needs, eight railways from all parts of the nation terminate at tidewater, from whence the principal portion of their freight is floated to vessels and to the congested and enormously expensive water frontage of Manhattan Island—a frontage that should be devoted to the legitimate needs of water-borne commerce.

Labor-saving devices for freight handling, despite the availability of cheap electric power, are practically unknown in the Port, partly due no doubt to lack of coordination between rail and water interests. The question of an encircling outer belt line open to the use of all railroads under conditions that will guard against discrimination and excessive rates, is having no consideration, although it is a crying necessity for interchange and manufacturing purposes and, above all, for the preservation of the "open door" to the Port. This last need requires especial emphasis at this time in view of the projected development of a municipal export terminal at Jamaica Bay, suitable Barge Canal terminals, and the Hackensack River development, all of which will be largely worthless in the absence of an unrestricted outlet to all of the railroads that serve the Port. The deadening effect of the control by one railroad of access to any great industrial development, is well known.

As to any improvement of internal methods of distribution, the whole subject appears to be at a standstill awaiting the abatement of the fever for much needed rapid transit passenger facilities.

Summarizing, it seems fair to state that, from a freight transportation standpoint, the Port of New York, embracing Jersey City, Newark, Elizabeth, Bayonne, Perth Amboy, Hoboken and Weehawken, as well as Greater New York, instead of throwing aside local jealousies and adopting a broad policy that will bring the greatest good to the greatest number, is growing like "Topsy," with no comprehensive harbor or terminal policy. No private corporation or group of individuals can alone bring about the needed reform. The hope seems to lie in an agitation of the question in journals like "Engineering News," and before commercial organizations in the various communities that are tributary to the Port, with a view to starting a movement that will result in some definite action.

In this connection it may be of interest to quote from a recent report of the Montreal Harbor Commission, after a systematic study had been made of port conditions in this country and abroad.

> (1) The ports that are doing the biggest business, and doing it efficiently, are the ports that have kept their facilities ahead of actual requirements.
>
> (2) The ports that have remained stationary or lost in prestige have been those that neglected to provide facilities before business was forced to seek elsewhere the same facilities provided by rival terminals.
>
> (3) Unity of authority, concentration of business, depth of water areas, and facilities for despatch of business are the prominent characteristics of successful port administration.
>
> (4) The necessity of providing large and convenient storage areas where cargo may be collected and cared for.
>
> (5) The lowest cost of handling cargo from the hold of the ship to consignee and vice versa, was found to be in a port where one authority controlled the entire operation, and where the transit sheds were three to five stories high.

Admitting that there is an urgent need for action to improve terminal conditions in the Port of New York, the question arises—in what way can this best be accomplished? The good results that Boston and vicinity have reaped from the organization of the Metropolitan Districts on matters of community interest, such as water supply, sewage and parks, prompts the thought that it may be feasible for New York and the neighboring cities on both sides of the Hudson, to have a "Metropolitan Freight Transportation District," embracing all parts of the Port. To determine upon the wisdom of organizing such a district and to secure concrete results, it would seem feasible to bring about the appointment, jointly by the States of New York and New Jersey, of an "Interstate Terminal Commission" composed of men thoroughly qualified to pass upon questions affecting the physical and business relations between rail and water carriers and the public, for the purpose of making recommendations for joint legislation after an investigation of harbor conditions in this country and abroad.

The Port of New York lies not altogether in New York, as its name implies, but likewise in the State of New Jersey, and it may safely be asserted that without joint action, any broadly effective improvement in the terminal conditions is hopeless.

Competitive ports are awake to the need of energetic measures to keep abreast of the times, and it would seem as if the Port of New York should not wait to do likewise until her supremacy is more seriously threatened.

The Cost of Electric Operation of Steam Railways.

One of the subjects to be reported upon at the International Railway Congress this year is the electrification of steam railways. In the "Bulletin of the International Railway Congress" for January, there appeared a long paper on this topic by Mr. George Gibbs, M. Am. Soc. M. E., who has had the chief responsibility for carrying out the electric traction work for the Pennsylvania and Long Island railroads.

