further on in the Question Box they would see the type of oil-feed apparatus this company is using: a brass pin in a hole, a few thousandths of an inch larger than the pin, size being varied according to the season. Another thing that had much to do with the figures was that they are offering a bonus to the different foremen for the best oil record.

Mr. Olds said that regarding the 11-cent man, as he understood it, those figures came from Kansas City, and he wished to say a word. He thought the figures were not made upon a test with the old type of motor, but with the newer type of motor, with the bearings packed with wool waste and lubricated with oil. He gave further detailed results obtained by Mr. Smith of that road. Mr. Olds said he fully believed in the oil bearing. That it not only reduced the cost of lubrication, but that it lengthened the life of the bearings.

J. W. Bridge, of the West Penn Railway, described and submitted a sample of the oil cup devised on that road.

The nominating committee then presented the following nominees for office:

President—H. H. Adams, Baltimore, Md.

First Vice-President—F. G. Simmons, Milwaukee, Wis.

Second Vice-President—J. S. Doyle, New York.

Third Vice-President—Paul Winsor, Boston, Mass.

Secretary and Treasurer—S. W. Mower, Detroit, Mich.

Executive Committee—W. S. Twining, Philadelphia; Fred. N. Bushnell, Providence, R. I.; W. Boardman Reed, New York, and A. D. Campbell, Seattle, Wash.

On motion, the report was received and the secretary authorized to pass the ballot of the association for the nominees, which was duly done.

President Baker expressed, in a few well-chosen words, his thanks to the members for their co-operation during the term of his administration.

President Adams, First Vice-President Simmons, Second Vice-President Doyle and Third Vice-President Winsor each acknowledged the honor of their election to office, and promised to do all that lay in their power to advance the interests of the association.

On motion of Mr. Olds a vote of thanks was extended to the retiring president, Mr. Baker, the motion being carried by a rising vote. The third annual convention then adjourned.

PROCEEDINGS OF THE AMERICAN STREET RAILWAY ASSOCIATION

WEDNESDAY MORNING SESSION

The twenty-fourth annual meeting of the American Street Railway Association was held at the Philadelphia Museum, Philadelphia, Sept. 27 and 28, 1905.

W. Caryl Ely, president of the association, called the meeting to order at 11:15 on Wednesday morning.

The president stated that an address of welcome was to have been delivered by the Hon. John Weaver, Mayor of the city of Philadelphia. Mayor Weaver had been under the impression that the address of welcome was to have been made on Monday morning, and he had made such address to the members of the Mechanical and Electrical Association. In the absence of the Mayor, the members of the American Street Railway Association might consider that the words of welcome addressed to the affiliated associations would apply to the parent body. President Ely then delivered the following annual address:

ADDRESS OF PRESIDENT ELY

For the third time the selection of the place of annual meeting has been made by the executive committee solely with the desire to locate it at the place deemed by all to be the most desirable from the point of view of the association as a whole. The merits of Philadelphia as a place of meeting were so conspicuous as to force themselves unaided upon the attention of the executive committee. Yet notwithstanding the fact that pursuant to the new method of procedure, the tent of the association has been pitched here purely of our own volition, the courtesies and attentions which have been and are being showered upon us by the president and other officers of the great company which has in its charge the street railway transportation interests of the city, and of the chairman and officers and members of the manufacturers' and local committees which have assisted in making all the arrangements for the meeting, could not have been exceeded had they been solely responsible for our being here. The conditions here for the holding of such meetings as this are almost ideal. The fine hotel wherein our headquarters are located, together with the other hotel accommodations of the city, are ample and convenient in that regard. These buildings of the Philadelphia Commercial Museum and their accessories are splendidly adapted to the purposes of the exhibits. Philadelphia herself possesses attractions to every patriotic citizen scarcely equaled by my other city. Her early history as the first meeting place of the Continental Congress, the birthplace of the Declaration of Independence, the glorious part played by her and her sons in the War of the Revolution and as a meeting place of the Federal Congress, are enforced upon our attention almost at every turn. She seems to have preserved more of the landmarks of the early days than any sister city. To us in our particular line she appeals not only by reason of her almost superlative position as a manufacturing city, but also as the place where the immortal Franklin conducted the experiments which perhaps may be characterized as the foundation of electrical science. Manufactures incidental to transportation are here conducted upon a large and interesting scale, and the electrical transportation interests of the city are large and intensely interesting, but to crown it all at this particular juncture in the affairs of this association, when we are about to take steps that will bind us all together in one harmonious set of organizations, working for the common good together along well-defined and coherent lines, what place could be more fitting for our meeting than the City of Brotherly Love?

In the general field of electric railway work, the events of the last year have been noteworthy. The work of electrification of certain portions of some of the great steam railroads is progressing, and although the projects under way have not yet been completed, nevertheless the continued investigation of the subject has served to make more clearly apparent the relations that ought to obtain between the steam and electric railways of the country, in order that the public, as well as the companies themselves, may realize the greatest benefits from their operation.

Many of the larger steam railroad systems are changing their policy regarding the construction of electric railways from one of active and in some cases bitter opposition to either passive acquiescence or quiet assistance. This is an approximation to the conditions that ought to and some day surely will prevail.

The ideal railroad situation, both from the point of view of the companies and the public, would comprise a heavy long-distance railroad doing the freight and through passenger business, aided by a light interurban railway with frequent stations upon which the suburban and interurban passenger business would be transacted, and in connection with these two factors the street railways within and adjacent to the intermediate and terminal cities would perform the functions of ordinary street railways, as well as those of bringing to and taking from the depots of the first-mentioned systems travelers and their baggage. In this equation we have three factors, each of which supplements the others, and if such a system could be conceived as having been constructed at one and the same time with reference to the relations existing between them we would there have exhibited the ideal transportation system, calculated to serve the convenience and economy of the railroad companies and the public in the very highest degree. Possibly this ideal system may not be hoped for, but a modification of the attitude which has been heretofore exhibited by the managements of nearly all the great steam railroad corporations toward street and interurban railways may do a great deal to procure for all concerned the benefits outlined.

The consolidation of small properties into large and strong organizations continues, and may well be said to be the order of the day. We think it must be conceded that the public and the companies themselves have been benefited in every instance. These large organizations have the means with which to employ men of greater skill and experience in the mechanical and operating departments; to provide better tracks and equipment and give better service than would be possible upon small weak properties.

The standard of transportation employees is continually being raised, and all railway organizations are giving greater attention to the proper instruction of employees, thereby insuring better service and greater safety to the public. The instruction car and other educational apparatus are now becoming regular features of the equipment of many of the large companies, wherein all motormen are required to demonstrate their proficiency in the operation of such equipments before they are given charge of cars. In many cases such instruction is supplemented by schools, where lectures are given on technical and popular subjects by men of prominence.

The conditions attending street and interurban railway employment are continually being improved. The business is becoming established and recognized as one offering solid and substantial rewards to the men who take it up as a profession and life work. Nevertheless it is a far cry to perfection. Much remains to be done, in the accomplishment of which it is difficult to conceive a more potent instrumentality than this association when reorganized and readjusted with reference to its affiliated organizations and all others interested in street and interurban railway work.

In the line of technical investigation, the work of the Electric Railway Test Commission at the St. Louis Exposition is of great value. The testing began at St. Louis in the middle of June, 1904, and was continued there until the middle of November, when the corps was transferred to Anderson, Ind., where the tests continued until the latter part of March, 1905. Immediately upon the completion of the tests the commission proceeded with the editing of the report. It was expected that the printed report would be ready for distribution before this meeting, but by reason of the large amount of work done and the care required in the preparation of the published volume, it will not yet appear for some little time. It will comprise a bound volume of about 500 pages octavo, and it is believed will be of great value as a contribution of fact concerning some of the things that have been long embraced within the realm of almost pure conjecture. The importance of such investigations, and indeed of all the measures now being taken toward securing the facts concerning everything involved in our business, and making them available for all, instead of locking them up in the breasts of a few, cannot be overestimated.

Notwithstanding the rapid advance in the state of the electric railway art, I think it will be conceded by all that the ratio of advance has not been what it should have been, nor indeed anything like what it would have been if those engaged in the business had been brought properly in touch with each other through the medium of some recognized authority which was at one and the same time the repository of the experience of all, a common investigator and classifier of facts and experiences, accessible to all for advice and assistance and always ready to furnish desired information. Causes must be revealed before defects can be finally remedied, and the ascertainment of cause depends upon thorough, careful, long continued and scientific investigation.

With the growth of interurban roads, the necessity is becoming more and more apparent of their owning, if not all, at least a greater portion of their own right of way. It is especially important where high speeds are desired, as it is practically impossible to make fast time within the limitations created by vehicular traffic and the location of the ordinary highway. All now agree that wherever practicable private rights of way should be acquired in the first instance of widths ample for the accommodation of double tracks, and in many cases it is considered desirable to grade the right of way and locate the first track and construct the bridges with reference to the future accommodation of a second track. The experience of the steam railroads with double and single-track construction is being repeated by the electric interurban railroads. There is practically no difference between them, except that of motive power. In all other things it would seem that good, common judgment would dictate that we avail ourselves of the long experience of the steam roads. Double tracks are much simpler, easier and safer of operation, and the increased fixed charge occasioned by the double track is, in the judgment of experienced operators, more than compensated by the saving in despatchers, signal men and other like employees, and the injuries and damage accounts, to say nothing of the greatly increased carrying capacity.

In the consideration of this branch of the case are involved proper traffic agreements between interurban and city roads, and the laying of T-rails in cities where practicable to accommodate the deeper flange and broader tread of the wheels of the interurban cars. It is interesting to observe the growing tendency on the part of municipal authorities to recognize the good to be derived from the installation of T-rails in paved city construction. There is also a noticeable recognition of the value of adequate terminal facilities for interurban roads in cities. In some places union depots are being constructed for the handling of passengers, freight and express, and especially is this true in the Middle West.

The convenience of passengers, especially commercial travelers, in the Middle West has brought about the adoption by the interurban railway companies of Central Ohio and Indiana of a coupon book, which is known as the Ohio Interurban Coupon Book, and is recognized upon a number of connecting lines. This is not only proving a convenience to the public, but is having a tendency to regulate fares upon a better basis, which in a number of places have been fixed too low in the beginning, due no doubt to the misconception of the cost of electric railway work which has so generally prevailed in the past. The element of mystery has been pretty well eliminated from the electric railway business, and it will be difficult for anyone to successfully demonstrate the possibility of a lower rate of fare than 5 cents in cities, or from 1½ cents to 2 cents a mile upon first-class, well-constructed and safely-operated interurban railroads.

While speaking of the features of safe operation, it seems proper to mention as a subject worthy of careful consideration the standardization of wheels for interurban practice. In many places steel or steel-tired wheels are being adopted. The best operators agree that they should be productive of good results.

It is pleasing to note that the adoption of safety devices is becoming more general. The first great burden upon the directors, as well as the operating officers of street and interurban railways is the safety of the passengers entrusted to their care. The elimination of the grade crossings of steam railroads, the installation of block signals and other automatic signals, safety gates, etc., indicate that in electric railway practice, as in steam, the minds of all traffic managers are on the alert to conserve the safety of the traveling public.

Progress is being made in the problems involved in practical operation of single-phase electric railways. While the manufacturers and engineers have been experimenting in these matters for several years, it is only within the present year that railroads have been equipped with this system. The motors and equipment are so designed that the cars may be operated on the standard 500-volt direct-current system in cities, and on 2200-volt single-phase alternating current between cities. The principal advantage gained is that no rotary converters are necessary in sub-stations, stationary transformers being alone necessary, thus decreasing costs of plant and superintendence. The principal disadvantage which has developed has been the poor acceleration, but this defect is now being remedied. The further progress along this line of development will be watched with great interest, especially when considered in connection with the problems which are attendant upon the electrification of the steam railroads.

It will be remembered that at Detroit three years ago much time was consumed in the consideration of the question of steam turbines, and much doubt was expressed concerning them. The progress in the installation of the steam turbine in railway-generating stations affords another notable illustration of the rapid progress in the electric art. The Philadelphia Rapid Transit Company has recently installed turbine units of 6000-kw capacity each, and the Pennsylvania Railroad electric lines on Long Island are operated by stem-turbine units of 5500 kw, while the plans of the New York Central in the neighborhood of New York include 60,000 kw of steam turbines in units of the same size as that of the Philadelphia Rapid Transit Company. The devotion of so much of the time of the St. Louis and of this convention to the subject of power is not to be taken as an infringement of the prerogative of the Mechanical and Electrical Association, but it is to be attributed to a desire manifested by the managers to follow up the subject continuously to some definite conclusion.

The matter of fire protection in car houses has received a great deal of attention from street railway companies and insurance companies during the past year. Tests of sprinklers have been conducted at Cleveland, Ohio, and Newark, N. J. The Newark test was attended by W. Boardman Reed, engineer of maintenance of way and buildings, New York City Railway Company; Albert H. Stanley, general superintendent, Public Service Corporation of New Jersey, and H. S. Wilgus, engineer of way and structures, Brooklyn Heights Railroad Company, representing this association. The question of insurance of street railway properties is closely linked with the important question of fire protection. For several years attempts have been made to establish a system of insurance that would comprise exclusively street and electric railway risks. It is a subject of the greatest importance, and the belief is becoming general that a great saving can be effected in this item of general expense. On the reorganization of this association there will undoubtedly be established an insurance committee, which in connection with the Accountants' Association, will thoroughly investigate this matter, and undoubtedly make a report that will be of great value to all concerned.

With this brief general resume of the progress of electric railway work during the past year, I will leave the subject and come to those that in their nature are fundamental; those that affect the every-day life of the corporations, and in their last analysis practically determine their rights to exist and to hold and manage their property and enjoy the legitimate profits therof. At this juncture it may be interesting to note the magnitude of the interests involved in street, interurban and elevated roads at present included in the electric railway industry. In the United States in the year 1904 there were operated 993 roads, having a total of 30,187 miles of track, operating 75,904 cars and representing a total capitalization of about three and one-quarter billions of dollars, while in Canada there were 42 roads with a total of 900 miles of track, 2639 cars and a total capitalization of sixty-nine and one-half millions of dollars. In addition to these figures, there are to be considered the roads in Mexico and certain of the colonies of the United States. When considered in connection with billions of invested capital, the questions alluded to above become of all-absorbing interest and importance to this association. For many years past there has been evidenced in this and similar organizations a disinclination to discuss such questions, or even investigate them to any great extent. Within the past two years, however, there has appeared a growing desire in this association for the investigation of such questions, and the collection of accurate data and information concerning them. With a view of ascertaining the subjects uppermost in the minds of the men engaged in the practical consideration of the problems to-day surrounding electric railways, I have within the past few months addressed inquiries, both oral and written, to many thoughtful and able men, and am now able to state that from nearly every one there has come a response pointing out the necessity for information and the facts. It may be of interest to you if I quote from one of the letters written by an officer of this association, one who is the active manager of an important property, and by reason of business association intimately acquainted with the operation of a number of other railway properties. My correspondent writes as follows:

> I hope and believe that the association will be reorganized at the coming meeting along the lines which have been suggested and which have recommended themselves to the executive committee, and the Bureau or Department of Statistics and Information, which I have considered would be of the greatest benefit to member companies, will be promptly organized and work begun, so that the information obtained by it would be soon available for use.
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> In the Middle West and on the Pacific Coast public opinion is being very rapidly crystallized by individuals presuming to represent public interest, to the end that municipal control and ownership of public utilities may soon become an issue in municipal and State politics
>
> A great mass of erroneous information is being recorded and published, which is tending to influence the public mind, and which, if not refuted in some manner by a recognized association or authority by the publication of correct and verified information, will tend to seriously affect invested interests in these utilities. It seems to me that it is within the reasonable scope of our association to cause to be circulated and widely published statements of facts that will controvert statements made by these self-constituted censors of the public good.

Others of wide experience, several of whom are perhaps in closer touch with public sentiment and what is going on in the world along these lines than any other individual members of this association, have said to me in substance: "The question is up; it will not down at our bidding; one side of the case only is being presented and argued, and the arguments in favor of the proposition are largely based upon alleged propositions of fact that are either erroneous, or concerning which a gross misconception prevails." Our side of the case has never been presented, nor indeed has any publication of the facts as we know them ever been made to the public. The forum resounds with the cries of agitators and demagogues, aided by many honest but misguided or misinformed men, while among the representatives of the vast interests which are thus injuriously threatened silence prevails. Some have indeed taken the position that a wave of sentiment is sweeping over the land that is founded upon error and will dissipate itself. That it is founded upon error we all believe, but at present the indications are that there is pretty nearly an unanimous sentiment in favor of taking means to assist in correcting the misunderstanding which seems to prevail.

At the meting of the New York State Street Railway Association, held at Lake George last June, the feeling was pretty nearly unanimous that the subject should be taken up and thoroughly investigated, and that association determined to actively assist this association in its investigation in any way in which it might be called upon. In the most interesting paper there presented by Henry W. Blake, editor of the Street Railway Journal, the author said:

> It is now apparent that a serious wave of agitation in favor of municipal ownership, so-called, is sweeping over the country; that the principle is un-American and contrary to our theories of government which have so far proved so successful. * * * What has been or can be accomplished in this direction under autocratic, bureaucratic or socialistic governments is not the question in America unless we adopt one or the other of these forms of government. The question is, can or cannot municipal ownership and management be more successful under our present forms of State and municipal government than the system which has operated so successfully in this country? So far, the education of the American people upon the subject of municipal ownership has principally been academic, theoretical, haphazard and unbusinesslike, generally conducted by those who have no practical familiarity with the subject.

I must content myself with this brief quotation from Mr. Blake's admirable and very exhaustive paper, and commend the same to each and every one of you.

At the twenty-eighth convention of the National Electric Light Association, at Denver and Colorado Springs last June, an exhaustive report upon the subject of municipal ownership was read by Arthur Williams, of the New York Edison Company. The report is confined to the question as affecting electric light properties, but its bearing upon railway interests is clearly evident, and the pamphlet of nearly 200 pages abounds in statements of fact that if given thorough and wide publicity, would undoubtedly do much to change the feeling in the minds of the ordinary property-owning citizen and voter in our great municipalities. Mr. Williams, among other things, refers to the statement which has been given general circulation, that electric lighting in Chicago costs something less than $60 annually per arc lamp, and then shows from an exhaustive presentation of the figures and facts involved in that case that many important items of cost are deliberately omitted in the Chicago lighting accounts, notwithstanding that the omissions, as he states, have been frequently brought to the attention of the municipal authorities. Some of the items are the rental value of the offices occupied by the lighting department; services rendered by other departments of the city government, including the legal department, and that through which supplies are purchased; the paving of the streets for original subway work, as well as for repairs, which is done by and charged to the street department; water, taxes, insurance, interest and depreciation.