In view of Mr. Gibbs' extended experience in steam railway work as well as in electrical work, he is among the best qualified engineers in the United States to speak authoritatively upon this subject. We therefore reprint below the concluding portion of Mr. Gibbs' paper, containing the sections dealing with the design of electric locomotives and those relating to the first cost and cost of operation of electrified steam railways.

It is particularly interesting to note Mr. Gibbs' comparison of the cost per car-mile with electric and with steam traction on the Long Island R. R and on the West Jersey & Seashore R. R. On the West Jersey & Seashore R. R. the cost of operation per electric car-mile was within two cents as much as the cost of steam operation. On the Long Island R. R., where a frequent train service with short trains is necessary, the electric system made a much better showing, the cost of operation per electric car-mile being 17.8 cts. as compared with 27.95 cts. for cars hauled by steam locomotives. These, however, are operating costs only and take no account of the interest charge on the electric equipment. If this were added to the cost of electric operation there can be little doubt that the steam locomotive would make the better showing.

Mr. Gibbs' paper follows:

ELECTRIC LOCOMOTIVES.—Electric locomotives for heavy service are still in the development stage; much has been done towards perfecting their design, but much remains to be done before the questions of their design and practical performance reach the stage of accumulated knowledge which we possess of these elements in steam locomotives.

In the earlier stages of the art, attention was mostly directed to the perfection of electric apparatus; the importance of the mechanical features of the machine in its adaptation to track conditions, were not fully appreciated. In fact, it was assumed that the characteristics of rotary motion and uniform torque, possessed by an electric motor, made its application to a locomotive a simple matter, and removed one of the chief defects of a steam locomotive, the unbalanced reciprocating weights and unsymmetrical turning effort, which were held to be destructive to track.

Experience has taught, however, that there are other elements in a locomotive which may be even more destructive, namely, unduly low center of gravity and improper weight and wheel-base distribution. Defective design in these respects becomes especially noticeable in a machine where power is applied with exraordinary compactness, and where the machinery for its development is naturally centered around the driving axles, and the weight concentrated below the wheel tops. It appears to be a fact that in present designs of electric locomotives, a given total weight and individual wheel weight is more destructive to track than the same weight distributed as in steam locomotives. It is noticeable in motor cars even, that the quite moderate axle weights of a motor truck have an unfavorable effect upon the track.

The importance, therefore, of a study of the electric locomotive problem from standpoints other than that of power development, is being recognized and the cooperation of practical railway men in the design is being sought.

The first electric locomotives were practically powerful motor cars; that is, single-reduction motors were mounted on bogie trucks and carried a body and cab for housing the control apparatus. Then steam locomotive design began to be copied in the use of rigid frames carrying at times four axles and motors, and gearless motors of large capacity and great weight were employed. In the greater number of the earlier designs all weight was adhesive for driving—a feature which was supposed to constitute one great advantage of an electric over a steam locomotive.

These heavy and powerful locomotives at high speed began to manifest their bad riding qualities, and they were suspected of being "hard on track." In order to bring out the facts experimentally, the Pennsylvania R. R. Co., who were about to design locomotives for their tunnel entrance into New York City, constructed a special test track with apparatus for measuring side pressures upon the rail; they built sample locomotives of different designs and instituted a series of tests of electric and steam locomotives to determine their relative riding qualities at speed.

It was found that all types of locomotives were practically steady at speeds under 40 miles per hour, but that above this speed marked differences appeared; that the steadiest riding machines were those with high center of gravity and with long and unsymmetrical wheel base. In other words, that the nearer steam locomotive design is approached in wheel arrangement, distribution of weight, height of center of gravity and ratio of spring-borne to under-spring weight, the less the side pressures registered on the rail head.

In addition to the excessive side pressures on the rail head, due to the oscillation and "nosing" of a low center of gravity machine, abnormal track effects may be caused by the vertical pounding due to a large non-spring-borne motor weight, or to weights with imperfect spring cushion. A remedy for all of these defects appears to mean a radical departure in the design of a high speed locomotive, both as to its running gear and as to the form of motor drive. It means a combination of driving and carrying wheels, an unsymmetrically disposed wheel base and the setting of the motors on the main frames above the axles. The extent of the departures in practice thought desirable for heavy high *speed locomotives, is shown in the diagrams* and photographs of the Pennsylvania locomotive.*

First Cost of Electrification.