Mr. Williams further calls attention in his valuable report to the consular reports upon municipal ownership, issued by the Department of Commerce and Labor of the United States Government during the month of May. He says that they seem to have been referred to by the press of the country as favorable to municipal undertakings, but that he has been able to find little, if anything, in them which justifies this view. That making no allowance for the omissions usually found in municipal bookkeeping, with very few exceptions they appear rather to support the opponents of municipal ownership and operation.

Since reading Mr. Williams' report I have read the consular reports referred to, which comprise the reports of United States consular officers upon the subject of municipal ownership from 1897 to 1905. Even the brief examination which in the time allotted to me I have been able to give these reports, convinces me of the correctness of Mr. Williams' conclusions, and I commend the pamphlet, No. 2256 of the Daily Consular Reports, to the careful attention of those present.

Within the last year the Mayor of a great Middle Western city has called to his aid the manager of the street railways in the city of Glasgow, who has made an investigation and report. While the contents of the report have not been made public, it is my understanding, and those of others who have conversed with the expert, that the opinion of the expert, Mr. Dalrymple, is not favorable to municipal ownership of street railways in the cities of this country under existing municipal conditions.

Let us pause for a moment and reflect upon the fact that in the neighboring city of New York, according to statements in the Metropolitan press, one of the great political parties is contemplating prosecuting the coming municipal campaign upon the principle of municipal ownership of street railways and other so-called public utilities. From figures obtained from the presidents of the different railroads in the city of New York, it appears that there are approximately 34,000 men employed in street railway work in that city. This number of men constitutes nearly 6 per cent of the total vote cast in the last Mayoralty election in Greater New York, and more than 50 per cent of the plurality received by the successful candidate. If an average wage of $60 a month is assumed, these men are paid and receive more than $24,000,000 per annum. These figures are the more remarkable when it is considered that all, or nearly all, of these 34,000 men have fathers, brothers, and others eligible to vote who are more or less dependent upon them.

I think there could be little doubt concerning the probable tenor of a report from Mr. Dalrymple upon the desirability or non-desirability of this proposition in Greater New York.

However, it is not my purpose to now enter upon a discussion of the doctrines involved in the question of municipal socialism. The foregoing are intended as mere allusions, made in order to attract your attention to the importance and desirabliity of investigation along certain lines intimately affecting the interests which you represent, and brings us to the question of the reorganization and reformation of this association and those associated with it. I take it that it will not be necessary for me to make any extended statement at this time concerning this matter. The proposed new constitution and by-laws have been sent, together with a letter from your president, carefully explaining their purpose and all that has been done in relation thereto, to all members of this association, and also, accompanied by a communication from the membership committee, to all non-member electric railway companies, throughout the countries which are within the jurisdiction of the association. This proposed form of constitution and by-laws will now be brought before you for final action. They embody the result of two years' careful and thoughtful work, and it is believed by your executive committee and a large number of others who are prominent in the association, that they are well adapted to bring about an organization which will be of great value. There are many questions of detail that will remain to be settled after their adoption, and I desire to say now, once and for all, that there is not in the mind of any of those who are responsible for the proposed changes a thought in derogation of the autonomy or dignity of any of the affiliated associations. It is intended that in a well-defined and intelligent way the work of all the associations shall be carefully laid out in advance, so that by harmonious and correlative work the greatest advantage may be secured from the united efforts of all. In determining the work to be done the various committees will be consulted, so that the final programme will represent and constitute the common judgment of representatives duly accredited from each of the organizations. In behalf of the parent organization, any intention to weaken or unnecessarily interfere with any of the affiliated organizations is expressly disclaimed.

It seems proper to say that it is intended that there shall be a well-equipped general secretary's office, where will be properly collected and cared for, information concerning electric railway properties and questions which may hereafter seem of such importance to the association as to require investigation. The accumulation of such data will be systematized, and the members of the association will from time to time by announcements and notices be made conversant with the resources of the secretary's office, and in every way encouraged to call upon the secretary for information.

It is also intended that a great deal of work shall be done by small compact working committees, whose records shall be kept on file in the office of the general secretary, and that he shall be secretary ex officio of all of said committees. However, I find myself in danger of going too much into detail, and I will conclude my reference to this subject by saying to you that I heartily believe that the adoption of the new forms of organization and their careful working out will result in unqualified benefit to all.

The first product of the reorganization has been the Manufcturers' Association. It has succeeded almost beyond the most sanguine expectations of its promoters, and the exhibit which has been assembled here affords the very best justification of the change that has been made. Splendid as this exhibit is, it has been assembled here without any expenditure of time or money on the part of any of the officers of this association. The Manufacturers' Association not only pays its way, but it has provided this hall, which is our meeting place, and in other ways is contributing to the comfort and convenience of the members of our different associations. I did not feel that I could close these remarks without referring specially to the gentlemen who, by their unremitting efforts, have assembled here this really beautiful and complete exposition of articles used in electric railway work, and provided so generously for our entertainment and pleasure. I feel, however, that I ought to warn you not to devote too much time to the examination of these exhibits, lest you be caught in the predicament of the friend of Mr. Dooley, who, to use that gentleman's language, "wint to th' Cintinyal in Philydelphy an' los' th' use iv his legs thravelin' fr'm th' display iv mohair shawls to th' mannyfacthry iv open-face watches."

In concluding, I wish to return my sincere thanks to all the members of the executive committee, and many others, both in and outside of this organization, but interested in its work, for the invariable courtesy and patience with which they have met many trying situations that have arisen during the past year, and with which they have always met my requests for assistance. I trust that when you leave this place it will be with a feeling that this, the twenty-fourth annual meeting of this association, has been its crowning achievement. I thank you again for the invariable forbearance which has been shown to me as your presiding officer, and bespeaking a further continuation of it, I await the pleasure of the convention.

The next business was the approval of the minutes of the last meeting, and they were approved as printed.

The secretary then presented the report of the executive committee. This report consisted of the minutes of the various meetings of the committee held during the past year, on Feb. 3 and 4, June 12 and 13, and Sept. 26. On motion of W. P. Read, of Salt Lake City, the report was accepted and ordered to be filed.

The secretary then presented his annual report.

REPORT OF SECRETARY AND TREASURER

In substance the report of Mr. Penington is as follows:

New members since last meeting:

Chattanooga (Tenn.) Rapid Transit Company.
Cleveland & Southwestern Traction Company.

Columbus (Ohio), Dayton, Springfield & Urbana Electric Railway.

Dubuque (Ia.) Union Electric Company.

Fairmont (W. Va.) & Clarksburg Traction Company.

Fitchburg (Mass.) & Leominster Street Railway.

Hampton (Va.), Newport News & Old Point Railway & Electric Company.

Lansing (Mich.) & Suburban Traction Company.

Macon (Ga.) Railway & Light Company.

Madison (Wis.) Traction Company.

Manila Electric Railroad & Light Company.

New Haven (Conn.) Consolidated Railway Company, of New Haven.

Philadelphia & West Chester Traction Company.

Richmond (Ind.) Street & Interurban Railway Company.

Sheboygan (Wis.) Light, Power & Railway Company.

Spokane (Wash.) Traction Company.

Wellston (Mo.), St. Louis, St. Charles & Western Railroad Company.

Tacoma (Wash.) Railway & Power Company.

The number of members Sept. 20, 1904, was 196; eighteen new members have joined, six have withdrawn, and two have been suspended for the non-payment of dues, leaving 206 members at this date.

The financial statement showed cash on hand Sept. 20, 1904, $7,646.56; receipts to Sept. 15, 1905, $5,278.29; expenses to Sept. 15, 1905, $6,192.65; cash on hand Sept. 15, 1905, $6,732.20.

Mr. Penington concluded his report as follows:

As the executive committee of this association desires a technical man to act in the capacity of secretary, also a man who can devote his entire time to the work of such office, this is, in all probability, the last year I shall serve the association as secretary. In looking back over the past ten years I can truthfully say that I have filled the office of secretary to the best of my ability. Of course, there have been errors made, but "to err is human," as everyone knows. I wish to take this opportunity of thanking the many friends, old and new, whom I have made during the years of my work for their kindness and assistance, and, in case I have been unfortunate enough to have gained the ill will of any, I sincerely trust that it has not been lasting. I hope you will call upon me at any time in case I can render any assistance.

President Ely spoke of the fidelity with which Mr. Penington had performed his duties, and he was sure that no one who had ever come in contact with Mr. Penington during the ten years of his work cherished any feeling toward him but that of respect and warm friendship. The president stated that suitable resolutions would be reported by a committee appointed for the purpose, expressing the feeling of the members with regard to the service of Mr. Penington, with the hope that when Mr. Penington looked upon these resolutions he would know that they emanated from the hearts of his friends.

On motion, the report of the secretary and treasurer was received and filed.

The president stated that a number of letters had been received from different persons expressing their regret at being unable to attend the meeting. The president further said that he wished at this time to express the thanks which he owed to the members of the executive committee and many other gentlemen connected with the association for their very kind and valuable suggestions made to him, at his request, concerning the remarks in his address. The president stated that the next business would be the report of the committee on the reorganization of the association. As this was a very important matter, it seemed proper that it should be presented in its entirety, so that all might understand thoroughly the great amount of work and thoughtful investigation that had been bestowed upon the question of reorganization.

The secretary then read the minutes of the various joint conferences between the representatives of the parent association and the allied organizations.

At 1 o'clock the association took a recess until 2:15 o'clock.

WEDNESDAY AFTERNOON SESSION

The president called the meeting to order at 2:15 o'clock.

The president stated that he had addressed a letter in his official capacity to the presidents of the different street railway associations and clubs, asking for suggestions in regard to the plan of reorganization of the association. He was pleased to state that in every instance he had received replies, many of which were very interesting. The writers approved of the idea, and suggested that it might be possible to arrive at means whereby the work of the State associations might match in with the work of the American Street Railway Association and its affiliated organizations. Some of these associations had formally designated delegates to represent the associations at this meeting. Among them the New England Street Railway Club had designated E. E. Potter; the Ohio Interurban Railway Association had designated Fred W. Coen and Harry P. Clegg; the New York State Street Railway Association had designated J. H. Pardee; the Massachusetts Street Railway Association had designated Messrs. E. P. Shaw, F. H. Dewey, R. S. Goff, E. E. Potter and H. C. Page.

The president stated that he had written letters of invitation to attend the present meeting to all the past presidents of the association and had received letters of regret from D. F. Longstreet, Robert McCulloch, J. M. Roach, C. B. Holmes, Thomas Lowry, Henry M. Watson and H. M. Littell. Some of these gentlemen had taken occasion to refer to the matter of the plan of reorganization in a very commendatory way.

The president stated that he had also sent an invitation to some of the members of the different State Boards of Railroad Commissioners and had letters of regret from some of them; also from the president of the National Association of Railroad Commissioners. He was pleased to see a general manifestation in the interest of the work of the association on the part of the members of the different State Boards of Railroad Commissioners.

The president stated that the executive committee decided it would be a good thing to secure the attendance at the meeting of Henry L. Doherty, of the National Electric Light Association, who had been chiefly instrumental in bringing order out of chaos in the work of that association, and whose efforts had produced results which were very gratifying to the men in that branch of the business.

Mr. Doherty addressed the meeting and said that he had never realized so keenly the scope and perplexity of the street railway industry until faced with the responsibility of delivering an address upon the association work which it demands. The wide scope of this work not only dictated the necessity for wise planning of the individual company organization, but an equally wise and comprehensive organization of the association. The work in the street railway field required a knowledge of thermodynamics, mechanical engineering, electrical engineering, legal matters, materials, amusements, municipal engineering, and especially regarding paving, proper relations with State and municipal authorities, the newspapers and the general public. The association, to administer benefits to the fullest extent of its possibility, must be comprehensive, and therefore probably complex and expensive.

Mr. Doherty referred to the fact that proposed changes in every organization are apt to meet with opposition from chronic objectors to progress. These persons forget that while all changes are not improvements, yet all improvements are the result of changes, and for better results changes must be made. He would suggest that the association be known as "The American Traction Association," because such title seemed to be comprehensive. He urged the necessity of well-located, well-equipped permanent headquarters under direction of a permanent secretary. The entire organization of the association should be primarily intended to protect and develop the interests of existing properties, and ample funds should be provided from these properties to properly maintain the organization.

He believed that it was recognized that the industry is so complex in character that it is impossible to consider all matters of importance in one short annual session. It was also evident that all officers or employees of a company could not be absent at one time, yet there was practically no earnest worker in a traction company, from the president down to the laborer, who would not be benefited by some convention scheme or other plan that by increasing his knowledge or acquaintanceship with other men in the same line of work, his labor would be rendered more valuable to the company. He considered the following divisions of self-evident value: Traction electrical engineering; accounting; park and amusement superintendence; transportation superintendence; traction law. He considered that the adoption of a "question box" on a comprehensive scale was the most valuable adjunct in any association work. He referred to the great value of the question box in the National Electric Light Association and the Ohio Gas Light Association. It had been arranged that all information collected by means of the question box shall be put in the hands of a competent revision committee, and from it a very comprehensive hand book would be evolved. Information held by one man can in this way be made common to the entire fraternity, and the field of research and experimental work can thus be reduced to that portion which is unknown to all.

Mr. Doherty further said in planning the reorganization of the association that it was well to keep in mind that a special wave of antagonism seems to be passing over the country against corporations, and this wave of antagonism was particularly directed against quasi-public corporations. The corporation is held up as the tool of the rich for the oppression of the poor, while the reverse was really true. In the superficial treatment of the press and platform, the theory which gave the corporation birth is lost sight of. Some enterprises, by their very nature, can only exist by the employment of immense amounts of capital. Ability to incorporate is simply a legal means of co-operation. If such co-operation is not provided for, the undertakings requiring considerable capital would be only open to the few men who are possessed of the required capital, and these enterprises will exceed the capital available in large amounts. Therefore the possessors of large amounts of capital could make these enterprises as productive as their greed might dictate. Legalized incorporation is simply a means for co-operation on the part of capital, which enables the men of moderate means to join their interests and render their capital as productive as that of the man possessed of great wealth. Ability to incorporate is not essentially necessary to the rich, but absolutely essential to others.

Mr. Doherty further said that sooner or later those who want to see the truth prevail rather than sensationalism must take steps to give the voter the reasons why the ability of incorporation should be increased rather than lessened. Industrial associations for this reason should arrange provision for communication and co-operation among themselves. A marked tendency toward more rigid control on the part of municipal and State authorities was evident. The State or city now presumes to prescribe the service rendered by quasi-public corporations, fix the rates and assess them for taxation. Owing to faulty tax laws, individuals and firms, and corporations other than quasi-public corporations, can escape their just burdens of taxation by securing through concealment or otherwise, low assessment values on their property, while the quasi-public corporation, if compelled to pay taxes and fix rates on the same valuation, is bound to secure either inadequate rates or unjust taxation burdens. For this reason the quasi-public corporations must explore the resources of political economy to provide and enforce honest taxation of all property. He mentioned this simply as an example why more intimate communication should exist between organizations such as the Ohio Gas Light Association, the American Street Railway Association and the National Electric Light Association. As a conclusion to his remarks, Mr. Doherty made the following recommendations, based on many years of experience in association work:

First.—Listen to the recommendations of your active workers with a receptive mind.

Second.—Do not forget the fact that improvements cannot be secured except by changes.

Third.—Do not criticise unless you can see positive harm, and then sparingly, unless you can offer some better suggestion.

Fourth.—Do not oppose the man who is trying to do the work, but support him. Put a premium on interest in association affairs and work in behalf of association advancement.

Fifth.—Accept and act favorably upon the recommendations of workers aiming to secure organization upon higher and broader lines. If the plan suggested by them cannot be executed, delegate authority to either your officers or a special committee chosen by your officers to reorganize under some comprehensive plan which they may adopt and for the success of which they are willing to accept the responsibility. Give them full power to take all necessary steps, fix initiation fees, dues, accept new members, etc., and thus save waste of the most valuable thing required to secure progress, viz., time.

The president expressed the thanks of the association to Mr. Doherty, and stated that at a proper time a resolution expressive of such thanks would be adopted and spread on the minutes.

The secretary then read the proposed constitution and by-laws of the American Street and Interurban Railway Association. Since the proposed constitution and by-laws were printed in the Street Railway Journal for Sept. 2, a meeting of the executive committee has been held, at which a number of changes have been embodied in it. The revised constitution and by-laws are published in full on page 610 of this issue.

The president declared the subject of the adoption of the proposed constitution and by-laws to be before the meeting for consideration.

After some discussion as to whether the bond of the treasurer should be given to the association or to the president, and whether the annual fees should be based upon the gross receipts for the fiscal years "ending June 30," or "for the fiscal year of the respective companies whatever the date might be," the wording given on page 610 was adopted.

C. S. Sergeant, of Boston, called attention to the fact that it is provided in article 2 of the by-laws that the vice-presidents shall equal in number the number of affiliated associations, and in article 6 it is provided that the executive committee shall consist of the president, the vice-presidents and one member appointed by each of the affiliated associations, and that it was provided further that the executive committee may admit affiliated associations, which he understood to mean new associations, and the question raised in his mind was at what time can they be admitted. If they could be admitted only at an annual meeting he saw no trouble, but if they were to be admitted at any other time he did not see how the vice-presidents could be made to correspond with the number of affiliated associations.

Mr. Beggs answered that the admission of affiliated associations could only occur at an annual meeting, and that there would be no trouble on account of the points raised by Mr. Sergeant.