It is difficult, in fact, practically impossible to give any general statement of the first cost of electrification which can be safely applied to individual cases. In the case of an entirely new line, built for traction by electricity, unit cost may be made to apply, but in the case of conversion of an existing steam line there are many collateral costs to be considered aside from those of electric equipment. In few cases will an electrified steam *railroad be conducted precisely in the same manner* as that previously done by steam; that is to say, multiple unit train service at frequent intervals will displace part or all of the infrequent locomotive train service; existing tracks, yards and terminals, stations, signaling, and telegraph lines must be changed to a greater or less extent to adapt the road to the new class of service; special rolling stock must in part be purchased and in places new real estate acquired.

It therefore results that each electrification must be dealt with as a separate and individual problem and cost figures for one situation will generally not apply to *another, even if the other road is of similar* character. Generally speaking, the cost of converting a steam railroad is very high under American conditions. Taking into account the changes in the physical property and equipment it will at times mean a doubling of the existing capitalization.

The high cost of conversion will act as a deterring factor upon additional electric construction until a sufficient number of installations are made to furnish evidence of the advantages and economy of electric traction; in fact, railway managers although watching closely, and with interest, the pioneer installations of *electric operation on steam roads have not been anxious* to duplicate experiments in advance of a demonstration of the results, and are awaiting this demonstration.

The systems available for heavy traction are the A. C.-D. C. and the straight A. C., either single phase or polyphase. Comparative first cost figures for these two systems would be interesting, but are available only from estimates for the reasons before given and because of the fact that the systems are not in the same stage of development; thus, figures of cost for A. C.-D. C. would be more exact than in the case of the single phase because figures for the latter system must be made on *assumptions of present methods of* application, and these methods are, it is thought, susceptible to important modifications.

Considering the electrical items of installation, the chief elements of cost may be grouped under three headings; the power-house, the transmission system from power-house to the cars, and the train equipment.

Of these three divisions, in general the power-house is the least expensive and the train equipment the most.

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*See Engineering News, Nov. 11, 1909.

For illustration, and comparing figures for the two systems, an estimate may be given of the case of a trunk line road with dense suburban traffic conducted by multiple unit trains and with an important through business conducted by electric locomotives. The percentage of the total electrical cost carried by the three equipment divisions were as follows:

	A.C.-D.C. system.	A.-C. system (single phase).
Power-house	23%	25%
Transmission, power-house to cars	35%	22%
Train equipments	42%	53%
	100%	100%

These percentage figures are given to show the relative importance, as regards cost, of the three divisions for the two systems, and shows the larger proportion carried by the train equipments of the single phase system.

The actual money value of the various costs would not be useful without a detailed presentation of the case, but the important fact developed was that there was little difference figured for the total first cost of either system, in other words, as at present developed, it appears that for a dense suburban service conducted by multiple unit trains, or, in the case of locomotive haulage in terminals or over short lengths of a main line, there would be little difference in first cost between third rail A. C.-D. C system and the single-phase, alternating-current system; in fact, the figured differences are so small as to be within the limits of error in calculation. As however, the length of line increases and as the frequency of trains becomes less and the weight of the trains increases, the single-phase system becomes cheaper in comparison with the A. C.-D. C. and a substantial saving in first cost can be effected by the use of single phase on such lines. In fact, for long, trunk-line work and with the average density of traffic found on American railways, the first cost of the A. C.-D. C. system would certainly be prohibitive, whereas there will be found instances where this will not be the case with the alternating-current system. It is, of course, a matter of importance to determine the prospect of reducing first cost. This might be accomplished by lowering in price of apparatus, or by a radical change in system, or by both. There appears to be a reasonable prospect of some substantial reduction in the first cost of electric apparatus, as the market for it broadens, but the manufacturers do not promise very radical reductions. As to the prospect of a change to a system inherently simpler and cheaper than existing ones, it would be unprofitable to predict what the future may bring forth; a system which would eliminate the element of transmission, power-house to cars, would seem to open up a prospect of important simplification and cheapening, but such a system does not appear to be in process of development.

Cost of Operation.

This is a matter of the highest importance to railway officials, since the question of net yield is the foundation for an investment. High first cost may act as a deterrent in the rapid introduction of an improvement, but in the end a new system will prevail if the operating results, as measured by the net earnings, show a betterment. Under another heading, will be given a summation of the advantages of electric traction and a statement of its probable field, but it is here proposed to give such concrete examples of operating costs as are available to the writer. It is to be regretted that the list is not longer, but it includes, perhaps, the only cases in which important installations have been in complete operation for a long enough period to furnish comprehensive figures.

The installations referred to are those on the Long Island R. R. and the West Jersey & Seashore R. R., and figures are presented for two complete years' operation in each case.

Below are condensed tabular statements, taken from the complete monthly and yearly tables, of the figures which can be usefully given without lengthy explanation. They may be referred to as follows:

Table I. gives a concise statement of the comparative physical characteristics of the electric installations on the two roads, from which a general idea of the magnitude of the operation may be gathered.

Table II. gives average number of cars in trains and the average weight per car. It will be noted that the average weight per car changes slightly in the two years, due to a change in the ratio of the motor to trailer cars.

Table III. gives comparative figures for electrical quantities and efficiencies and is of interest in showing the distribution of the various losses in electrical energy from the power-house to the cars. The figures for power consumption per ton-mile and per car-mile represent fair averages for electric installations of the character in question and in a climate which requires a considerable consumption of energy in winter for heating the cars. Electric heating adds very largely to power consumption, as will be illustrated when it is stated that, in summer months, the watt-hours per ton-mile at substations on the West Jersey & Seashore R. R. were about 63, while in mid-winter months this figure rose to 100; the larger part of this difference is due to the additional energy required to light and heat the cars in winter. It is interesting to note also that the efficiency of the electric system from the power station to the point where the current leaves the substation for feeding into the third rail is from 70 to 80%, depending upon the loading during the various months; in the busy months, the efficiency will at times run as high as 85%. The losses from the substation to the cars in the direct-current feeder system cannot be accurately measured, but in the cases cited it is estimated to be between 5 and 10%. The figures given for "current used for other purposes" illustrate the considerable and useful consumption of power for running shop motors, lighting stations and operating the signal system.

Table. IV. gives the cost of generating current at the power-house and cost of the current when delivered at the cars. The former figures include all power-house operating and maintenance expenses, but no fixed charges, taxes or depreciation charges. The "delivered cost" includes the operating and maintenance cost for transmission lines, third rail, track bonding, and substations, and allowances for losses in transmission of the current and its conversion to direct current delivered at the car contact shoes. It should be noted, however, that the above figures do not include any maintenance expenses other than for electrical apparatus, and no portion of the general expenses of the railroad.

Table V. gives the monthly car mileage and cost per car-mile; the total yearly mileage and the average car-mile cost; and average yearly cost per 1,000 ton-miles moved. The cost per car-mile includes the following: The cost of power, maintenance of third rail and track bonding, maintenance of car bodies and trucks, maintenance of way and equipment expenses, conducting transportation and traffic expenses, general expenses, wages of motormen and train crews; in fact, all operating expenses of the railroad. In comparing the costs per car-mile, the difference in weight of cars, given in Table II., should be noted. It should furthermore be explained that in the case of the Long Island R. R., all trains may be termed "local" as the average length of the run on the so-called express service is only about 2½ miles, whereas on the West Jersey & Seashore R. R. about one-third of the total train-miles are made in cross-country express service with an average length of run of about 25 miles between stops, and the remaining service termed "local" averages 2½ miles between stops, or about the same as express service on the Long Island R. R. In other words, the Long Island installation may be considered purely local service in a densely populated district, whereas the West Jersey service approximates main line railway conditions with long runs.

Table VI. gives a list of the principal defects reported, and is of interest in showing which portions of train equipment require the largest amount of attention. The item for blown fuses appears excessively large, but it should be remembered that the purpose of these fuses is to guard against excessive current in the various critical portions of the equipment, and the fuses are purposely adjusted so as to be blown under exceptionally severe conditions; they are easily and quickly replaced by the train crews and cause little delay to service.