H. H. Vreeland said that it had been evident to every member of the association for a number of years that some change was necessary in the form of organization and the method of conducting the business of the association. A great change had come in connection with the properties which the association originally represented. At the time of its organization the association had to do with horse cars and horse car problems. There has been a very rapid evolution from that, and business had advanced in every direction save that of the methods of conducting the affairs of the association. It was recognized, when the association met in New York City some years ago, that it would be impossible for the association to go ahead under the then existing method of holding meetings in cities to which it was invited by the local street railway companies, as such companies were required to assume practically all the expense of entertaining the association. At the New York meeting it was first suggested that a Manufacturers' Association, similar to those associations which have been in existence for many years in connection with steam railroad organization, should be organized, to take charge of the exhibits at conventions and the entertainment of the association, so as to place the association in a position to go to whatever city it was thought best in the wisdom of the executive committee to hold its convention. A year passed without any action, but there was a great deal of discussion. Many of the members took the position that something intangible would slip away from the association if they let any one take the management of the exposition and the entertainment of the association except the railroad company in the city in which the meeting was held. Fortunately, better judgment prevailed, and the association to-day had an allied organization which had arranged at this convention an exhibit and entertainment such as the association never had before in its history. This had been done without any expense to the association or to the railroad management of the city. This has placed the association where it should be—in a position so that it can go to any city in the United States to hold its conventions, irrespective of any question of the ability of the local railway companies to entertain the association or any question of disposition to do so.

Mr. Vreeland said that the time had now come when a decided change should be made in regard to the method of running the association. It had been evident to everyone who had been connected with the association for some years past, that if the companies were paying only $25 a year in dues they were not getting more than $25 worth of value out of it. Everyone had an opportunity of considering and discussing the changes proposed, as the question had been up for the last two or three years. Mr. Vreeland referred to the fact that the organization of the American Railway Association, with which he had been connected for a number of years, and its affiliated associations, is identical with the plan proposed here, and that in the case of the American Railway Association it had produced the very best results. Instead of some one in the East groping on a proposition and another man on the Pacific Coast groping on the other end of it, they took all questions up and endeavored to establish a uniform standard. Among other things, they have established a uniform standard time for the United States for the operation of railroads, and have established a uniform system of rules and regulations for the operation of trains and telegraph orders, so that an engineer in Maine could run an engine in California or in any other State. The business of the American Street Railway Association should be conducted in such manner as to be of similar value to the members. There must be a change if the association was to go on; it could not go on as it had been doing. The proposed plans had been considered at very great length, the committee had had the judgment of experts, and the association was now presented with a plan under which it could go on and work along higher lines, produce better results, and keep pace with the development of the industry.

President Ely said that sometimes an erroneous impression prevailed concerning the thought that underlies such work as this. On behalf of those who have been laboring on the proposition, the present executive committee and the past executive committees and others, he wished to disclaim any idea of doing some academic or theoretical thing. What they desired to get was something intensely practical; they had been moved largely by monetary considerations. The plan presented had a commercial purpose. The questions of what was going to be secured by the plan, what it was going to cost, and where the money was to come from with which to defray the expense, were three hard business propositions that have exercised the minds of all who had worked upon the subject. The personnel of the executive committees for the past two years who had worked upon the problem was that of men who had little time for sentiment; it was a hard business proposition, pure and simple. A great deal of time had been devoted to the consideration of the schedule of dues, and consideration was given to the number of companies in the different classes and what they would pay under the new plan. The benefits derived by the companies in the different classes and the amount of dues they would pay had been very carefully weighed. The larger companies, it should be remembered, are the ones that can get along the best without such an association. The larger companies have so much revenue that they can afford to hire experts to determine every question that perplexed the minds of their managers, but the smaller companies cannot do that. The small companies have imposed in the past upon the good nature of the large companies in securing information from them; the large companies cannot stand that any longer—the burden involved is too great. Mr. Ely said that a gentleman who has a great system of street railways wrote him recently that it could well afford to pay the association for a proper bureau of information to supply the information that was asked from his company $1,000 a year in addition to the dues, and that money would be saved to his corporation in that way. President Ely referred to Mr. Goodrich, of Minneapolis, who had told him that he always tried to give the information that was asked for, and to give careful thought and study to the preparation of it, but he said that the heads of departments were very busy, and although he turned these requests for information over to them, coupled with the request that they receive careful investigation and reply, he knew that much went out which was not satisfactory to him. It is not the larger companies that are benefited most by the association, but the small companies. Going half-way down the list, from the companies with a gross income of $50,000, to those with an income of $500,000, $1,000,000 and $2,000,000, those are companies that have problems that are of sufficient importance to require thorough expert investigation, the same as those which confront the $10,000,000 companies, but while they have the demand for such information they have not the revenue to make the special investigations. Therefore, the companies in the middle of the list will receive more benefit than the large companies. It resolves itself in this kind of co-operation to the point it always does—where you get men enlisted together to work co-operatively for the mutual good—that those with the largest resources contribute the most,—those who could best get along without such co-operative work, join in the work for the benefit of others. It seemed to him that the list of fees would be found to be well balanced.

At the close of Mr. Ely's address Frank G. Jones, who temporarily occupied the chair, put the motion to adopt the new constitution to a vote, and the proposed constitution and by-laws, as amended by the executive committee, and further amended by Mr. Beggs' suggestion, were adopted.

The secretary announced that the Engineers' Club and the Manufacturers' Club, of Philadelphia, tendered to the officers and members of the association the privileges of the respective club houses for this week.

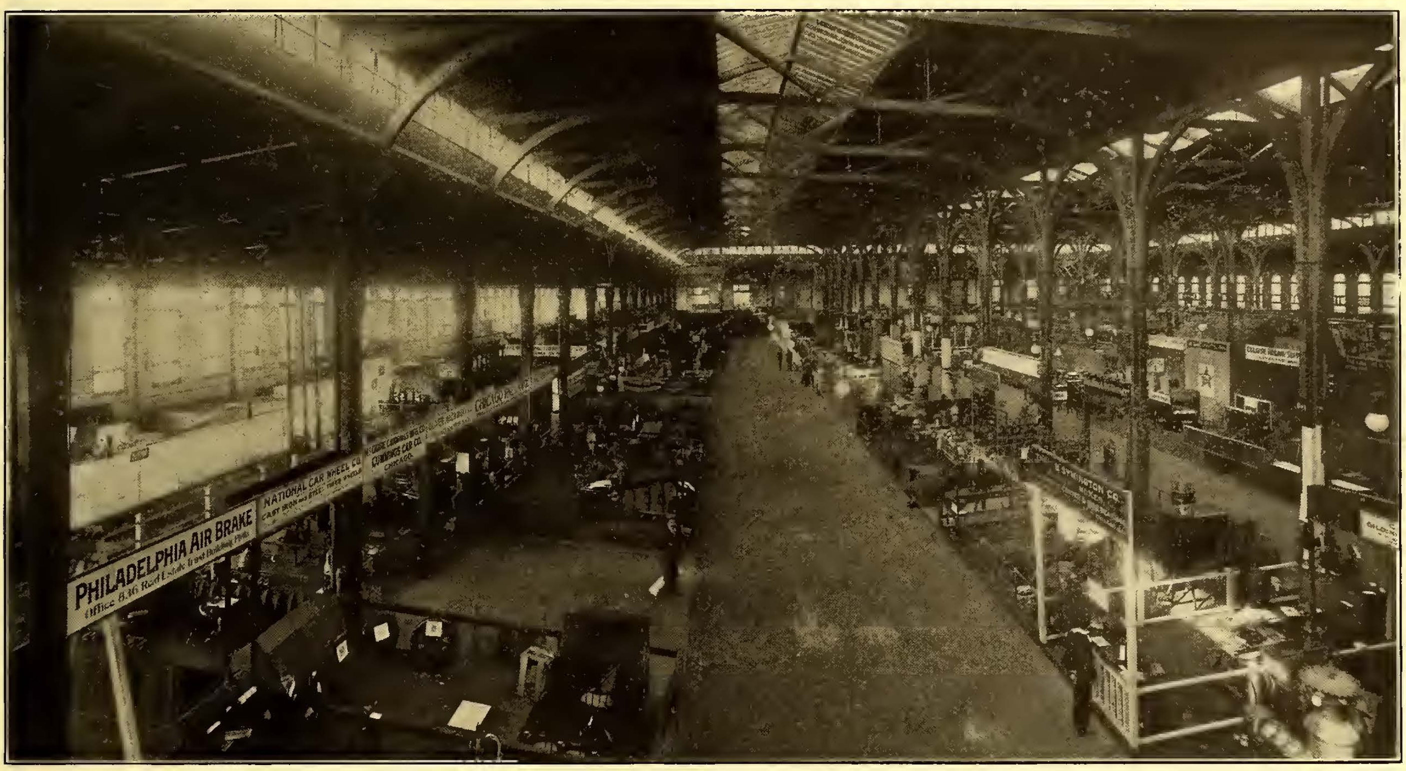
Chairman Jones announced the appointment by President Ely of the following committee on nominations: Messrs. Parsons, of Philadelphia; Vreeland, of New York; Sergeant, of Boston; Stebbins, of Columbus, Ohio; Read, of Salt Lake City.

Chairman Jones announced the appointment by President Ely of the following committee on resolutions: Messrs. Allen, of Utica, N. Y.; Rigg, of Reading, Pa.; Smith, of Omaha.

H. J. Davies, of Cleveland, stated that in line with the suggestion in the address of the president and the recommendation of the executive committee, he wished to move the appointment by the president of a standing committee of five upon insurance and fire protection. The duties of this committee shall be to gather statistical information and to study the subject of fire insurance, and more particularly the protection of street railway property against loss by fire and the consequent loss to business. The more important part of the duties of the committee would be the subject of the better construction of car houses and better protection against loss or damage by fire, as the loss to the company, owing to interruption of business consequent upon fire, is much greater than the amount which is likely to be collected from any insurance company after a fire. Fire protection is more important than fire insurance. Properly protected car houses can be insured at a much lower rate than car houses as they now exist, as a rule. A reduction in rates would follow naturally the better protection of the houses. The rates on car houses at present are much too high. Reports from more than 400 street railway companies of the amounts paid by them for insurance in the past ten years, and the amount of losses sustained, indicate that the losses have been less than one-third of the amount paid for insurance, so that there has been great profit in the insurance of railway property to the insurance companies. This committee could verify the figures and gather information which will be of benefit to every member of the association, and there would be presented to the committee plans for the insurance by street railway companies themselves of their own property at actual cost.

Chairman Jones put the motion, that the president of the association appoint a standing committee of five, to be known as the fire insurance committee, and the motion was carried.

The meeting then adjourned.



GENERAL VIEW OF NORTH EXHIBIT HALL AT THE PHILADELPHIA CONVENTION, LOOKING SOUTH

THURSDAY MORNING SESSION

Vice-President Beggs called the meeting to order at 11 o'clock, and stated President Ely was engaged on other business in connection with the affairs of the association.

The first business of the meeting was the reading of the paper on "Notes on the Design of Large Gas Engines with Special Reference to Railway Work," by Arthur West. In the absence of Mr. West, J. R. Bibbins extracted the paper. This paper will be found on page 592.

Chairman Beggs, in calling for discussion on the paper of Mr. West, said he was one who thought that great economies would be brought about in the production of power through producer gas engines, and therefore papers such as that of Mr. West were extremely interesting. Some three or four years ago, at a meeting of the association, he had stated that he thought it would be possible to reduce the cost of power at least one-half by the use of gas engines. He, therefore, hoped that the members would discuss the paper very freely.

C. O. Mailloux suggested that the paper by J. R. Bibbins on "The Application of Gas Power to Electric Railway Service" might be read and both papers discussed at the same time.

Mr. Bibbins then presented his paper. (See page 594.)

Chairman Beggs, in calling for discussion on the papers, stated that on behalf of the association he wished to express thanks to the authors for the valuable work which they had put upon the preparation of these papers, and he hoped that the papers would draw forth some discussion and inquiry.

C. O. Mailloux, of New York City, thought the names of the authors which appeared in these papers were sufficient guarantee of the merits of the papers. Mr. West for many years had been engaged in the designing of steam engines of the Corliss type, and was considered at the time he left the steam engine field, if he had left it, one of the best authorities in the designing of steam engines; hence, in going into the designing of gas engines, he brought with him a most valuable experience. He said that Mr. Bibbins had for a long while given much study to the gas engine, and had been connected with the gas engine since it had become a factor. There was too much meat in these papers to be discussed in detail, but there were one or two points which showed in themselves the progress the gas engine is making. At the last convention there was a reference to the subject of gas engines, and he had taken a part in the discussion. He called attention last year to the fact that from the data at hand, the evidence went to show that the two lines in the diagram of comparative costs crossed at a value corresponding to $2 or more per ton for coal. That meant for any value of coal corresponding to about $2 per ton, the two systems, the steam plant and gas plant, were about equal. This year Mr. Bibbins gives a diagram where these two lines cross at $1 per ton. He thought that was a very significant fact. It showed that the cost of the gas engine power must have been greatly reduced in some way. Either that has been brought about by reducing the cost of the machinery itself or the cost of its maintenance, or by increasing its efficiency, and it would be very interesting to him, in fact he considered it the most interesting feature of the entire paper, if Mr. Bibbins would give out of the vast fund of knowledge which he possessed on the subject some clew as to the reasons which have brought about that result. If that ratio kept on we might reasonably expect to find that these two lines in the course of another year will start at zero and cross at some point near zero in the cost of coal. The line representing the cost of power by gas engines has been flattened; there is a smaller angle with respect to the axis of the cost of coal. While in most systems a lessening of expenses is largely due to the reduction in initial cost of equipment, to better methods of manufacture, and to a simplifying of the apparatus itself, yet he was interested in knowing whether the increasing efficiency of the engine and the reduction of repairs and maintenance, may not have had a great share in reducing that cost.

Mr. Bibbins replied that he did not quite understand to what diagram Mr. Mailloux referred, whether it was to a paper presented by Mr. Bibbins to the Ohio Gas Light Association.

Mr. Mailloux replied that he had reference to a lecture on the subject given by Ralph D. Mershon, before the New York Electrical Society.

Mr. Bibbins replied that he was not quite familiar with the assumption taken in the paper by Mr. Mershon, but assumed that Mr. Mershon worked up his diagram for an electric lighting plant, in which the load factor on the system is barely 25 per cent, usually lower than that. If reference was made to his assumption in the last sheet of the report, it would be found that he had taken a load factor corresponding to an average plant, which is 66 per cent. That is really the greatest factor in determining the exact crossing of these two lines. He was not familiar with the prices which Mr. Mershon used in preparing his diagram. The costs he had used are shown in the assumptions and they are quite recent. It will be noticed on the diagram that the lowest set of figures referred to the cost of fuel only. There, of course, the gas plant has a great advantage. In the second set of figures the cost of fuel is represented added to the cost of operating. He had estimated the cost of operating, labor supplies and repairs at 0.5 cents per kw-hour. Without looking for absolute definite information he was obliged to take the same figure for both plants, and he had shown that it was very possible in the gas plants that these items might be still less.

Mr. Mailloux remarked that the price was high.

Mr. Bibbins answered that such was the case, but as he had taken them for both stations the comparison was not unfair. The other set of diagrams takes into account the fixed charges. The present cost of anthracite coal brings it well within the range of power plants generally. For instance, it is possible to obtain in Cleveland and Buffalo, which are comparatively central points, pea anthracite coal at $3.12 per ton; No. 1 buckwheat coal at $2.45 per ton, and No. 2 buckwheat coal at $2 per ton. This, it could be seen, brings the anthracite producer plant well within the range of ordinary purposes. Where plants are located in the bituminous field or adjacent thereto, there would be no question about their economy.

Charles Hewitt, of Philadelphia, said that he well appreciated the difficulty of preparing diagrams such as Fig. 10, as he had attempted on several occasions to prepare similar diagrams. He didn't, however, think that these should be accepted without some question and some comment. He was not prepared to question Mr. Bibbins' line of cost for the gas plant, but the line showing the cost per kw-hour for the steam plant seemed to him to be open to question. Whether the diagram represented the comparison between two particular plants or not, he could not say, as he had not had an opportunity to read the text of the paper. If it did, all that he could say was that the steam plant indicated in the diagram is very uneconomical. Anthracite buckwheat coal runs between 11,000 and 12,000 heat units per pound of coal. Fig. 10 shows that this coal would run from 6.5 lbs. to 8 lbs. per kw-hour. The poorest plant with which he was personally familiar showed better results than that. He was familiar with plants running non-condensing which showed 4.5 lbs. of coal from year's end to year's end. The consumption will run as low with good coal as 4¼ lbs., seldom over 4¾ lbs., and the average for the year will be 4.4 lbs. to 4.5 lbs. Running condensing with the same quality of coal, it is perfectly possible to run at 3.5 lbs. of coal. The saving in coal with the gas plant is sufficiently large, it seemed to him, without magnifying and without putting a curve in the diagram which shows an abnormally inefficient plant. Mr. Hewitt further said that the same result was shown in Fig. 15, in which, it seemed to him, the difference between the cost of operating the steam plant and the cost of operating the gas plant was magnified. Thus, with coal at $2.50 per ton, the diagram shows that the cost of operating the plant would be over 9 mills per kw-hour. He was perfectly familiar with plants which are running at 6 mills with buckwheat anthracite coal, including all operating costs and repairs, but not the interest on the plant. It is a very uneconomic plant that will run the year through at 1 cent. So that it seemed to him that if the diagram in question is intended to represent the average results throughout the whole country, it is very high for the steam end of it, and therefore magnifies the difference between the two lines, assuming the cost for the gas plant is correct. He expressed himself as not being quite clear in regard to the table for operating costs for the London Metropolitan Boroughs. Thus Table IV. gives the cost for fuel, supplies, labor, repairs and works, and then the total for eleven plants; but the total did not agree with the other items, or with the total of 2.8d., which Mr. Bibbins had quoted. He also wished to know what is meant by the cost of "works," which is by far the largest item.

Mr. Bibbins replied that the records of the British power plants are uniformly expressed in "works cost." Unfortunately, the head of the table has simply "works" instead of "works cost." That includes the four items: fuel, supplies, labor and repairs, without any fixed charges or management expenses, and corresponds to what in this country we call "operating expenses." It will be noticed that this paper is expressed in pence instead of cents, and therefore the cost, as he quoted them on the platform, was 2.8. Just below operating expense in the per cent of works cost, he had taken the works cost as 100 per cent and shown the distribution of expenses in the operating cost. The management expense increases that amount by 29 per cent in the case of the steam plant and 23 per cent in the case of the gas plant.

As regards Fig. 10, he was somewhat apprehensive that that diagram would be misunderstood, and therefore had taken pains to mention that it referred to a non-condensing plant. The equipment at St. Louis consisted of the three-cylinder vertical gas engine belted to a generator and an engine of similar capacity. It could not be expected to get the same economy out of these two plants as out of the large central station, not from the fact that the equipments were not equally comparable, but it must be borne in mind that the results were obtained with a non-condensing plant. He thought it was safe to say that the relative coal consumption between steam and gas plants would be about two to one. In the present case the ratio is higher, as the steam station is now condensing. He asked if that answered the question.

Mr. Hewitt replied that he did not raise any special question about the curves, except to state that it seemed a high line for the steam cost. The intermediate line in Fig. 10, B.HP., it seemed to him, would be a fairer average line for stations running with anthracite coal. Non-condensing stations using anthracite coal can be run for 4.5 lbs., and are so run, and that is one-half of the difference shown on the two lines in question.

Mr. Bibbins replied that, assuming 4.5 lbs. of coal at the calorific value quoted by Mr. Hewitt, 11,000, that would bring the comparative efficiencies in about the ratio mentioned, two to one. It would be noticed from Table III., which gives the results from the Walthamstow station, that the average consumption was 1.78 lbs. of coal per kw-hour for twelve days' operation, or, as stated further on, about 2 lbs. of coal for anthracite coal, including extra coke for banking and raising the steam required to blow the producer. As to the diagram showing the comparative costs of steam and gas, Fig. 15, he had probably erred in the matter of assigning a cost of .5 cent for the three items: labor, supplies and repairs. That, however, did not affect the relation between the two, and he preferred to assign that equal value, in order that any particular quantity might be applied to other data. It would readily be seen if any advantage could be obtained in the gas plant that the power gas line would be lower, and consequently the intersection of the two would be nearer the cheaper grade of coal.

Mr. Mailloux inquired if Mr. Bibbins was able to give any information as to whether a change in the size of the plant would have any effect on the relative arrangement of these lines.

Mr. Bibbins replied that that was a difficult question to answer definitely. There was one point which had a bearing on it, and that was the fact that a small gas engine will show an efficiency quite comparable with a large one, therefore the choice of the larger engine is determined mainly by the capacity necessary in the plant running with the view of obtaining ordinary higher economy. He didn't see any reason for the change in the relative costs of these various items in the smaller plant, provided the same number of units was used. The number of units, of course, has an immediate bearing on the operating cost.

Mr. Mailloux said he did not think the question had been fully answered. He had intended to add to his remarks that the question of cost of installation, it seemed to him, had quite an important bearing on the upper line of total costs, and he would presume that the smaller plant would have a much higher cost per kw-unit than the larger plant, as is found to be the case with steam plants, at least within certain limits. In the present connection he would also like to ask Mr. Bibbins to give information as to whether the cost per kilowatt of gas engines had not been considerably reduced within the last year.

Mr. Bibbins replied that he agreed with Mr. Mailloux that the smaller plant would cost more per kilowatt, even though the same number of units were installed. At the same time the relative uneconomy of the steam plant will increase much more rapidly with small units, and this fact might readily more than balance the increased capital cost. The producer in smaller sizes is much more efficient than the boiler, and the same is true with the engine, although it is impossible to tell whether the same relation will hold. He didn't think he was in position to give Mr. Mailloux any correct data as to whether the cost of gas engines had been reduced in the last year; that was something which was not in his field.

Mr. Mailloux suggested that the floor should be given to L. C. Marburg, representing the Allis-Chalmers Company.

Mr. Marburg said regarding Table VII., he would inquire if the overload capacities had been taken into account in comparing the relative cost of the steam engine and the gas engine. He thought from the price given for the steam engine plant that it is evident that a reciprocating steam engine could be obtained which would have a 50 per cent to 100 per cent overload capacity momentarily. He understood from Mr. Bibbins that the way he rated the gas engine is on the basis of 10 per cent overload capacity only. That might explain the point brought up by Mr. Mailloux as to the relative cost per kilowatt in the case of the steam engines and gas engines as given in the paper.

Mr. Bibbins replied that the gas engines were rated at a 25 per cent overload capacity. The steam engine would have a greater overload capacity.

Mr. Marburg answered that that naturally would explain why on the curve given as to the relative costs for steam engine plant and gas engine plant the advantage is in favor of the gas engine at such a low cost of coal as given.

Mr. Bibbins stated that Mr. Marburg probably misunderstood the matter; that Table VII. applies to the tender in the European plant, and it has no bearing on the diagram he had prepared. The diagram was prepared from the assumption shown in Table VI.

Mr. Marburg replied that in that table the price of $40 per brake-hp was given again. It would naturally be of interest to know what the overload capacity was.

Mr. Bibbins replied that the basis for an overload capacity in the case of the gas engine was 10 per cent. It was possible to assign an overload capacity in the same way on the steam engine. To take the steam engine at such capacity will give its best economy at about 80 per cent load, as is normally the case. He had taken the engine so that it would give its best economy at the average load of 75 per cent of the full load. If we take the engine on the basis of 10 per cent below its maximum the steam consumption would be much higher, although the fixed cost would be considerably reduced.

Mr. Marburg remarked that it would seem impossible to obtain a load factor of 66 per cent if the overload capacity of the machine is so small. That is a good load factor for a reciprocating steam engine.

Mr. Mailloux said that the point which Mr. Bibbins made, it seemed to him, was largely influenced by the form of steam motor used and its efficiency curve. One could see at once that it would be quite different in the case of steam turbines, which have a notoriously flat efficiency curve, and it seemed to him that if the comparison were made with the steam turbine it would be found in the first place that the line of cost for steam power would be much flatter for a smaller angle than it now is, and in the second place, the cross line would go further up. In the case of the comparison of the gas plant predicated as the basis of the calculations of the steam turbine plant, the line at which the two would cross would be more nearly at $2.

Mr. Bibbins inquired if Mr. Mailloux was assuming only 10 per cent overload in the two cases.

Mr. Mailloux said that he did not think it would be necessary to make an assumption in the case of steam turbine, because the efficiency curve is so nearly flat for three-quarters of its range. That if it was assumed that the normal capacity was 10 per cent of the stalling load, that the comparison would be still more favorable to the turbine, and this would force the point of intersection between two curves at same point at least as high as $2 per ton.

On suggestion of Mr. Mailloux, Mr. W. E. Winship was given the floor. Mr. Winship said he thought he could add a few figures on the gas-engine plant that might be somewhat interesting. They had installed for the Gould Coupler Company at Depew, N.Y., a gas-engine plant consisting of three Westinghouse vertical engines rated at 235 hp each, with Loomis-Pettibone gas system. The plant cost almost exactly $115 a brake-hp to install. They estimated that it would have cost $90 per horse-power for a steam plant, equivalent to the gas plant, excepting as regards coal consumption. In regard to the overload capacity, they figured that by installing a storage battery they could get the same overload capacity out of the plant. After the batteries are installed the plant will have cost about $130 per brake-hp, and for the same overload capacity as the steam plant. Their coal consumption, based on coal containing 13,400 B. T. U. per pound, has been on a monthly average 2.26 lbs. per kw-hour on the switchboard, with a load factor on the plant of roughly 50 per cent for twenty-four hours' operation. On a series of days when their load power was approximately 64 per cent or 65 per cent, the coal consumption went down to 2.02 lbs. as an average of the days when that condition existed. The lowest record for twenty-four hours' period of operation, when the load was especially good, was 1.79 lbs. of coal for a kw-hour on the switchboard. That load is very similar to what is used in street railway work. The peaks, when the load is heavy, are fully 60 per cent above the average, and when the peaks are lighter, they are fully 100 per cent above the average load. The conclusions were that with coal at $2.30 per ton, and with the plant operated for about fourteen or sixteen hours a day, the steam plant and the gas plant would have just balanced each other, but that with the twenty-four-hour operation the gas plant is more desirable. In regard to the reliability of the plant, he could state that it has been fully as reliable as any steam-engine plant that could have been put in. They had only had the valves in the engines ground once, with the exception of one valve, which they ground twice. They used the splash lubrication.

Mr. Winship further said that there are two points worthy of attention in any gas engine installation. There is a criticism which could be made in regard to the admission of the engines, especially where it is electric ignition. Some means should be provided for changing the igniters when the machine is in operation. The speaker did not know of any engine in which that is provided for. Another need is for some indicating instrument for determining roughly the heat contents of the gas. Of course, there are calorimeters by which the heat contents of the gas may be determined, but there is no rough and ready instrument to put in the gas producer house. The need for such an instrument is especially pronounced in bituminous gas plants where the color of the flame does not give any idea as to the heat contents of the gas. There ought to be such an instrument, and it did not seem to be a very difficult problem to design one.

Mr. Hewitt remarked that it might be of interest to some of the members to know the latest results in steam turbine plants which he had received only a few weeks ago from New England. As opposed to the 2.26 lbs. of coal, which Mr. Winship gave as the average for thirty days, the results show 2.4 lbs. to 2.6 lbs. per kw-hour with bituminous coal. The average is 2.5 lbs. for turbines as against $2\frac{1}{4}$ lbs. for gas engines. One of these plants has five units of about 1000 kw; the other has two units, and he thought in the latter case there were about 1500 kw using superhated steam.

Mr. Bibbins stated that in regard to changing the igniters, there is a system in vogue now which makes possible the changing of an igniter when the engine is running. In the plant in Philadelphia each cylinder is equipped with an igniter plug, which has two contacts, and either one may be thrown in or out by a little switch. There are four different sources of current for supplying the igniters, and each cylinder is provided with a double set of igniters. If one of the igniters gets into trouble the other can be quickly cut in. If any of the gentlemen present were sufficiently interested he would be glad to go to the pumping station with them and show them the gas engine in practical operation.

REPORT ON NOMINATIONS

The committee on nominations made its report at this point. John B. Parsons, chairman of the committee on nominations, presented the following list of nominees:

For president, W. Caryl Ely, of Buffalo.

For first vice-president, John I. Beggs, of Milwaukee.

For second vice-president, Calvin G. Goodrich, of Minneapolis.

For third vice-president, James F. Shaw, of Boston.

(Under the new plan of organization the members of the executive committee are made up of the officers and the presidents of the affiliated organizations. At a later period in the meeting, President Ely announced the following members of the executive committee: H. H. Adams, of Baltimore, on behalf of the Mechanical Association, and S. L. Rhoads, of Philadelphia, on behalf of the Claim Agents' Association. As the Accountants' Association had not yet elected a president for the ensuing year, the name of the member of the executive committee representing the Accountants' cannot be given until next week.)

On motion, the report of the committee on nominations was accepted, and the secretary was authorized to cast the ballot of the association for the gentlemen named, which was accordingly done.

In response to calls for a speech, President Ely remarked that if he should say that the action taken by the association in electing him again to the presidency was not gratifying to him, he would not be telling the truth, but when he said that he had devoted a great deal of time to the association for the last year, and considerable time the year before, and that he could see that there was a lot of work to be done during the coming year, to be commenced immediately, and that the members should have selected some other person as president to go ahead at the present time, for several reasons, he would also be telling the truth. He said that when his friends had come to him and said very nice and very pleasant things, he had grave doubts about whether they applied to him or not, and whether he really deserved all that had been said. He had said to these individuals that it seemed to him to be a time to put in a new man. The association had agreed upon a form of organization, and as he was not conceited, he thought there were a lot of men available from whom a selection for president could have been made, but it seemed to him that he had been caught with the goods on and could not get away, and, of course, he would stand. But there is a great deal of work to be done, and the new plan of organization cannot succeed unless hard work is put upon it and unless that work is participated in by all the leading members of the association. Everybody in the association must be called upon to co-operate.

President Ely believed that if every member of the association did his duty, the organization which would result in a couple of years would be so big and useful to every member that the common sense of all connected with the association would lead them to say, "Why did we not inaugurate this ten years ago? What were we doing?" He expressed his appreciation of the great honor conferred upon him. He would do his best with the assistance of the members, which assistance he trusted they would all give, and in conclusion, he desired to say that he appreciated the action of the association as a very great honor.

Mr. Beggs said that he wished to say a word of approval of the action of the nominating committee in the selection of Mr. Ely. As many of the members know, there were a number of gentlemen who in the kindness of their hearts approached him with the idea three days ago that he should be made the president of the association. He had taken the position that the incumbent of the presidential office at this juncture should not be changed; that the future of the association depended largely upon the work that had been under consideration for the past two years, and should be largely left in the hands of the head of the association who had been so intimately connected with it. Mr. Beggs appreciated the honor conferred upon him in selecting him as the first vice-president of the association. He wished to pledge to Mr. Ely his best support in assisting Mr. Ely in what was to be done. He understood fully the burdens which the president was assuming, and he desired to pledge to the association the best efforts he could give to its advancement. He did not know whether Mr. Goodrich was present at the session or not, but he was glad that Mr. Goodrich had been continued as vice-president in the association, and that those were coming into office who were familiar with what was intended to be accomplished under the new form of constitution and by-laws.

The president said that the choice of vice-presidents was an admirable one. Everyone knew from experience how wise and how able and how effectively Mr. Beggs worked. It was a great thing for the association to have services like his at its disposal. It was worth money to anybody to have John I. Beggs work for him. President Ely also said that Mr. Goodrich was a very able man and a splendid organizer, and from the talks he had had with Mr. Goodrich during the past year, he knew that his heart was in this work. The same was true of Mr. Shaw, the third vice-president. Although he had not been a member of the executive committee during the past year, he had several times, at the invitation of the president, left his work, and he thought the members could rest assured that the affairs of the association would be taken hold of in a way which would produce results. Outside of the official personnel of the organization there were a large number of gentlemen who were very much interested in the work who had been freely called upon during the past year, who had given very freely of their time and made most valuable suggestions. At some proper time in the future proper recognition should be paid them of their help, because they were very valuable men. As could be readily understood, sometimes a man working along lines like these has doubts as to the outcome of the plans which are made. He had been greatly strengthened during the past twenty-four months by the suggestions and by the expressions of men notable in the world of railway achievement, and he wanted to mention one. Yesterday he was at luncheon with Dr. Wilson, the president of the Commercial Museum. Dr. Wilson had invited Theodore N. Ely, who has charge of the entire motive power of the Pennsylvania Railroad, to take luncheon with him also. There was a short talk between them, and Theodore N. Ely requested a short statement from the president of what they were doing. Then Theodore N. Ely, who has been a member for years of the executive committee of the Railway Association, and also of different engineering societies, outlined what he thought as a rough suggestion, would be the plan they should have and what he said would be of immeasurable advantage to the association. If he had been reading the proposed form of reorganization carefully he could not have sketched and outlined it much better than he did. The suggestions he threw out were very pleasing to the president at that particular moment. Theodore N. Ely further said that there was no question in the minds of the men who to-day are directing the great railway systems, that the Master Car Builders' Association and the Master Mechanics' Association and the different organizations relating to steam railway work had been of immeasurable value to the steam railroads, and had put forward by years the time of arrival at the present standard of steam railroad work, and he said further that the wisest man, the man who can see furthest to-day, can see but a short distance and can form but a faint impression of the work the members of the American Street and Interurban Railway Association were engaged in. The electrical development is occupying and engrossing the attention of the foremost men in steam railroad work, and he argued great good to the railroad industry from this organization.

The president, in conclusion, said that if the members worked wisely and well, taking good advice and following it, and all co-operated, that in a year's time he believed the association could make an amazing stride.

The association then took a recess for luncheon.

THURSDAY AFTERNOON SESSION

President Ely called the meeting to order at 2:15 o'clock. At the afternoon session the papers on "The Single-Phase Railway System," by Charles F. Scott, and on "Electric Railway Equipment," by W. B. Potter, were read. Both of these papers are published elsewhere in this issue.

There was a lengthy discussion on these papers which will appear in a later issue.

On motion of W. E. Harrington the following resolution was passed:

Resolved, That a vote of thanks of the association be extended to the authors of the very interesting and valuable papers presented at this convention; and be it further

Resolved, That this association appreciates the courtesy of the manufacturers in permitting the preparation of the character of papers presented and the attendance of their experts in connection therewith.

On motion of Mr. Harrington the following resolution was also adopted:

Resolved, That all regular standing committees of this association shall hereafter consist of three members.

Mr. Beggs, who was appointed chairman of the committee to prepare suitable resolutions with reference to the services of Thos. C. Penington as secretary and treasurer of the association, offered the following on behalf of the committee:

Whereas, Thomas C. Penington, who has been the secretary and treasurer of the American Street Railway Association for ten years past, having severed his official relation because of the determination of the association to establish headquarters in the city of New York, and the necessity of continuous attention to its affairs by the secretary; therefore, be it

Resolved, That the American Street Railway Association does hereby record a minute of its earnest appreciation of Mr. Penington's fidelity to its interests, his devotion to its welfare and the eminently honest and satisfactory manner in which he has discharged the rusts imposed upon him; and

Resolved, That Mr. Penington's relations to the individual members of the American Street Railway Association have established friendships which will last through life, and they part with his services as an officer with the deepest regret and with lasting appreciation of his kindly thought and attention to themselves and their friends during the many conventions which have been held under his able assistance. Respectfully submitted,

JOHN I. BEGGS,
C. G. GOODRICH,
W. E. HARRINGTON.

The resolutions were unanimously adopted by a rising vote.

Mr. Beggs stated that for two years past there had been a committee of the association upon the matter of rates paid by the government for mail service on the cars of the members of the association. That committee had done nothing during the past year, and he therefore offered the following resolution:

Resolved, That a committee of three active members of this association be appointed to present to and urge upon the honorable Postmaster-General and the honorable committee on postal affairs of the Congress of the United States the necessity of allowing and providing for much larger compensation for carrying the mails on street and interurban railways, both for postal car and pouch service, and likewise the necessity of modifying the conditions under which such service is performed.

The resolution was adopted.

The president appointed as a committee on United States mail service the following-named gentlemen: John I. Beggs, of Milwaukee; G. Tracy Rogers, of Binghamton, N. Y., and P. F. Sullivan, of Boston.

The following report of the committee on rules was presented:

REPORT OF STANDARD RULES COMMITTEE

The standard rules committee respectfully submits the following report:

First—At the instance of the committee the secretary sent out a circular to all the members of the association, requesting suggestions applicable to the last report of the committee, together with any ideas which would enable the committee to make further progress in their work. The replies received indicated to the committee that the rules governing city lines had to a large extent been adopted.