The excessive number of fuses blown on the Long Island R. R. in 1908, was partly due to the use of stock fuses which were found somewhat too small for the increased requirements due to heavy loads and increased severity of service in that year. The considerable number of flashovers of motors on the Long Island R. R., was also largely due to very severe local service. Breakage of contact shoes is almost entirely due to striking material left by trackmen in the path of the shoes, but occasionally shoes are broken in striking the approach blocks where the third rail is interrupted at street crossings. It will be noted that there were a large number of defective trolley poles reported on the West Jersey & Seashore R. R.; this is due to the use of wheel trolleys and the ordinary type of cross-span overhead trolley wire; it illustrates, that while this type of construction was installed in the best manner, it is not suitable in practical service with trains of three or more cars operating at fairly high speed.

TABLE I.—STATISTICS OF TWO STEAM RAILWAYS CONVERTED TO ELECTRIC TRACTION.

	Long Island R. R.		West Jersey & Seashore R. R.
	1907.	1908.	1907-1908.
Route miles of track	37.6	43.9	74.6
Miles of single track	90.0	98.69	152.5
Miles of high tension pole line	41.0	42.0	69.59
Miles of high tension circuit (3-phase)	70.24	80.03	417.54
Miles of high tension circuit (1-phase)	14.1	9.7	None.
Miles of conduit	9.09	9.09	.....
High tension transmission voltage	11,000	11,000	33,000
Number of substations	6	6	8
No. of portable substations	2	2	None.
Capacity of substations	19,500	19,500	17,000
Cap. of portable substations	2,000	2,000	None.
Capacity of power-house	16,500	16,500	8,000
Number of motor cars	130	132	80
Number of trailer cars	84	82	None.
No. of baggage & mail cars	5	5	8

TABLE II.—WEIGHT OF CARS AND MAKE-UP OF TRAINS.

	Long Island R. R.		West Jersey & Seashore R. R.	
	1907.	1908.	1907.	1908.
Average cars per train	3.70	3.94	2.95	3.45
Average net tons per car	37.8	36.5	47.9	47.4

Table VII. classifies the principal detentions of all kinds due to electric equipment and gives the total train minutes of delay due to same. It also gives the totals reduced to figures of "car-miles per detention" and "car-miles per minute of detention." In compiling this table, detentions due to collisions and derailments have been omitted, as having no direct bearing upon the behavior of electric equipment.

GENERAL REMARKS UPON TABLES.—As before stated, the two roads have been in operation for a sufficiently long time to rather definitely establish the behavior of all apparatus in practical service. There is no indication that in subsequent years of operation there will develop cause for extraordinary maintenance in any particular items due to the accumulative effect of service. It should be noted, however, that no account is taken of possible advances in the electric art, which might make the equipment obsolete; in other words, no "depreciation" account has been kept. In a rapidly advancing art, replacements on account of "change of type" are quite possible contingencies, but much difference of opinion exists upon this whole subject in America and its pros and cons cannot be entered into in this general report.

Of the total cost per car-mile, one-third is due to cost of supplying power to the car, including maintenance of all parts of the electric system on the car, and of this figure about one-half is the cost of the power alone. In both roads, the load conditions at the power-houses are not favorable, nor is the quantity of power turned out as large as it is expected to be in the near future, so that the item for cost of power at the car should come down considerably as the magnitude of the operation increases. Other items also in the total cost per car-mile, namely, general expenses of various kinds and wages of motormen and train crews, are largely affected by density of traffic and have a downward tendency.

The list of detentions looks quite formidable, but when analyzed the general result is found to be good. Motors, as before stated, have been brought to a high state of

TABLE III.—ENERGY CONSUMPTION.