Second—The committee finds a diversity of opinions and ideas in relation to the rules for the government of interurban lines, and they recommend the rules adopted by the American Railway Association for the operation of steam railroads, which are the result of years of study and experience, be adopted by interurban lines as far as practicable, and we further recommend that the secretary of this association furnish to each member a copy of these rules, and that the members of the association inform the standard rules committee as to the applications of those rules to the lines which they operate, making such suggestions and recommendations to the committee as will be of value in the prosecution of its work.

The committee further recommends that the work of the standard rules committee be continued, and that at least two members of said committee shall be operators of or familiar with the operation of interurban lines.

Respectfully submitted,

E. G. CONNETTE,
W. E. HARRINGTON,
ROBERT McCULLOCH,
JOHN J. STANLEY.

On motion the report of the committee was adopted.

The president appointed the following-named gentlemen as the rules committee: E. G. Connette, Richard McCulloch and E. C. Faber.

The president appointed as the committee on insurance the following-named gentlemen: H. J. Davies, E. W. Olds and T. C. Penington.

The committee on resolutions then reported a set of formal resolutions, in which the thanks of the association were extended to the American Street Railway Manufacturers' Association, its officers and members; to John B. Parsons, president of the Philadelphia Rapid Transit Company, and the other officers and heads of departments of that company; to the officers of the Philadelphia & West Chester Traction Company; to the passenger railroad associations for reduced rates; to Dr. W. P. Wilson, director of the Philadelphia Commercial Museum; to the officers of the Engineers' Club, the Manufacturers' Club and the Southern Club for courtesies during the convention; to Mayor John Weaver; to the citizens of Philadelphia; to the local press; to the local entertainment and reception committees; to the hotels; to the local and long-distance telephone and telegraph companies; to the local postoffice officials and to all the civic, social and business interests of the city of Philadelphia, who have contributed in so large measure to the success of the meeting.

The resolutions were unanimously adopted.

On motion of Mr. Bean the following resolution was adopted:

Whereas, The Accountants' Association will be in session until Saturday afternoon, Sept. 30, 1905,

Resolved, That this association do now take a recess until the close of the last session of said Accountants' Association, at which time this association will stand adjourned sine die.

The meeting then adjourned.

CONVENTION NOTES

The arrangements for the convention hall and exhibit features were most complete and showed great care and elaborate preparation on the part of the local committee of the Manufacturers' Association. The exhibits are referred to at greater length elsewhere and will be described in extenso next week. The convention hall was improvised from a gallery over the south wing of the museum and which formerly was used for storage purposes. Here a spacious hall had been partitioned off with double doors, and the wall lined with paper to intercept any sound which might penetrate from outside. On the three remaining sides a series of tall windows gave all the light and ventilation required. The hall was decorated with potted plants, and the platforms with rows of palms and potted flowers. Behind the speaker's chair was a floral design reading, "Philadelphia, 1905, Welcome." The hall was amply large enough to hold all those in attendance on Wednesday and on other days. A similar room was provided at the other end of the gallery for the accountants. The American and Mechanical Associations met at the west end of the building.

The badges this year were very tasteful. They were in blue and gold, and showed a double-truck car mounted upon a keystone, upon which was a representation of a Liberty Bell. The design was surrounded by two flags and surmounted by an eagle. As usual, five colored ribbons were used, blue for the American Association, brown for the Mechanical, orange for the Accountants, red for the Manufacturers, and white for the guests. Following the practice last year, every badge was numbered and an index was published, both alphabetically and by numbers, of the attendants at the convention. The index was published on different days and in several editions. Edition 1 covered the registration for the first two days, and edition 2, that of the first three days. In view of the large number of names recorded, the accuracy with which these names were printed is worthy of remark.

The Philadelphia Rapid Transit Company and the Philadelphia & West Chester Traction Company issued books containing forty-eight tickets to each attendant at the convention. These books were distributed by the respective secretaries and were greatly appreciated by the attendants.

The interchangeable coupon ticket books have been placed on sale in Indianapolis. They are good over twenty Ohio, ten Indiana and two Michigan lines. The book sells for $10, or at a reduction of 16 2-3 per cent. It cannot be presented for payment on a ride which calls for less than two coupons.

THE BANQUET

The annual banquet was held Thursday evening, Sept. 28, in the clover ball room of the Bellevue-Stratford, which had been exquisitely decorated for the event with palms and cut flowers. A touch of appropriate sentiment was happily secured by including on the stage at one end of the ball room, partly screened amid banks of palms, a perfectly constructed model of a New York Broadway car, as built by the John Stephenson Company. The model was loaned for the occasion by the J. G. Brill Company. Another touch of "localism" that was fully appreciated by the diners was the serving with the "Sorbet Transit" of a miniature trolley car. About 200 guests enjoyed the unusually fine menu provided.

The menu card was cleverly designed to represent the great conquest of Franklin in the field of electrical science and the modern application of electricity to the traction industry. The design included an artistic presentation of a figures of Franklin, acting as a medium for diverting the electric current from the clouds to a modern electric interurban passenger coach.

During the dinner John B. Parsons, president of the Philadelphia Rapid Transit Company, acted as toastmaster, and added much to the enjoyment and success of the evening by his happy and well-chosen introductions. Responses to the toasts were made as follows: "Franklin's Day and Ours," Hon. John Weaver, Mayor of Philadelphia; "The Association," W. Caryl Ely; "Our Canadian Brethren," George Tate Blackstock, K. C.; "Corporations and the Commonwealth," Thomas N. McCarter; "Street Railway Management," John I. Beggs; "The Trolley," Gen. Eugene Griffin; "The Ladies," James Rawle.

THE THEATER PARTY

Invitations to attend a theater party on Wednesday evening were extended by the Manufacturers' Association to all those in attendance at the convention. The entire seating capacity of the New Lyric Theater was secured and the attendance was very large. The play given was John C. Fisher's colossal production of "Babes in the Wood," and it was heartily enjoyed by about 1800 of those in attendance at the convention. No local hits were introduced in the performance, but the production was an excellent one, and this method of entertainment proved very popular, judging by the demand for tickets.

THE RECEPTION

The reception at the Bellevue-Stratford, on Tuesday evening, was the most elaborate ever held at a convention of the association. It was held in the ball room and adjoining foyers at the hotel, and was attended by a large number of the delegates and ladies. A list of the patronesses was published in our last issue, and included ladies whose husbands are prominent in Philadelphia railroading, manufacturing and social circles. The ball room itself was beautifully decorated, and an orchestra on the stage furnished excellent music for dancing, which was participated in by some of those in attendance. About half-past 10 an elaborate supper was served in an adjoining room, and most of the guests departed about 12 o'clock.

ANNUAL MEETING OF THE MANUFACTURERS' ASSOCIATION

The annual convention of the Manufacturers' Association was held on the afternoon of Sept. 27. Under the constitution of the association the terms of office of five of the members of the executive committee expired this year. Three of these were re-elected, and the committee now consists of: J. R. Ellicott, of the Westinghouse Traction Brake Company; John A. Brill, of the J. G. Brill Company; Charles Knickerbocker, of the Griffin Wheel Company; Charles K. King, of the Ohio Brass Company; George J. Kobusch, of the St. Louis Car Company; Charles C. Peirce, of the General Electric Company; Howard F. Martin, of the Pennsylvania Steel Company; James H. McGraw, of the McGraw Publishing Company; John W. Nute, of the St. Louis Car Wheel Company; Frank C. Randall, of the National Electric Company; Newcomb Carlton, of the Westinghouse Electric & Manufacturing Company; William Wharton, Jr., of Wm. Wharton, Jr., & Company; Fred S. Kenfield, of the Kenfield Publishing Company; E. H. Baker, of the Galena Signal Oil Company; E. M. Williams, of the Sherwin-Williams Company.

George Keegan was re-elected secretary of the association.

The executive committee, after the election, did not formally organize, but E. H. Baker, of the Galena Signal Oil Company, was elected chairman pro tem.

THE CHICAGO SITUATION

The public meeting campaign of Mayor Dunne, of Chicago, was begun last week. At the first of these meetings, held Tuesday evening, Sept. 19, at Lincoln Avenue and Roscoe Street, the Mayor unfolded his "contract plan," for bringing the companies to terms. In explaining why he had abandoned his plan to condemn the lines of the traction companies, according to his declared policy in numerous speeches during the city campaign, Mayor Dunne said:

"When I was making my campaign last spring I understood that the franchises had expired on only about 20 miles of tracks, of which the city could take immediate possession; that was the Adams Street line. After my election I appointed special counsel to look into the matter and they found that the franchises had expired on 130 miles of line, and that within two years franchises would expire on 114 miles of additional lines. They found that within two years 274 miles out of a total of 700 will be at the disposal of the city without condemnation proceedings.

"During the campaign we said we would offer the companies fair, reasonable, and full price for their properties. Although we have endeavored in every way to get these companies to place a price on their property, they have refused. We agreed that if we couldn't buy the properties we would condemn them. We advocated that proceeding, because we thought we had only a few miles of track at our disposal. We find that all we have to do is to take possession of these 274 miles of trackage, which cover the most populous districts of Chicago. These 274 miles will reach 1,100,000 people.

"We can dispossess the companies of these lines by placing a policeman at each end of the track on which the franchise has expired. That is the situation as I found it when I presented my message to the City Council July 5, proposing that a company be organized to build a street car system for the city. That plan has been before the people nearly three months. It has been calumniated and villified, but no defect has been discovered in it."

Mayor Dunne then read his message and commented on it. In reference to the referendum he declared:

"No ordinance shall ever pass, unless over my veto, which does not contain a provision that it shall be submitted to the people for their approval."

The Mayor said he favored his "contract plan" to a purchase of the companies' properties, as proposed in his "city plan," because it would be six months before the question of issuing the Mueller law certificates could be submitted to the people, and six months more to test their validity in the courts. To save delay he proposed the contract plan. Work could be begun at once, and the test of the Mueller law certificates could be had while the work was going on.

"The company I propose to organize is a constructing company," he said. "Every dollar it earns over the cost of construction and operation and the payment of 5 per cent on the money borrowed will go to the city. The City Council will pass on the plans and specifications, and on every contract made."

The Chicago City Railway on Tuesday, Sept. 26, submitted terms on which it asks a twenty-year franchise. The company agrees:

To interchange transfers and route through cars over Union Traction lines.

To rehabilitate lines with new cars and grooved rails, and to furnish service as required by City Council.

To accept a twenty-year franchise in lieu of all present rights and let the city purchase after a stated time.

To change all cable lines to trolley power, using underground trolley in State Street and down town if desired.

To sweep and sprinkle streets occupied by its lines.

To fill, grade, pave and repair 16 ft. of street occupied by its lines.

To make public reports of its earnings.

To pay compensation on a percentage basis, increasing with length of grant, charging 5 cents fare.

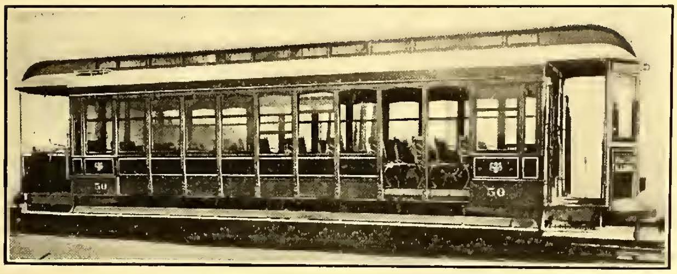
With an offer variously estimated to be equivalent to $30,000,000 or $35,000,000 in cash to the city, and providing for the termination of all rights under the ninety-nine-year act and ordinances, at the expiration of twenty years, General Counsel E. R. Bliss, of the City Railway Company, laid the entire traction proposition before the Council committee Wednesday afternoon, Sept. 27.

In the event that the city desires to own and operate the street cars at an earlier date, the ordinance provides that it shall have the right to purchase the lines at specified times, the Council to insert the dates, by paying the cash value of the physical property at the time of purchase and also the price fixed by arbitration as the value of the unexpired part of the franchises.

CONVERTIBLE CARS FOR SHREVEPORT COMPANY

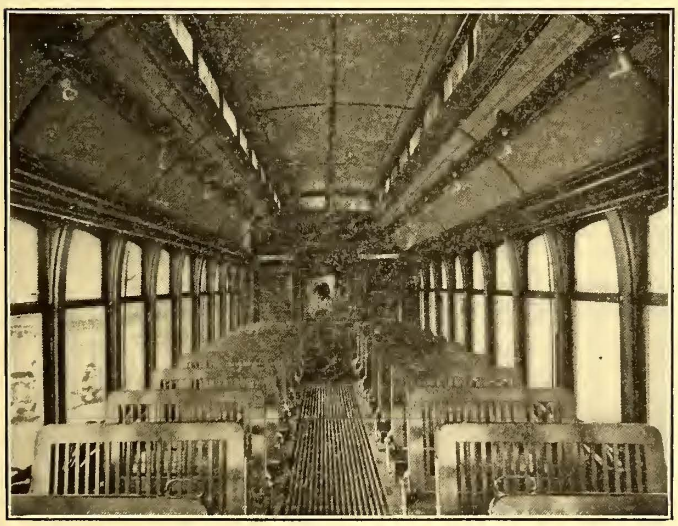
The Shreveport Traction Company has lately received from the American Car Company several of the convertible cars illustrated, built under the Brill patents. Shreveport is the second city of commercial importance in the State, and does a large business in lumber and cottonseed oil. The convertible type mentioned is in considerable use in the Gulf States, where the climate is semi-tropical.

The sill step is a modification of the Narragansett type, and is wider than appears in the illustration, giving ample room for a secure foothold. The cover plates for the openings over these steps when the panels are drawn down may be plainly seen in the picture in their folded position. When the car is closed, these plates are raised flush with the floor and present an even surface. The value of this extra step will be at once recognized when it is



CONVERTIBLE CAR FOR THE SHREVEPORT TRACTION COMPANY, SHOWING TWO OF THE PANELS REMOVED

noticed that double trucks having equal sized wheels are used under the cars. With such trucks the car floor is too high to be easily and safely reached by a single step. The running board is the same height from the track as the platform step, and from sill step to car floor is same height as from platform to car floor. These heights are respectively 18 ins., 14½ ins. and 7½ ins. In the view of the exterior of the car two pairs of windows are shown raised at different heights, and a pair of sashes and panels are raised entirely into the pockets in the side roofs. The operation of raising and lowering the sashes is so simple that conver-



INTERIOR VIEW OF SHREVEPORT CAR

sion is practically instantaneous. The interiors are finished in golden oak, with three-ply birch veneer ceilings tinted a light green. The seat backs are provided with brackets between the backs and posts, which enclose the space and also provide hand grips for the use of passengers in entering and leaving by the side openings. The platform at front end of car is intended for use of motorman only, while that at rear end is long and of the "Detroit" type, divided with a hand rail.

The cars are mounted on Brill No. 27-G-E-1 trucks, having solid forged side frames and wheel base of 4 ft. and 33-in. wheels. Each car has a motor equipment of four 40-hp motors. The length over the body is 30 ft. 8 ins., and over the crown pieces, 41 ft. 4½ ins.; over the panel from the crown piece, 4 ft. 6 ins. at the front end, and at the rear end, 6 ft. 2½ ins. The width over the sills, 8 ft. 1 in.; width over the posts at the belt, 8 ft. 5 ins.; sweep of the posts, 1½ ins.; distance between the centers of the posts, 2 ft. 7 ins. The side sills are 2½ ins. x 7¾ ins., and the Z-iron sills, 6⅛ ins. x 8 3-16 ins. x 15-16 in.

THE NEW B. F. STURTEVANT COMPANY WORKS AT HYDE PARK, MASS.

As far back as 1901 the growth of the B. F. Sturtevant Company, formerly of Jamaica Plain, Mass., demonstrated the need of a new location, and a fire in that year which destroyed a large amount of valuable machinery naturally hastened the development of a new factory. This is now located about three-eighths of a mile north of the Readville station in the town of Hyde Park, and the plant comprises a group of buildings thoroughly representative of the latest ideas in production economy. The company manufactures heating and ventilating apparatus, industrial railway systems, general factory equipment, engines, dynamos and motors. The site consists of about 20 acres, with a frontage of 1300 ft. along the New York, New Haven & Hartford freight yards near Readville, occupied by about a dozen buildings, with an aggregate floor area of 9 acres.

An industrial railway system of 2-ft. gage connects all departments; spur tracks from the New Haven yards facilitate the movement of raw material and products; traveling cranes, pneumatic, electric and manual hoists and electric elevators are scattered throughout the works, and all machinery is motor-driven with the exception of the ventilating fans and air-compressor equipment. The building construction is of composite character, consisting of steel interior columns and main steel girders, with brick walls, timbered floors and plank roofs. Ribbed glass is used in all windows except those on the first floor. About 3800 Grinnell automatic sprinklers are in service; fire hose is stored in red-painted boxes for emergency use; self-closing fireproof doors are installed between many of the departments; fire pails are frequent in conspicuous places, and at night watchman service is maintained. Water at 90 lbs. per square inch is available from the Hyde Park system, and a 1000-gal. per minute Blake Underwriters' Line pump is in a house near the power plant.

The boilers in the power plant are of Stirling make, with a total rating of about 1000 hp, and the plant naturally contains mechanical draft apparatus and a Sturtevant economizer. The generating sets were built by the company, and are at present two in number, 100 kw and 250 kw. The power house supplies all the steam used in the different buildings, the steam pressure being reduced from 160 lbs. to serve different purposes.

All the electrical distribution is carried out upon the two-wire plan at 220 volts direct current for both power and lighting. General illumination is supplied by General Electric 110-volt enclosed arc lamps run two in series, and all special lighting is by 16-cp, 220-volt incandescents. The air compressor in the power house is a Laidlaw-Dunn-Gordon machine with compound steam and compound air cylinders, distributing air at 100 lbs. pressure throughout all the shops.

There are about 100 electric motors in the plant, varying in size from ¼ hp to 40 hp, all being of the company's own make. Both group and individual driving of machines are in use. All motors above 10 hp are equipped with General Electric circuit breakers, enclosed fuses being used in smaller sizes. Starting boxes and controlling switches are located either on posts close by the machines, or in the case of some connected motors, upon the machine frames. Practically all the motors used in group driving are hung from the ceilings. At various points in the factory where power is required for testing or other temporary purposes, plug boxes are installed upon certain of the vertical columns within easy reach of the floor.