		1907		1908	
		Long Island R. R.	West Jersey & Seashore R. R.	Long Island R. R.	West Jersey & Seashore R. R.
1.	A. C. kilowatt-hours received at substations	20,341,826	....	21,899,739	....
2.	Efficiency of H. T. transmission, %	96.2	....	97.7	....
3.	D. C. kilowatt-hours delivered from substations	16,138,965	14,585,900	18,138,515	16,088,300
4.	D. C. kilowatt-hours used for electric traction	13,466,995	13,530,659	16,201,962	14,780,145
5.	D. C. kilowatt-hours used for other purposes	896,075	389,672	901,934	731,771
6.	Kilowatt-hours lost in conversion from A. C. to D. C.	4,202,861	5,882,510	3,761,224	5,997,020
7.	Efficiency from power-house to substation bus-bars	78.52%	72.15%	81.3%	73.8%
8.	Total ton-miles (passenger cars)	141,541,106	184,615,535	180,129,860	192,472,541
9.	Passenger car-miles	3,808,479	3,855,580	4,945,719	4,044,025
10.	Passenger train-miles	1,021,102	1,305,663	1,251,877	1,172,894
11.	Watt-hours per ton-mile at substations	95.2	73.29	90.0	76.8
12.	Watt-hours per ton-mile at power-house	121.2	101.58	110.6	104.0
13.	Kilowatt-hours per car-mile at power-house	4.51	4.86	4.028	4.95
14.	Kilowatt-hours per car-mile at substation	3.54	3.51	3.276	3.66

TABLE IV.—CURRENT AND MAINTENANCE COSTS.

	Long Island R. R.		West Jersey & Seashore R. R.	
	1907.	1908.	1907.	1908.
Cost per kilowatt-hour at power-house	0.804 cts.	0.697 cts.	0.680 cts.	0.592 cts.
Cost per kilowatt-hour at cars	1.705 cts.	1.461 cts.	1.302 cts.	1.151 cts.
Cost per car-mile for maintenance of electrical equipment on cars	0.71 cts.	0.76 cts.	....	....
Net output in kilowatt-hours at power-house	....	31,517,200	....	22,887,800
Pounds of coal per kilowatt-hour	....	3.29	....	3.36
Cost of coal per ton: 2,000 lbs.	....	$2.51	....	$2.18
Number and capacity of power-house units	....	3—5,500 kilow.	....	4—2,000 kilow.

TABLE V.—CAR-MILE COSTS.

Month.	Car-miles (1 = 1,000). West Jersey & Seashore R. R. 1907.	1908.	Long Island R. R. 1907.	1908.	Cost per car-mile, cts. West Jersey & Seashore R. R. 1907. Cents.	1908. Cents.	Long Island R. R. 1907. Cents.	1908. Cents.
January	294	281	235	201	27.50	29.29	28.16	26.97
February	255	271	214	186	30.90	28.53	30.04	27.87
March	270	291	241	224	23.90	26.57	28.05	24.77
April	244	331	281	271	24.30	21.34	24.05	23.94
May	267	323	347	382	21.50	19.97	21.39	20.90
June	292	344	349	478	22.50	18.92	22.32	18.00
July	435	451	392	628	15.30	16.17	15.73	13.53
August	478	485	400	632	14.90	13.71	15.59	13.26
September	411	369	299	509	15.85	17.17	19.87	14.79
October	317	312	306	441	23.50	19.55	22.37	17.21
November	292	282	245	345	21.40	20.42	25.93	22.29
December	295	292	212	360	22.60	22.68	27.48	22.45
Total	3,854	4,044	3,526	4,662	21.30	20.46	22.45	17.80
Cost per 1,000 ton-miles	....	....	....	....	$4.406	$4.307	$5.94	$4.86

TABLE VII.—DELAYS DUE TO ELECTRIC EQUIPMENT.

	1907 Long Island R. R. No.	Train Minutes.	West Jersey & Seashore R. R. No.	Train. Minutes.	1908 Long Island R. R. No.	Train. Minutes.	West Jersey & Seashore R. R. No.	Train. Minutes.
Motors	13	197	21	404	35	270	20	134
Control equipment	21	286	180	2,209	72	644	99	509
Air brakes	8	84	40	247	38	428	44	54
Miscellaneous mechanical equipment	7	74	80	1,073	57	964	45	427
Miscellaneous electrical equipment.	58	1,006	316	1,564	44	781	183	693
Failures of power due to 3d rail...	17	218	8	103	36	792	3	47
Failures of power due to trolley...	..	...	86	1,122	...	...	223	3,498
Failures of power due to S.-S. & Trans.	5	25	13	80	31	190	36	284
Track troubles	7	263	7	146	1	15	1	18
Snow and ice on 3d rail	8	161	72	1,751	16	244	9	69
Shoe fuses blown	..	...	...	...	107	1,881	...	...
Unclassified and unknown	15	179	120	844	53	552	27	108
Total	159	2,493	943	9,543	490	6,761	661	5,841
Car-miles (passenger & baggage)...	3,526,227		3,855,580		4,662,230		4,044,025	
Car-miles per detention	22,177		4,088		9,514		6,118	
Car-miles per minute of detention..	1,414		404		689		692	

perfection and detentions caused by their failure on the road are rare and largely due to overloading. The temptation in electric service is constantly to overload, either quickening the schedule, increasing the number of stops or adding trailer cars; this is due to the fact that the apparent limit of capacity of railway motors is their ability to make schedule and it is often not remembered by the railway superintendent that this is far beyond the heating capacity of the motors.

Where all cars in a train are motor cars, overloading cannot be as readily accomplished as where trailers are hauled, especially if the motors have been designed to take care of continuous running conditions with the minimum number of stops, as is generally the case.

The multiple unit control system is a very complicated assemblage of delicate apparatus, but works surprisingly well and, properly maintained, gives little trouble.

Table VI. is confined to the statement of delays and troubles on the train equipment; but in Table VII. the troubles due to the other parts of the electric installation, namely, the third rail, transmission lines, substations and power-house, are included and it is interesting to note the unavoidable delay caused by these features of an electric installation.

Cost Compared With Steam.

Considering the figures for the year 1908, it is seen that the Long Island road operated their electric mileage at a cost of 17.80 cts. per car-mile; the steam train mileage cost 27.95 cts., a difference in favor of electric traction of 10.15 cts. per car-mile. On the West Jersey & Seashore R. R., the electric mileage cost 20.46 cts. per car-mile as against 22.30 cts. for the steam mileage, or a saving for the electric service of 1.94 cts. per car-mile.

The relative unfavorable showing on the West Jersey for electric saving is in part accounted for by the difference in character of the service on the two roads, as before explained, and by the fact on the Long Island road the average length of train in steam service was about the same as in the electric and the stops frequent; it was, therefore, costly service. On the West Jersey the average cars per steam train was twice that of the electric and much of the service was long distance express with few stops and of an exceptionally economical character.

TABLE VI.—DEFECTS OF TRAIN EQUIPMENT

	1907. Long Island R. R.	West Jersey & Seashore R. R.	1908. Long Island R.R.	West Jersey & Seashore R. R.
Flash-overs	23	None	42	1
Main fuses blown	50	..	60	..
Shoe fuses blown	1,169	844	4,812	1,934
Trolley fuses blown.	None	358	None	711
Bus fuses blown	158	51	182	169
Controller fuses bl'n.	None	138	None	118
Heater & Pump fuses blown	379	359	590	383
Total fuses blown	2,023	1,955	6,028	3,504
Hot motor axle bearings	6	8	25	2
Hot journal bearings.	6	44	34	28
Grounded armatures.	9	6	27	6
Short circuited armatures	1	In above	9	In above
Grounded fields	1	2	2	1
Commutators	5	None	16	None
Contact shoes replaced	500	925	672	564
Pump motor armatures	10	1	15	2
Control	86	180	139	99
Brake equipment	15	40	26	15
Short circuits (misc.)	5	...	9	...
Trolley poles	Not used	981	Not used	469

Operating Costs; A. C.- D. C. vs. A.C.

A comparison of this kind must at present writing be based on estimates and opinion, as no operating figures for the A. C. systems are obtainable. It is the opinion of the writer that the maintenance costs of the single-phase system, as at present. developed, will be somewhat higher than for the A. C.-D. C.. but not by an important amount; eventually the maintenance costs should be about the same for either system. The total operating cost figure, however, will probably be in favor of the single phase system, because of the higher average efficiency of this system and the lower operating cost of substations. The importance of the savings possible for the single phase will depend upon the character and extent of the traction scheme, becoming greater as the length of line increases and the density of traffic decreases. It is impossible, however, to generalize safely and each case should be considered upon its own merits.