Several motors are effectively used in the pattern shop and foundry. In the former, the flask shop band, cross-cut and splitting saws, boxing machine and the lathe are all driven by a 10-hp motor, while the carpenter shop or pattern making division proper is equipped with two 10-hp motors which operate two band saws, a buzz planer and a double surfacer, five lathes, a drill press, core box machine and wood trimmers. Both these motors are required in ordinary work, one serving as a possible relay in case of accident. In the foundry, two 20-ton electric traveling cranes are in regular use, one upon each of the runways, and the floor between the runways is served by 1½-ton electric traveling hoists with 10-ft. span, built by the company. The cupolas are two in number, of Whiting make, 56 ins. and 72 ins. in diameter. The former is supplied with air by No. 8 Sturtevant pressure blower driven by a 30-hp motor, and the latter by a No. 10 blower driven by a 40-hp motor. In the brass foundry, blast for the furnaces is supplied by a No. 3 Monogram blower, and the entire machinery, consisting of a spur cutter, a magnetic separator, a tumbling barrel and emery wheels, is driven by a 5-hp motor attached to the wall. In the core department is a Blake wire straightener, driven by a 5-hp motor.

All the elevators in the works are electrically driven. The principal traveling cranes are all of Whiting make, with Sturtevant motors. Armature punchings and commutators are built up in the uppermost floor of the fan and heater shop, adjoining the testing building. The storage of commutators and parts is effected on divided pigeon-holes, numbered according to the shop scheme for quick reference. The armature baking room is 40 ft square, entirely fireproof, and it contains two steam-heated baking ovens, fitted with sheet-iron doors and discharge ducts. At the other end of the building is the special storeroom for electrical supplies. The balance of this floor and of the intermediate floor below is devoted to winding, assembling and testing. The electrical designs are worked out in the office building.

Heavy testing is mostly carried out upon the first floor. Here is a testing plate 30 ft. x 60 ft., completely equipped with steam and electrical connections; engines may be run condensing or non-condensing, and efficiency tests, compounding tests and heat runs conducted. The winding department on the third floor is arranged conveniently with bench scales, reel frames, magnet connections at intervals of 20 ft., lamp banks and armature racks. Small traveling cranes and hoists are constantly in use on this floor, which is equipped with a floor plate for testing motors and blowers. A complete permanent switchboard forms part of the testing room equipment, and all direct-current voltages from 80 to 550 are available for testing, as well as alternating voltages up to 2500, the latter being used in insulation break-down tests. On the rear of this board are circular bus-bars, to which flexible cables may be clamped as may be convenient. Variation in voltages is obtained by operating motor-generator sets. Portable test tables and lamp banks are available; a water rheostat plant is located on the roof, and instruments are stored in the office, which is being equipped for curve tests upon samples of iron used in the machines. The foundry of the company supplies this material, which runs evenly most of the time, but which needs checking magnetically now and then.

The architects and engineers for the B. F. Sturtevant Company were Lockwood, Greene & Company, of Boston. The construction of the plant, including the entire industrial equipment manufacture, was carried out by the Sturtevant Company.

MINOR B. R. T. IMPROVEMENTS

Some very important improvements are to be made at the Ridgewood Incline and storage yard of the Brooklyn Rapid Transit Company. These are to consist of new steel, concrete and earth work, new track work on the elevated structure and on the surface, and some special work at Fresh Pond Road on the Lutheran line, which will require some tapping and blasting for new track. At the storage yard on the Lutheran line more than $100,000 will be spent in new track work, inspection pits, and a new inspection shop to cost $65,000, also a new bridge and considerable overhead work.

The rearranging of the Thirty-Sixth Street and Fifth Avenue terminal is progressing satisfactorily. The total cost of the improvements there will be in the neighborhood of $350,000. They include the arranging of the surface yard with inspection pits, the elevated yard with a new inspection shop, the boiler house with new retaining walls, also extensive alterations to the Union Station building and the building of a machine shop. Extensive work is under way at the Ninth Avenue depot of the company, located at Ninth Avenue and Twentieth Street, on the extension of the storage facilities, etc. All cars of the Seventh Avenue, Vanderbilt Avenue, Fifteenth and Court Street lines are handled at this depot, which in the past has been cramped for space. At present the capacity of this depot is only 200 cars. When the improvements are made there will be facilities for handling 400 cars. The total cost of these alterations and improvements will amount to more than $400,000, divided as follows: New tracks and rearranging of them, $65,000; excavating, $25,000; new sheds, $268,000; new shop, $25,000; new office and club house, $22,000.

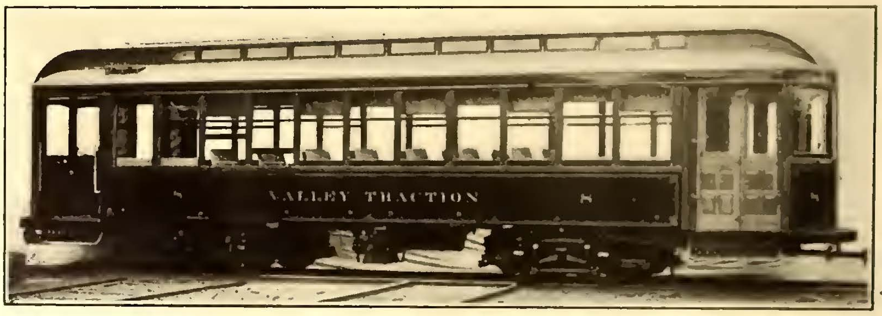
The Brooklyn Rapid Transit Company Sept. 22, placed an order with the Baldwin Locomotive Works for 300 trucks, 150 sets, to be used on a new order for 150 cars of the convertible type, such as were first placed in use during the early summer and which have been described in the Street Railway Journal. This is the second order that has been given for this new type of car. The placing of it will do away with many of the old type single-truck cars remaining in service, and will make 350 of this new type in all. The first shipment of the order for 150 will probably arrive in Brooklyn some time during January. One feature of the new car is the elimination of the dangerous running board Another feature is the use of four motors instead of two as on the old car.

BOLAND INTERESTS PLAN NEW LINE FROM JACKSON TO DETROIT

Articles of association have been forwarded to the Secretary of State of Michigan by a new company which will construct and operate a second electric railway from Jackson to Detroit. The new company is known as the Jackson, Ann Arbor & Detroit Electric Railroad Company. It is planned to accomplish the purpose of the company by extending the Boland line, running from Jackson to Dexter. This line is now operated in conjunction with the Jackson & Battle Creek Traction Company. The officers and directors of the new company are: W. A. Boland, president; Charles W. Osborn, vice-president, and N. S. Potter, secretary and treasurer. The board of directors is as follows: W. A. Boland, of 31 Nassau Street, New York; Charles W. Osborn, with Russell Sage, of 31 Nassau Street, New York; N. S. Potter, of the Jackson City Bank; Hon. Silas B. Dutcher, president of the Hamilton Trust Company, of Brooklyn, N. Y.; Henry R. Carse, cashier of the Hanover National Bank and a director in other New York financial institutions.

SEMI-CONVERTIBLE CARS FOR CHAMBERSBURG, PA.

The Valley Traction Company, Chambersburg, Pa., has lately received from the J. G. Brill Company a number of semi-convertible cars. These cars have the patented "grooveless post" arrangement, which does away with the runways, or grooves, in the posts and the trunnions on the sashes, which were formerly employed. The sash stiles are made of brass, and there is a brass tongue-and-groove sliding connection between the two sashes, so that the lower rides upon the upper. When the tops of both sashes are abreast, catches which hold the upper sash in its lowered position are automatically released, and both sashes are conducted into the roof pocket by means of a pair of bow-shaped steel guides which extend from the top plate to the lower ventilator rail within the pocket. This very simple means of guiding the sashes into the pockets is a decided improvement over the old method, particularly as it does not require cutting grooves in the posts, and also reduces the width and depth of the roof pockets.



ONE OF THE FINE DOUBLE-TRUCK SEMI-CONVERTIBLE CARS USED IN CHAMBERSBURG, PA.

The seating capacity of the new cars is forty-four passengers, the seats being of spring cane and transversely placed, with the exception of four longitudinal corner seats. The seats are 36 ins. long, leaving a 24-in. aisle. Ash in natural color constitutes the interior finish, and the ceilings are of a soft porous wood and are neatly decorated. Removal sashes are used in the vestibule doors. The weight of a car and trucks with full electrical equipment is 42,840 lbs. Among the builder's specialties included in the equipment are angle-iron bumpers, "Dedenda" gongs, "Retriever" signal bells, ratchet brake handles, "Dumpit" sand boxes, etc.

The general dimensions of the cars are as follows: Length over the end panels, 30 ft. 8 ins., and over the crown pieces and the vestibules, 42 ft. 8 ins.; panel over the crown piece and the vestibule, 6 ft. The width over the sills and sheathing is 8 ft. 4 ins.; distance between the centers of the posts, 2 ft. 8 ins. The side sills are 4 ins. x 7¾ ins., and the end sills are 5¼ ins. x 6⅞ ins. The sill plates are 15 ins. x ⅜ in. The thickness of the corner posts is 3⅝ ins., and of the side posts, 3¼ ins. The trucks are of the Brill No. 27-G-1 type for fast and heavy city and suburban service, having a 4-ft. wheel base and 33-in. wheels.

FINANCIAL INTELLIGENCE

Wall Street, Sept. 27, 1905.

The Money Market

A decidedly firmer tendency characterized the money market during the week, rates for all maturities ruling substantially higher than those recently quoted, and from present indications a still firmer market is likely in the near future. The demand for funds from local sources has not been heavy, but the banks and other lenders continued to offer sparingly, even at the higher level. In addition to the usual outflow of funds to the interior for crop-moving purposes, which promise to be heavy for several weeks longer, the local institutions will be called upon to meet other heavy demands within the next thirty days. This week the syndicate payments on the Pennsylvania Railroad and the Atchison issues becomes due, but it is understood that the greater part of these obligations have been discounted. Provision must also be made for the Oct. 1 interest and dividend disbursements, and later the payment of an installment on account of the Japanese loan will have to be taken care of, besides several smaller issues now pending. Gold engagements at London for import to this side have been increased during the week, the total now amounting to $5,929,000, and it is reported that $5,000,000 additional gold is en route from Australia to San Francisco. The future movement of the yellow metal, however, depends largely upon developments in the exchange and money markets, and the opinion prevails that unless demand sterling declines sharply, or money rates advance to a higher level, further large engagements are unlikely at this time. The European markets continue firm, but practically unchanged as to rates. At London discounts are quoted at 3 per cent, Paris 2⅛ per cent, and Berlin 3⅜ per cent. The bank statement, published a week ago, was more favorable than expected, the banks sustaining a loss in cash of only $2,689,600. Loans decreased $9,381,300, and deposits decreased $13,157,400. There was also a decrease in the required reserves of $3,289,350, which resulted in an increase in the surplus of $599,750. The surplus now stands at $5,255,050, as against $26,251,025 in 1904, $14,569,300 in 1903, $3,236,625 in 1902, $16,293,025 in 1901, and $1,2442,600 in 1900. Money on call loaned at rates ranging from 3½ to 4½, most of the transactions being made at 4 and 4¼ per cent. Time money was quoted at 4¼ and 4½ per cent for all periods from two to seven months. Commercial paper was fairly active and strong, specialists reporting a ready sale of the best names at 4½ per cent, and liberal sales of other names at 5 per cent.

The Stock Market

Trading in the stock market has been upon a somewhat larger scale during the week, and although prices displayed more or less irregularity as a result of realizing sales, the general tone of the market ruled firmer. Speculation, however, has been largely of a professional character. Operations for foreign account at no time assumed large proportions, and judging from the volume of commission house business, public interest in the market continues extremely light. There was less apprehension regarding the monetary situation, further advances in rates for both call and time loans being almost entirely ignored. In the early dealings prices were influenced to a great extent by the additional engagements of gold for import to this side, the total now amounting to nearly $11,000,000, including the $5,000,000 reported in transit from Australia to San Francisco. Further engagements of the yellow metal, however, are not expected, the inflow having been temporarily checked by the sharp advance in prime sterling bills to 4.8565. At the beginning of the present week the market was under heavy selling pressure by Western houses, which carried prices off 1 per cent or more, but in the subsequent dealings the upward movement was resumed, and the closing was near the highest of the week. Underlying conditions continue exceptionally strong; gross and net railway returns, as a rule, show gratifying increases over those for the corresponding period of last year, and according to the reports from the Western traffic managers there is every reason to expect a continuance of the present heavy movement of merchandise. Other favorable influences were the continued activity in the iron and steel trade, the advance in the price of copper metal and the increase of 50 cents a share in the dividend distribution in Anaconda Mining stock. A noteworthy, strong feature of the market was Canadian Pacific, which made a new high record price. Pronounced strength was also exhibited in Reading, Union Pacific, Great Northern, Northern Pacific, Illinois Central, Louisville & Nashville, Delaware & Hudson and Chicago & Northwestern. Toward the close there was heavy buying of United States Steel common on persistent reports of an early resumption of dividends in the stock. Sloss-Sheffield Iron & Steel and Tennessee Coal were also strong features.

The local traction issues were generally strong, especially Brooklyn Rapid Transit, which was heavily bought by Philadelphia houses and by strong local interests. The strength was accompanied by rumors that the Long Island Railroad Company had acquired a large interest in the property.

Philadelphia

Trading in the local traction issues has been upon a much smaller scale this week, but the tendency of prices has been toward a higher level, in sympathy with the strength prevailing in other quarters of the market. The list included less than a dozen issues, only one or two of which developed any degree of activity. In the early part of the week interest centered largely in Philadelphia Company common. There was some disposition to sell on the part of the speculative element, which carried the price down to 47¼, but subsequently there was an advance to 47⅞, on what was considered good buying. At the close there was a reaction to 47½. Total transactions amounted to about 10,000 shares. Philadelphia preferred was practically neglected, the trading consisting of a few small lots at 48½ and 48⅜. Philadelphia Rapid Transit displayed moderate activity, and after an advance to 28¾, the price eased off to 28, a loss of ⅛. Over 7000 shares changed hands. Philadelphia Traction responded to an increased demand by advancing from 99½ to 100¾, on the purchase of about 700 shares. Consolidated Traction of New Jersey held firm at 83⅜ and 83½. Union Traction sold at 62 and 61⅞ for about 700 shares. Other transactions included United Companies of New Jersey at 267½ ex. the dividend, 150 United Railways of San Francisco preferred at 89¾, Railway General at 3⅞, and American Railways at 53⅛ and 53.

Baltimore

Trading in traction issues at Baltimore has been broader, and prices with few exceptions have shown an upward tendency. United Railway issues again furnished the leading feature, trading in them being stimulated by reported heavy buying by the pool, and by persistent rumors of a deal of some kind. Definite news regarding the company's future, however, was not forthcoming. Interest centered largely in the income bonds, which were heavily dealt in. From 66¾ at the opening the free incomes rose to 67⅞, but later reacted fractionally. Upward of $30,000 changed hands. The certificates, representing bonds deposited, for the first time sold on a parity with the free bonds, about $75,000 changing hands at prices ranging from 66 to 67⅜. The 4 per cents ruled quiet and firm, upwards of $70,000 selling at from 92¾ to 93¼. The stock displayed considerable activity, about 2500 shares being dealt in at prices ranging from 16⅞ to 16¼, while more than 10,000 shares of the deposited stock sold at from 16½ to 17½, and back to 17. Other transactions included Norfolk Railway & Light 5s at 94, Virginia Electric Railway & Development Company at 100 and 99¾, City & Suburban 5s at 114½, Norfolk Street Railway 5s at 113, and North Baltimore 5s at 121⅜.

Other Traction Securities

Trading in the Chicago market was more active than for some weeks past, and prices generally scored substantial gains over those ruling at the close of last week. Interest centered in the stocks of the surface lines, prices being influenced largely by the sharp rise in Chicago Union common and preferred in the New York market. There was also talk of important developments pending regarding the Chicago street railway situation. Chicago Union Traction rose from 8½ to 10, an advance of 1½ points, while North Chicago moved up 4 points to 74 on the purchase of about 400 shares. West Chicago advanced from 50 to 55, and a small lot of City Railway brought 192, an advance of 2 points over the preceding week's closing bid quotation. The elevated issues also shared in the improvement, about 400 shares of Metropolitan common selling at 25 and 25¾, while the preferred rose from 70 to 71⅜. Northwestern sold at 23, and South Side Elevated ruled firm at 97. Chicago & Oak Park common brought 4¾, and the preferred sold at 17 and 16⅞. The activity and strength in Boston & Worcester common was the principal feature of the Boston market, upwards of 2200 shares changing hands, at from 29½ to 30¾, and back to 30¼. The preferred stock was weak, the price running off 1½ points to 74 on the sale of small lots. Massachusetts Electric common broke from 16¼ to 15, and closed at the lowest, aggregate transactions being about 800 shares, but the preferred held steady at 59 and 59½. Boston Elevated sold at 153½ and 154. Boston & Suburban common sold at 21 and 20, and the preferred at 66. West End common was reactionary, sales taking place at from 101¼ to 99¾, and of the preferred at 113½. In the New York curb market, Interborough Rapid Transit was considerably less active and weak, about 2500 shares changing hands at from 216⅝ to 211½, a loss of 4½ points. New Orleans Railway common declined from 37 to 36, but later recovered to 36¾, while the preferred advanced from 78¼ to 80. Washington Railway common sold at from 43 to 41¾ for 600 shares. Other transactions included 80 American Light & Traction at 102, $20,000 Washington Railway 4½s at 90½, $35,000 Public Service 5 per cent notes at 97⅛ and 97½ and interest, $25,000 Jersey City, Hoboken & Paterson 4s at 76½ and interest, and $30,000 United Electric of New Jersey at 75¾ and interest.