An estimate may be given for the particular case referred to under the "first cost" heading, in which it was figured that about 13% less energy at the power-house would be required for the single phase than for the A. C.-D. C. system. This, together with the saving in substation operation, would show an operating saving of about 1 ct. per car-mile, or, say, between 4 and 5% of the total operating cost.

A Bituminous-fuel Suction Gas Producer.

A suction gas producer, in which ordinary cheap coals can be satisfactorily used, has been sought by many designers of gas power-plant apparatus without notable success. One such producer, designed by Mr. Geo. L. Morton, Birmingham, England, is reported to have successfully passed many severe tests. This producer is described in the January issue of "Engineering Review" (London), from which the following items are taken:

The Morton plant is as simple as an ordinary anthracite suction plant, consisting of a generator, steam raiser, cooler and scrubber.

The generator, which is the subject-matter of the patents, may best be described as a rectangular shaft, having on the front side a projecting space; this projection slopes downwards, the angle of inclination approximating to the angle of repose of the face of a heap of fuel. From the outer end of this projection a return slope connects with the shaft near the base.

The generator is of the down-draft type, and is charged with fuel from the top through an opening provided with a movable lid. The top part of the shaft is a fuel container. Just below the commencement of the projection, but on the back and therefore opposite, is placed the main air inlet to which a pipe from hand-driven blower is attached. The projecting space is long and narrow, and on each side of the space are secondary air inlets, whilst at the angle formed by the meeting of the two slopes is a further air inlet.

At the base of the shaft is a grate with ordinary fire bars. Below is an ash container with airtight door for removal of ash, etc. On a level with the fire bars on the front and under the return slope is a chamber, closed by an air-tight door, for raking out the fire; this chamber projects beyond the generator casing, and on the top of this is the gas-pipe leading to the cooler and scrubber, which are connected with the expansion box and engine.

The generator is started cold, by charging in broken gas coke up to the level of the air inlet from the blower. A fire is kindled on this and coke is charged until the container is full; all air inlets are closed; the blower is worked and the fuel is blown up to incandescence. As soon as combustible gas is formed the engine is started, the main inlets opened and steam is admitted. The generator is now working by the suction stroke of the gas engine. As soon as the engine is fully at work the two side air inlets are opened and steam is admitted. When the coke in container has fallen sufficiently, raw coal is charged in, and the air inlet at meeting of the slopes is opened and steam is admitted.

AN ENGLISH BITUMINOUS-FUEL SUCTION GAS PRODUCER.
Designed by Mr. G. L. Morton, Birmingham, England.

The coal in the container, resting on the incandescent coke bed, gives off its volatile matter and continues doing so until reduced to coke. This volatile matter, as gas, is drawn down to the gas outlet and follows the easiest path. This is provided by the sloping cover to the producer, for here the fuel cannot pack. The fuel along this slope is kept incandescent by the side air inlets and the volatile matter passing through the mass is reduced to a permanent gas. Free carbon is deposited but largely burned by the air admitted through the side openings. CO_2 is also converted to CO.

The container is always full of fuel above the commencement of the slope and as the lower part of the bed sinks fresh fuel rolls down the slope and no open spaces are formed where gases can collect and burn.

At night the generator is banked full of coal and is started up next morning by using the hand blower. From the time blowing commences until the engine is on a working load is only six minutes.

The engine has been run for 1½ hours with no load and then 45 B. HP. (94% full load) has been thrown on suddenly without slowing down the engine which within two minutes was cutting down the supply. After running at quarter load for 1¼ hours full load was thrown on quickly without slowing down. This engine was a "Dudbridge" type, rated by the maker at 55 B. HP. on city gas and at 42 B. HP. on producer gas. On gas from the Morton plant, 48 B. HP. was carried.

The consumption of an ordinary Warwickshire coal, containing about 10 gals. of tar per ton, is given as 1 lb. per B. HP.-hr. The gas seems to be of uniform quality, costing 36 cts. per 1,000 cu. ft. or one-fourth as much as city gas.