Announcements of dividend payment and increased earnings were probably responsible for strenuous movement in Cincinnati, Dayton & Toledo securities at Cincinnati last week. Some 4500 shares changed hands in small lots, advancing the price from 23¾ to 26½. Sales in the 5 per cent bonds amounted to $56,000 worth, at an advance to 97¾. Cincinnati, Newport & Covington common took an upward movement on new rumors of Widener-Elkins negotiations for the property; it opened the week at 38¼ and advanced to 40½; sales, 2800 shares. Cincinnati Street Railway sold at 147, a slight decline. Detroit United sold at 95⅝, a fractional advance, and $16,000 worth of the 4½ per cent bonds sold at 94½.

A record breaking week on the Cleveland Exchange. Cleveland & Southwestern was most active, about 3500 shares changing hands at from 12 to 14½. The report that the preferred dividend will be passed caused a drop two weeks ago, and since then insiders have been buying heavily. A pool to hold the preferred at 70 caused that issue to jump from 50½ to 62 on a few sales, aggregating less than 200 shares, and no more is to be had at less than 66. Northern Ohio Traction had another movement, advancing from 22¾ to 25 on sales of about 1800 shares. Muncie, Hartford & Fort Wayne made a slight decline on report that negotiations for the sale of the property to the Widener-Elkins syndicate were off for the time being, last sale being at 48. Western Ohio receipts strengthened slightly, selling at 15⅛. Aurora, Elgin & Chicago common braced up again and sold at 29⅞. Northern Texas bonds sold at 99.

Security Quotations

The following table shows the present bid quotations for the leading traction stocks, and the active bonds, as compared with last week:

	Sept. 20	Sept. 27
American Railways	52	52½
Boston Elevated	153	153½
Brooklyn Rapid Transit	68⅝	72
Chicago City	190	195
Chicago Union Traction (common)	8½	12⅜
Chicago Union Traction (preferred)	—	—
Cleveland Electric	79	78
Consolidated Traction of New Jersey	82	82½
Consolidated Traction of New Jersey 5s	109	109
Detroit United	93¼	93½
Interborough Rapid Transit	*215	212
International Traction (common)	34	39
International Traction (preferred) 4s	73	*74½
Manhattan Railway	165⅛	125⅞
Massachusetts Electric Cos. (common)	15½	15
Massachusetts Electric Cos. (preferred)	58½	57½
Metropolitan Elevated, Chicago (common)	25	25¼
Metropolitan Elevated, Chicago (preferred)	70	71
Metropolitan Street	126⅞	125⅞
Metropolitan Securities	80⅛	80¾
New Orleans Railways (common), W. I	36¾	36
New Orleans Railways (preferred), W. I	79	79
New Orleans Railways, 4½s	90¼	90⅛
North American	98	98
North Jersey Street Railway	28	28
Philadelphia Company (common)	47⅝	48
Philadelphia Rapid Transit	28	27¾
Philadelphia Traction	99	—
Public Service Corporation 5 per cent notes	96½	97
Public Service Corporation certificates	69¼	69½
South Side Elevated (Chicago)	97	97
Third Avenue	126½	126
Twin City, Minneapolis (common)	117	116½
Union Traction (Philadelphia)	61¾	61¾
West End (common)	100	99
West End (preferred)	113	113½

a Asked. W. I., when issued. * Ex-dividend.

Iron and Steel

The "Iron Age" says the past week has carried further the remarkable buying movement that burst upon the iron market two weeks ago, and the September tonnage is easily the greatest for a single month in the history of the trade. Veterans in the trade refer to the present market as the greatest in which they have participated. The United States Steel Corporation has bought 40,000 tons of Bessemer iron at $15 at furnace for delivery in September and October. Further iron will be required for October, and the corporation is expected to be a buyer of Bessemer at the rate of 40,000 tons a month well into next year. The total of its purchases in September is 80,000 tons. Bessemer iron is now squarely $15.50 at valley furnace. Coke manufacturers have advanced prices and are chary of long commitments. Rail buying and railroad equipment are still the backbone of the finished material markets. Fully 125,000 tons of rails have been booked in the week. The stringency in structural material is more marked.

U. G. I. INTERESTS GET WESTERN PROPERTIES—STORY OF CONSOLIDATION

Papers have been signed transferring four important Western traction companies to a Philadelphia syndicate headed by Randal Morgan, who is identified with the United Gas Improvement Company. The properties and the securities outstanding upon them are as follows:

	Bonds	Preferred Stock	Common Stock
Indianapolis Northwestern Traction Company	$2,470,000	$450,000	$2,550,000
Indianapolis Western	1,500,000	750,000	1,250,000
Columbus, Buckeye Lake & Newark	1,243,000	500,000	1,000,000
Columbus, Newark & Zanesville	1,250,000	400,000	850,000

All of these roads were built, financed and managed by Tucker, Anthony & Company. It is understood that the sale involves the transfer of about $14,000,000 in cash and securities. While these properties are not sold to the United Gas Improvement Company as a company, the fact that the Improvement Company has large traction interests in Indiana and Ohio which connect with the above four roads makes it quite possible that they will in time turn up in the ownership of these properties.

In this connection a statement coming from Philadelphia is of interest. It is to the effect that the purpose of the United Gas Improvement Company is to organize a separate company to consolidate the important traction lines in and around Indianapolis. In calling attention to the holdings of the United Gas Improvement in the territory mentioned, the authority quoted says that in order fully to understand the extent of the company's interests in Indiana it might be well to divide them into two parts—those which it is known practically to control and those in which it is rumored to be interested. Under the first class there may be included the following: (1) Indianapolis Traction & Terminal Company, (2) Indianapolis Street Railway, (3) Broad Ripple Traction Company, (4) Indiana Union Traction Company, (5) Fort Wayne & Wabash Valley Traction Company, (6) Union Traction Company of Indiana, (7) Indianapolis Coal Traction Company, and (8) Fort Wayne, Van Wert & Lima Traction Company. These lines Messrs. Morgan and Jones practically control. The other group—the lines in which rumor says the company is interested—are Indianapolis & Northwestern Traction Company, Indianapolis & Eastern Railway, Indianapolis & Martinsville Rapid Transit Company, Terre Haute Traction & Light Company, Evansville Electric Railway Company, Richmond Street & Interurban Railway Company and the Indiana Northern Traction Company. The companies have a combined capital (stocks and bonds) of $103,300,000, of which, however, only $85,947,500 is issued. The total is divided as follows: Stock, $45,250,000 authorized; $44,667,500 issued. Bonds, $58,050,000 authorized; $41,280,000 issued.

AMERICAN RAILWAYS REPORT FOR YEAR ENDED JUNE 30

The American Railways Company has issued its full pamphlet report for the year ended June 30, 1905. The income account compares as follows:

	1905	1904
Gross	$444,254	$443,196
Deductions*	180,757	172,734
Net	$263,497	$270,462
Dividends	234,742	234,180
Surplus	$28,755	$36,282
Previous surplus	418,065	381,783
Total surplus	$446,820	$418,065
Tranferred to fire insurance fund	89,000	......
Profit and loss surplus	$357,820	$418,065

* Includes expenses, taxes, depreciation, interest on funded debt, etc.

The general balance sheet as of June 30, 1905, compares as follows:

Assets—	1905	1904
Stocks and bonds	$3,226,433	$2,925,272
Bills and accounts receivable	3,427,441	4,865,311
Office furniture, etc.	3,253	3,216
Eng. dept. inst.	1,216	1,347
Discount on loans paid	......	5,496
Interest on bonds	23,812	52,870
Cash	62,895	43,987
Fire insurance fund investment	107,420	......
Total	$6,852,470	$7,897,500
Liabilities—		
Capital stock	$3,915,500	$3,903,000
Collateral trust convertible 5 per cent's	2,435,500	2,448,000
Bills payable	......	1,104,291
Bills audited	579	......
Vouchers payable	12,380	5,551
Accident insurance fund	5,669	3,094
Interest accrued	10,148	10,200
Taxes accrued	5,332	3,680
Insurance reserve fund	......	1,618
Fire insurance fund	109,541	......
Surplus	357,820	418,066
Total	$6,852,470	$7,897,500

President Sullivan says:

"Gross earnings of subsidiary companies, $1 471,938; an increase over 1904 of $64,972, or 4 2-5 per cent; after paying all fixed charges, interest and taxes, the net income was $263,497; dividends paid to the stockholders of the American Railways Company, $234,742; leaving balance of $28,755 to be added to the credit of surplus account, making the balance to the credit of surplus account, June 30, 1905, $357,820.

"We sold bonds in the treasury of the company at a profit of $46,500 over the amount carried on our books. This amount was credited to the cost of the bonds remaining in the company's treasury, and is not included in the earnings of the company.

"The total number of passengers carried was 33,222,013, showing an increase for the year of 1,746,321.

"During the year, believing it to be sound policy where our properties are so widely separated, we started a fire insurance fund for the purpose of doing most of our own fire insurance. For this purpose we transferred $89,000 from our surplus account to this fund. This insurance fund amounted on June 30, 1905, to $109,541, and is separately and securely invested.

"On May 1 the $100,000 income bonds of the Springfield Railway Company, Springfield, Ohio, matured and were paid off at par, showing a profit to this company of $19,988, which was charged off the capital stock of this company.

"During the year we purchased 413 additional shares of the capital stock of the Springfield Railway Company. The American Railway Company now own all but fifty-six shares of the entire capital stock of that company.

"During the year we have sold $1,500,000 of the 4½ per cent bonds of the Altoona & Logan Valley Electric Railway Company, which bonds were in our treasury. With part of the proceeds we paid off all of the floating indebtedness of this company, which amounted to $1,104,291 on June 30, 1904.

"During the year $12,500 of the American Railways Company's bonds were converted into stock, making the amount of stock outstanding $3,915,500. The privilege of converting the bonds expired on Nov. 1, 1904.

"During the year we have expended the amount of $360,383 for extensions and betterments."

EARNINGS OF THE CONSOLIDATED RAILWAY

The earnings of the Consolidated Railway, which operates the electric lines owned by the New York, New Haven & Hartford Railroad, are as follows for the year ended June 30, 1905:

Gross receipts	$4,567,979
Operating expenses	2,885,622
Net earnings	$1,682,357
Miscellaneous income	13,391
Total income	$1,695,748
Charges, taxes, etc.	1,264,414
Surplus	$431,334

Of this amount, $200,000 has been paid as a dividend to the New York, New Haven & Hartford Company, and the balance has been carried to surplus account.

REPORT ON NEW YORK ACCIDENT

The New York Railroad Commissioners have issued their report of the investigation conducted by them of the accident on the elevated line of the Interborough Rapid Transit Company at Fifty-Third Street and Ninth Avenue, which happened on Monday, Sept. 11, and in which twelve persons were killed and more than forty injured. Two men are held responsible for the accident. Neither of these gave testimony before the commission. One is Paul Kelly, the missing motorman, and the other is Towerman Cornelius A. Jackson, who refused to give any testimony.

The commissioners established that Kelly displayed the signal for a Ninth Avenue train, and that Jackson had his switches set for a Sixth Avenue train. They blame Kelly because he ran by the Sixth Avenue signal when he was running a Ninth Avenue train, and also because he did not obey the company's rule to slow down on approaching curves. They blame Jackson because he set the switches for Sixth Avenue, sending the train around the curve, when he should have had them set for the approaching Ninth Avenue train with properly set signals. This is the recommendation concerning the new signal system:

1. That the two signals at and near the switch point connecting the Ninth Avenue and Sixth Avenue southbound tracks be replaced by a double-blade semaphore signal, one of these blades to govern the operation of the Ninth Avenue trains, the other the operation of the Sixth Avenue trains. The size of these blades and lights to be used in connection with them to be approved by this Board.

2. That a stationary "slow" sign be placed at a proper point in a manner to make it conspicuous and so that it can be seen and read by motormen of all southbound trains.

3. That all southbound trains on the local track come to a full stop before reaching the above-mentioned semaphore.

4. That a rule to the above effect be issued, properly posted and a copy of it properly delivered to every motorman, conductor, trainman and all employees in any manner connected with the operation of the Sixth and Ninth Avenue lines.

5. That the above rule be rigidly enforced.

The report goes into a history of the wreck as gathered from the testimony of the officials of the road at the hearing. It tells about the tracks, the signals and the equipment, and concludes its findings, concerning the motorman and the towerman, as follows:

"That Jackson, the towerman, was in the tower operating room about one minute before the accident occurred.

"That the derailed train was running more than 15 m.p.h. when the head car passed over the switch points, and that no appreciable reduction in the speed of the train was made after the head car passed the switch point until the derailment.

"As a result of our investigation we find that this accident was caused by Motorman Paul Kelly violating the company's rules in running by a cautionary signal without reducing speed, and by running by a signal showing that the switch was set for a Sixth Avenue train, he running a Ninth Avenue one carrying proper signals for that line.

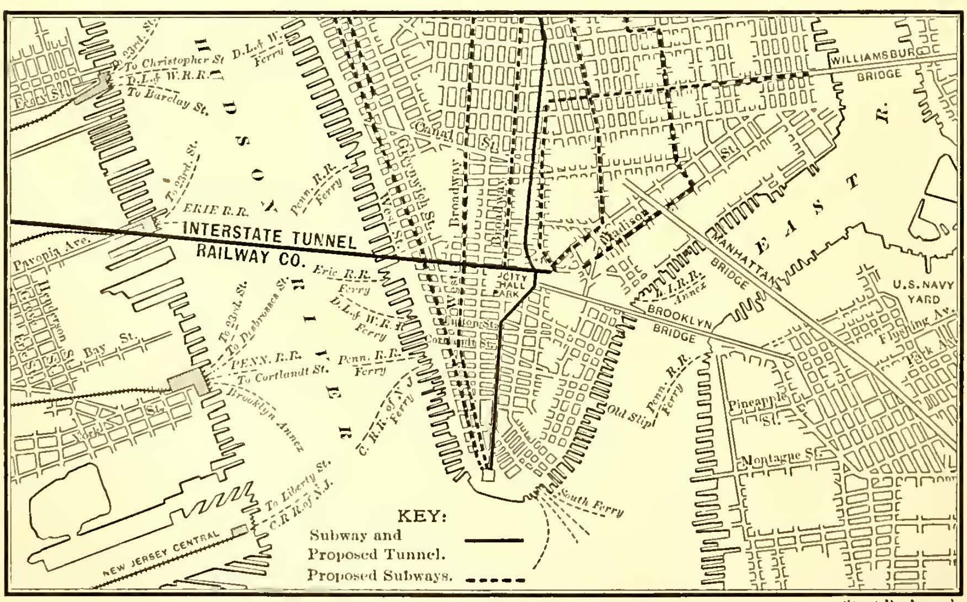
"We also find that Cornelius A. Jackson, the towerman, contributed to the cause of the accident by having the switch and signal set for a Sixth Avenue train, when a Ninth Avenue train displaying proper signals was approaching the junction."

HIGH-SPEED LINE FROM NEWARK TO JERSEY CITY, WITH TUNNEL UNDER THE NORTH RIVER TO NEW YORK

An announcement that assures the consummation of the plan for a high-speed electric railway from Newark to Jersey City, N. J., with a tunnel under the North River to New York, was made last week. It is to the effect that a combination has been formed of Public Service Corporation and Metropolitan Street Railway interests to carry out the project. In the interest of the plan two companies have been incorporated, one at Albany, the other at Trenton. The Trenton company is called the Interstate Tunnel Railway Company of New Jersey, and the Albany company is the Interstate Tunnel Railway Company of New York. The capitalization in each case is $7,500,000, and the incorporators are the same, being Thomas N. McCarter, of Rumson, N. J., president of the Public Service Corporation; Charles A. Sterling, of East Orange, N. J., secretary of that company; Albert B. Carlton, vice-president, and Mark T. Cox, of East Orange, a director of the same company; Herbert H. Vreeland, president of the Metropolitan Securities Company; John B. McDonald, vice-president of the Metropolitan; John D. Crimmins and R. A. C. Smith, directors of that company, and Henry D. Macdona, of counsel for the Metropolitan.

It is proposed to run the new tunnel from Erie and Twelfth Streets, Jersey City, to the new general terminal station planned for the Brooklyn Bridge. An application for the necessary rights has been made to the Rapid Transit Commission, and construction will begin as soon as the proper permission is given. It is estimated that the tunnel will take about three years to build and that it will cost in the neighborhood of $12,000,000, with the terminal. S. L. F. Deyo will be chief engineer of the company, and J. B. McDonald, who built the New York Subway, will have general charge of the work.

In connection with the tunnel the Public Service Corporation will build a new high-speed line from Newark to Jersey City, and it is believed that passengers from Newark will be landed at the City Hall, New York, in twenty minutes, the ride from Newark to Jersey City taking fifteen minutes, and five minutes more to go under the city. Arrangements have been made also for a joint passenger station at Jersey City, which will enable the Erie



ROUTE OF PROPOSED TUNNEL TO CONNECT LINES OF PUBLIC SERVICE CORPORATION OF NEW JERSEY AND THE ERIE RAILROAD WITH METROPOLITAN SYSTEM IN NEW YORK

Railroad to transfer its passengers direct to the new tunnel. The Erie has not yet decided on the location for its new terminal, but it has conferred with the projectors of the new tunnel, and it has been decided that there shall be a joint station.

The financing of the enterprise, it is understood, will be in the hands of the Public Service and the Metropolitan companies. According to the brief official statement issued by the Metropolitan Company, "the Interstate Tunnel Railway Company will be controlled and financed jointly by the Metropolitan interests, by the Public Service Corporation and the other interests which will furnish the traffic at the New Jersey end." Considering the close physical connection between the tunnel and the Erie Railroad, the conclusion is that the Erie is the "other interests," and will take a large part in financing the enterprise.

With the present projected tunnel and one other yet to be built, there will be four under the river between New York and Jersey City. The first is the Pennsylvania tunnel, now in course of construction, and two of the others are owned by the Hudson Companies of New York. One of these, now well toward completion, is the old Morton Street tunnel, which was taken up some years ago by William G. McAdoo. The accompanying map shows the projects now in contemplation.

Two separate companies, to be eventually merged, were incorporated in Trenton on September 23 for the construction, maintenance and operation of the proposed high-speed electric railway between Newark and Jersey City, which will be continued under the Hudson River by tunnel to New York. Their respective corporate names are Newark & Hackensack River Railway Company and Jersey City & Hackensack River Railway Company. The capital stock of each is $1,000,000, divided into 10,000 shares. The amount of capital paid in is $100,000 in each instance, and the incorporators, who are the same for both companies, are as follows: Thomas N. McCarter, of the Public Service Corporation; Charles A. Sterling, East Orange; Albert B. Carlton, Elizabeth; John J. Burleigh, Merchantville; Anthony P. Kuser, Bernardsville; Thomas C. Barr, Orange, and Mark T. Cox, East Orange.

THE WESTINGHOUSE SINGLE-PHASE LOCOMOTIVES ADOPTED BY THE NEW YORK, NEW HAVEN & HARTFORD RAILROAD COMPANY

The very interesting and important announcement is made in the paper by C. F. Scott, published elsewhere in this issue, that the New York, New Haven & Hartford Railroad Company is planning to use single-phase locomotives on its system. It is needless to say that this statement attracted the widest attention at the convention.

The contract taken by the Westinghouse Company comprises twenty-five locomotives for high-speed passenger service, each of which will weigh approximately 78 tons, and will be capable of maintaining a schedule speed of 26 m.p.h. in local service with a 200-train train making stops every 2.2 miles and reaching a maximum speed of about 45 m.p.h. between stations. In express service a speed of from 60 m.p.h. to 70 m.p.h. can be maintained with a train weighing 250 tons. To handle heavier trains two or more locomotives will be coupled together and controlled from the forward cab by the multiple-unit control system.

The motors will be of the Westinghouse single-phase commutating type, which can be used with direct current, so that the locomotive will be able to operate over the direct-current section now being installed by the New York Central Railroad Company, an important feature, as the New York, New Haven & Hartford Railroad utilizes the tracks of the latter company between Woodlawn and the Grand Central Depot in New York City. For a time the service will be confined to this section. It is therefore with an eye to the future rather than to present requirements that the alternating-current system has been adopted.

Each locomotive will be equipped with four gearless motors and with the unit-switch system of multiple control. The motors will be permanently connected two in series. On direct current the pairs of motors will be operated in series parallel, and on alternating current by voltage control. The motors will be spring supported and connected by flexible drive in such a way that all dead weight will be taken off the axles. On direct current each motor will be capable of developing a rated output of 400 hp.

Congratulations are due to the management of this progressive road for their courage and foresight in adopting a system capable of meeting their future requirements, and to the manufacturing company which has developed the apparatus for the system, which makes the electrical operation of large trunk railways a commercial success.

The Philadelphia Rapid Transit Company is reported to have placed a contract with the Pressed Steel Car Company for forty steel cars for its subway and elevated lines.

FRANCHISE LITIGATION IN DES MOINES

What is believed to be the beginning of extended litigation to determine the franchise rights of the Des Moines City Railway and the Interurban Railway Company, in Des Moines, has been instituted by the Des Moines Civic League in the District Court of Polk County. Petitions in quo warranto proceedings have been filed against both companies with the city of Des Moines as joint defendants in each case. In these petitions the Des Moines Civic League declares in brief that neither company has any franchise rights to operate in Des Moines. The cases, which will be tried in the equity courts, will be assigned for hearing some time in January.

It is generally understood that the cases will depend on the interpretation of the Turner franchise of 1866, although many other franchises have been acquired. The Turner franchise was a blanket grant giving the Turner company, known as the Des Moines Street Railway Company, the right to construct railway lines on any streets of the city that it desired. The vital clause of this franchise is that which gave the company an exclusive right to the streets for a period of thirty years from the time the first mile of track was laid, which was in 1867. This franchise does not place any time limit on its grant to the streets of Des Moines, except that the exclusive right is limited to thirty years. The present street railway company, which has acquired the Turner and all other franchises, contends that the Turner grant was a perpetual one, and gives the company the right to operate its lines on the streets of Des Moines for all time.

The Civic League contends that there can be no perpetual franchises under the Iowa laws, and holds that the Turner franchise expired at the end of the thirty-year exclusive right in 1896. According to the statements of the Civic League the companies have no franchise rights to any of the streets of the city, except the rights acquired under the franchise granted to the Des Moines Broad-Gage Street Railway Company in 1887. This franchise gave the company the right to six streets for a period of twenty-five years. This franchise will expire in 1912. The Civic League also contends that the freight franchise of the present street railway company, which was granted in 1895, expires in 1903, and that, therefore, the amendment thereto, granting the Interurban Railway Company the right to operate its cars over the tracks of the Des Moines City Railway, adopted in 1903, was wholly invalid, because the franchise which it attempted to amend had expired several months previous thereto. It is also contended that the ordinance of the City Council granting the company the right to lay tracks on Second Street for freight hauling purposes is invalid, because it was never ratified by a vote of the people as provided by the code of Iowa.

The following is a résumé of the franchises under which the Des Moines Street Railway Company has operated:

Turner Franchise.—Granted Dec. 10, 1866, to Des Moines Street Railway Company, for a horse line on any and all streets of Des Moines. Franchise made exclusive for thirty years from time first mile of track was laid, but is silent as to whether franchise rights continue after expiration of exclusive period. The franchise also provided that the company shall pay a tax of 3 per cent on net receipts for city purposes each year in lieu of all other taxes.

Broad-Gage Franchise.—Granted to Bayless, Teachout and Van Ginkel, of the Des Moines Broad-Gage Street Railway Company, Dec. 20, 1887, for a perior of twenty-five years. Ordinance specified streets to be used by said company as follows: Center, West Walnut, Fourth Streets, University Avenue, East Sixth Street and East Grand Avenue. After ten years from passage of ordinance the company is to pay annually to the city 5 per of its net earnings, but such payment is not to be construed as exemption from taxation same as other property.

Consolidation.—By resolution of City Council, Sept. 5, 1889, consolidation was authorized of Des Moines Street Railroad Company, Des Moines Electric Street Railway Company and Des Moines & Sevastopol Street Railroad Company. J. S. Polk effected this consolidation and first became identified with the Des Moines Street Railway system.

Electricity for Turner Lines.—Amendment passed by City Council, March 8, 1890, authorizing use of electricity instead of horses on lines operated under the Turner franchise of 1866.

Other Franchises.—Des Moines Rapid Transit Company, May 14, 1888, and March 12, 1889; Des Moines Belt Line Railway Company, May 16, 1888; Des Moines River Line Street Railway Company, Sept. 20, 1888; North Des Moines town franchise to all existing lines.

Final Consolidation.—In 1893 consolidation of all existing street railway lines with the Des Moines City Railway Company was affected, by which the present company claims to have acquired all franchise rights granted to preceding companies.

Freight Franchise.—By ordinance of City Council of Feb. 4, 1895, the Des Moines City Railway Company was granted privilege of carrying mail, express, freight and material for construction and operation of its lines. Five per cent of gross receipts from mail, express and freight business was required to be paid into city treasury for eight years from date of ordinance.

Suburban Franchise.—On June 8, 1903, Council amended the freight ordinance so as to permit suburban railway companies to operate over tracks of Des Moines City Railway Company.

CLEVELAND COMPANY PLACES INSURANCE

The Cleveland Electric Railway Company, which has been active in organizing companies for the purpose of insuring the properties of street railway companies against loss by fire, has made a three-year's contract with the stock insurance companies, reserving the right to write 10 per cent of the line, amounting to nearly $400,000, with the traction mutual companies as soon as they become operative; that is, as soon as these companies have secured $20,000,000 of sprinkled risks. Judging from present indications it will only be a matter of a short time before this is accomplished. At the start these companies would not care to take the entire line on a property like the Cleveland Electric. As has been outlined in these columns, the Electric Mutual Insurance Company will insure electric light and power stations and the Traction Mutual Insurance Company will cover car houses that are equipped with automatic sprinklers. The two will be supplemented by a stock company known as the Associated Railway Companies' Insurance Company. The stock company will not only insure power plants and sprinkled car house properties, but unprotected properties as well, at rates as low as those made by the "old line" companies. The management of all these companies is in the hands of Henry N. Staats, of Cleveland, an insurance underwriter of long experience.

In placing its insurance this year the Cleveland Electric Railway was enabled, by reason of the fact that six of its car houses are now protected by sprinklers, to secure a proposition from the Factory Mutual Companies, of New England, which heretofore have declined to write policies upon car houses and their contents. By reason of this competition it was enabled to secure a better proposition than ever before from the "old line" companies. The proposals were made under sealed cover, and the bid of the "old line" companies was so low that the business went to them.

While intimating that the new rates will effect a considerable saving in the cost of insurance, the officials of the Cleveland Electric Railway were unwilling, by reason of a pledge made to the underwriters, to make public anything relative to the per cent of saving made possible through the installation of sprinkler outfits. From a general agent of one of the companies carrying the risk, the Street Railway Journal representative was enabled to secure a clear idea of the new proposition. This gentleman stated that the stock companies imposed two conditions—that the insurance be written for three years, and that the companies be given all the business, except for the reservation mentioned.

In the past the Cleveland Electric Railway Company has made a practice of carrying its own insurance on its fire-proof power stations and storage battery houses. Last year it carried insurance on $1,962,500 of property, including car houses, shops, etc. Under the new contract the stations and battery houses valued at about $1,400,000, together with eleven car houses and contents, six of which have already been equipped with sprinkler systems, and the balance of which are now being equipped, make a total of $3,266,700 of preferred risks.

As soon as the remaining houses are equipped with sprinklers, all of this property will be carried at about one-third the rate, which is as low as any given on sprinkled manufacturing property in Cleveland. Other property, including unequipped car houses, oil houses, cars in open yards, etc., aggregating $405,800, was also insured. The investment for sprinkler outfits was about $120,000.

The 80 per cent co-insurance clause will apply on all building items; the 100 per cent clause on all car items, and the 90 per cent clause on machinery in power stations. The dynamo loss clause, the lightning and the automatic sprinkler clauses will attach to policies.

A couple alighted from a Market Street car at Fifty-Second Street, after getting transfers. No Fifty-Second Street car was in sight, so the young man said: "It's only a couple of blocks; let's walk." He was about to tear up the red transfers when the girl he was escorting interrupted him, saying: "Don't do that; give them to me." He handed them over and she walked to a letter box and dropped them in the slot. To the man's questioning look she said: "Oh! everybody out this way does that. You see, the mail man always finds among a number of the transfers dropped in the box one that is still good for a ride. So he is able to ride several squares to the next box, where he finds more transfers."—Philadelphia "Record."

STREET RAILWAY PATENTS

[This department is conducted by Rosenbaum & Stockbridge, patent attorneys, 140 Nassau Street, New York.]

UNITED STATES PATENTS ISSUED SEPT. 19, 1905

799,688. Car Brake; Thomas A. Steele, West Elizabeth, Pa. App. filed June 27, 1905. Comprises independently operated brake-shoes engaging respectively the tops and sides of the rails.

799,893. Car Wheel; John R. Davies, Waukegan, Ill. App. filed Jan. 14, 1905. A wheel center and tire having registering recesses, a dowel pin joining said parts, having its inner end equipped with a bearing through which pressure may be exerted in drawing the dowel pin inwardly to free it from engagement with the tire, whereby the tire may be detached without drilling holes therein.

799,894. Automatic Railway Switch; Frederick R. S. Ditmars, Galveston, Tex. App. filed March 18, 1905. When a trip mechanism is engaged by an approaching car the switch is thrown through a T-lever. The switch is normally held closed by a bell crank lever, one end of which is attached to the switch bar, while the other end is weighted.

799,896. Electric Contact Device; Robert W. Farrington, Buffalo, N. Y. App. filed Sept. 23, 1904. The bearing surface of the trolley wheel is made up of a series of pivoted shoes which successively make contact with the wire, presenting thereto a flat surface, thereby securing a greater contact area than can be obtained by the plain surface of the wheel.

799,907. Steel Car Wheel; Frank W. Hudson, St. Louis, Mo. App. filed March 31, 1905. A car wheel consisting of a soft steel body portion and hard steel inserts cast in the tread thereof.

799,908. Elevated Railway; David Humphrey, Cleveland, Ohio. App. filed May 18, 1904. An elevated structure of tubular construction throughout supports cars running on a single rail and having a guard rail at the top.

799,940. Automatic Switch Throwing Device; Clinton J. G. Rickerson, Colorado Springs, Col. App. filed April 17, 1905. A forwardly and downwardly movable plate is engaged by the approaching car to throw the switch through rack and pinion mechanism.

800,121. Car Fender; Joseph W. Seibert, Washington, Pa. App. filed July 20, 1905. Details of construction.

PERSONAL MENTION

MR. G. W. APPLER, who for two and a half years has occupied the position of superintendent of construction for the Northern California Power Company, of Reading, Cal., has been appointed general superintendent of the Rochester, Syracuse & Eastern Railway Company.

MR. J. G. SCHMIDLAPP, of Cincinnati, well known to the financial and railway interests of the West, who is a member of the Taft party, now in the Orient, will leave the party shortly to visit Japan, where he will spend a month or more looking into the traction development of that country.

MR. E. H. McHENRY, fourth vice-president of the New York, New Haven & Hartford Railroad, who has at present the supervision of the engineering department of the electrical division, will after Oct. 1 have direct supervision of the engineering department of the entire New Haven system.

MR. ELMER E. BARTON, assistant superintendent of Division 1 of the Worcester Consolidated Street Railway, has resigned to take a position with the Rio Janeiro Tramway, Light & Power Company, of which Mr. Frederick A. Huntress, formerly general manager of the Worcester Company, is general manager.

MR. EDWARD H. RICHARDS, formerly assistant general superintendent of the Boston & Worcester Street Railway, has been appointed superintendent of the Middleboro & Monument Beach division of the Southeastern Street Railway system. Mr. Richards has recently been superintendent of the Taunton & Pawtucket branch of the same system.

MR. B. B. WINCHESTER, of the Philadelphia Rapid Transit Company, is to succeed Mr. Frank A. Polhemus as superintendent of the New York & Long Island Traction Company. Mr. Polhemus returns to Cleveland and will rejoin the corps of the Cleveland Construction Company, now building several electric railways in the West. Mr. Winchester's headquarters will be at Hempstead, Long Island.

MR. O. A. HONNOLD has been appointed to succeed Electrical Engineer Hayward, of the Utah Light & Railway Company, of Salt Lake City, Utah. Mr. Honnold has been with the company since 1896. He is a graduate of Purdue University. After leaving college Mr. Honnold was for two years with the Detroit United Railway Company as assistant to the superintendent of construction, and was also two years with the Lachine Rapids Power Company at Montreal, Can.

HON. LUTHER ALLEN, one of Cleveland's most prominent business men, died a few days ago as a result of an operation for appendicitis. For the past five years Mr. Allen had been very active in the building of electric railways. He was interested in the Toledo & Western Railway, the Cleveland, Painesville & Ashtabula Railway, the Buffalo, Dunkirk & Western and the Toledo & Chicago Railway. At the time of his death he was president of the Toledo & Western Company, and formerly was president of the Cleveland, Painesville & Ashtabula Railway. He was interested in several banks and manufacturing institutions.

MR. FRANK HOOKER ALFRED, who is now associated with the Canadian White Company, Ltd., as general manager, with headquarters in Montreal, Can., was born Dec. 24, 1866, and educated at the University of Michigan and the Ohio State University. From 1887 to 1890 he was engaged successively as rodman, transitman and resident engineer on railroad construction. From 1890 to 1894 was with the Norfolk & Western Railroad, during which time he had charge of the field work in the construction of its terminals at Columbus, Ohio. From 1894 to 1896 he was with the engineering department of the Hocking Valley Railroad, and from 1896 to 1899 was engineer of maintenance of way of the Cleveland, Akron & Columbus Railway. From 1899 to 1900 Mr. Alfred was engineer of maintenance of way of the Wheeling & Lake Erie Railway, and from the latter date till 1902 was division engineer of the Pere Marquette Railway, of which company he has since acted as chief engineer.

MR. FRANCIS H. PEABODY, senior member of the firm of Kidder, Peabody & Company, of Boston, and director of the Boston Elevated Railway Company, died very suddenly Saturday morning, Sept. 23, at his summer home in Beverly, of heart failure. Mr. Peabody was born in Springfield, Mass., Oct. 9, 1831. He came to Boston at the age of seventeen and entered the banking house of J. E. Thayer & Brother as a clerk. In 1865 Mr. Henry P. Kidder, Mr. Peabody and Col. O. W. Peabody formed the firm of Kidder, Peabody & Company. Mr. Kidder died in 1886, and at that time Mr. Frank E. Webster and Mr. Frank E. Peabody were admitted to the firm. Col. O. W. Peabody died in 1896. Mr. Robert Winsor was admitted to the firm in 1894. Mr. Peabody married April 27, 1854, Miss Adelaide Kingsley, of Canton, Mass. They have one son, Mr. Frank E. Peabody, of Kidder, Peabody & Company.

MR. EDWARD G. CONNETTE, for several years vice-president and general manager of the Syracuse Rapid Transit Company, with which he had a long-term contract, has obtained permission from the directors of the company to accept the position of general manager of the Worcester Consolidated Street Railway, of Worcester, Mass. He will assume his duties on Oct. 1. Mr. John J. Stanley, of Cleveland, who is intimately associated with Mr. Horace E. Andrews, president of the Syracuse Rapid Transit Company, the Utica & Mohawk Valley Railroad and Cleveland, Ohio, roads, will succeed Mr. Connette as vice-president. Mr. John E. Duffy, who has been superintendent of the Rapid Transit under Mr. Connette, will continue as superintendent, but will have practical charge of the operation of the system, it being Mr. Stanley's intention to spend only two or three days a month in Syracuse. The Rapid Transit will be operated by Niagara Falls power by April 1. Cars from Rome by the electrified West Shore Railroad will come into Syracuse probably over the Burnet Avenue line of Rapid Transit.

MR. K. B. THORNTON has been appointed operating engineer with J. G. White & Company, of New York. Mr. Thornton was born at Montreal, June 23, 1873, and was educated in London, Eng. After taking a three years' course in electrical and mechanical engineering at the Central Technical College, South Kensington, London, he returned to Canada, in June, 1893, and entered the Royal Electric Company, Montreal, working in the several manufacturing departments, and also in the testing and drafting departments. In September, 1895, he was transferred to the operating department of the Royal Electric Company, which at that time was supplying light and power in and around Montreal. From that time until August, 1905, Mr. Thornton was intimately associated with the construction, operation and engineering details in connection with the generation and distribution of light and power for the Royal Electric Company, and latterly for the Montreal Light, Heat & Power Company, which finally secured a monopoly of all the electric companies in Montreal in 1903.