

Design, Maintenance and Operation of Electric Rolling Stock

A Comprehensive Symposium of Papers Read at the A. R. A. Mechanical Section Convention at Atlantic City on June 10 Epitomizes Present Practice in This Field

AT THE Atlantic City meeting of the Mechanical Section, American Railroad Association, begun this week, the committee on electric rolling stock, C. H. Quereau, New York Central Railroad, chairman, on June 10 presented as its report a symposium covering operating experiences and general data of most of the steam railroad electrifications in the country. Brief abstracts of some of the papers forming this symposium are given below:

A PIONEER ELECTRIFICATION

J. H. Davis, electrical engineer Baltimore & Ohio Railroad, reported for that road in respect to the Baltimore tunnels. The class LE-2 locomotives, although of obsolete design, are still in operation and are today handling the maximum tonnage freight trains over the division, notwithstanding the fact that while they have been in service steam motive power has been replaced twice in order to secure greater capacity. Their continuance in service is due to the flexibility of multiple-unit control in that they are now used in a three-unit combination, whereas they were originally in a two-unit combination.

The locomotives purchased in 1910 and 1912 are of the Detroit tunnel type and can be considered as standard for the present electrification. Future additions probably will be of this type, with minor modifications to increase capacity slightly. These will involve increasing weight to 120 tons and changing the gear ratio to 83:19, which will give tractive effort at the one-hour rating of 33,800 lb. with a speed of 12.2 m.p.h. This will permit handling maximum-tonnage freight trains (2,600 tons, including steam locomotives) without dangerous overloading.

After a number of contact conductor arrangements had been tried out, of which Mr. Davis gave details, the present standard construction, he said, was adopted. In this the insulator rests on a wood-block support, eliminating the use of any metal except for the fastening bolt. The guard boards are supported on a malleable iron casting, but this is mounted independently from the insulator support. When the new construction was first installed there was some apprehension lest it might be pushed over the insulator on curves due to the effect of creepage and expansion. Anchors, however, have not been found necessary, although the rail is laid on a maximum grade of 1 per cent and is subjected to heavy traffic conditions.

As to bonding, Mr. Davis reported that the original bonds of an early concealed type with compressed terminals had short life and have been replaced by bonds of cable type extending around the joint plates. These are of 500,000-circ.mil section, 43 in. in length, with expanded pin terminals. With 130-lb. track rail now being laid a cable bond passing under the joint plates is being used, with terminals at both ends applied at

the factory. While joint plates must be removed in installing this bond, it is shorter than the other, and increased life is expected because a bond placed outside of the plate is sometimes injured during replacement of ties, etc. Bonds applied to the head of the rail have been tried, but none has proved satisfactory for heavy traffic conditions.

RESULTS OF THE NEW YORK CENTRAL ELECTRIFICATION

C. H. Quereau, superintendent of electrical equipment New York Central Railroad, gave operating and other data regarding its electrified section. He traced briefly the history of the development, including the reasons for adopting electricity, giving among other things the following dates: First scheduled multiple-unit train, Dec. 11, 1906; first scheduled electric-locomotive train, Feb. 13, 1907; first switching service, April 14, 1907, and all scheduled trains July 1, 1907. Operation began with thirty-five locomotives and 180 multiple-unit cars, of which fifty-five were trailers. It

TABLE I—INSPECTION AND REPAIRS OF ELECTRIC LOCOMOTIVES

Year	Cost per 1,000 Miles		Total
	Labor	Material	
1912.....	\$18.88	\$14.60	\$33.22
1913.....	19.82	14.54	34.36
1914.....	21.55	21.34	42.89
1915.....	19.01	13.79	32.80

was later found important to have all multiple-unit cars equipped with motors, which was done. At present there are seventy-three locomotives and 241 motor cars.

To indicate the reliability of electric operation, Mr. Quereau stated that in 1918 there were thirty-seven detentions of electric locomotive trains and 50,127 miles were run per detention, and seventy-one detentions with the multiple-unit cars, or 83,469 miles per detention. In 1908, under steam operation, on the Hudson passenger division the figures were 664 detentions and 6,045 miles per detention.

The cost of inspection, repairs and maintenance of the electric equipment, as given by Mr. Quereau, are shown in Table I, which figures, he states, are fair averages for the twelve years of electric operation until 1918, when wages were appreciably increased by the government. These figures do not include fixed charges. Table II was given to show the relative numbers of steam and electric locomotives required.

TABLE II—ENGINES USED—HUDSON DIVISION

	Steam		Electric	
	53 Engines and 78 Coaches	17 Engines and 97 Multiple-Unit Cars	Harlem Division	
	41 Engines and 95 Coaches		11 Engines and 116 Multiple-Unit Cars	
	Switching Crews			
At G. C. T.....	16 crews	11 engines	11 crews	5 engines
At Mott Haven.....	20 crews	14 engines	12 crews	6 engines
Total.....	36 crews	25 engines	23 crews	11 engines
Shop crews.....	26 crews	20 engines	18 crews	12 engines
Total.....	62 crews	45 engines	41 crews	23 engines

Summarizing the electrification situation in the United States, Mr. Quereau directed attention to these facts: There are fourteen roads which have electrified divisions, on eleven of which there are tunnels; 925.37 miles of route and 1,906.05 miles of track have been electrified; of the seven roads using direct current, four are 600-volt, two 2,400-volt and one 3,000-volt; of the alternating current roads four, with single-phase equipment, use a voltage of 11,000, one road uses three-phase current at 6,600 volts, and one uses single-phase current at 11,000 volts with split-phase current on the locomotive; on five roads third rail is used, and on eleven there are overhead contact wires.

REGARDING THE NEW HAVEN

The situation regarding the New Haven electric rolling stock was reported by W. L. Bean, mechanical assistant. He stated that on the principal electric division (New York to New Haven) there are now 104 electric locomotives and twenty-seven multiple-unit and fifty-two trailer cars. All operate at 11,000-volt, single-phase and some are arranged to operate also at 660-volt direct current.

Mr. Bean divided the locomotives of the New Haven into two groups, standard types and experimental types. Of the former he referred to the one using gearless motors for fast passenger service, the first type built, which is now obsolete for single phase. The second standard type comprises the geared passenger, freight and switcher locomotives, respectively with these wheel arrangements, 2-6-2-2-6-2, 2-4-4-2 and 0-4-4-0. Of the experimental locomotives he mentioned the geared three-truck fast freight or passenger locomotives, 2-4-4-2; the geared two-truck fast freight or passenger locomotives, 2-4-4-2; the geared side-rod freight locomotive, 4-4-4-4, and the side-rod locomotives, 2-4-4-2.

The type that proved best for passenger and freight service is the geared type with twin motors; that is, two motors bolted together and driving one pair of wheels through helical springs. This type is now standard. For switcher service the same general type is standard, except that a single motor and an 0-4-4-0 wheel arrangement are used, better to adapt the locomotive for this purpose. Increased switcher power will be obtained by multiple operation of units.

Mr. Bean pointed out that in addition to standardizing the locomotive, the railroad has brought about a corresponding standardization of auxiliary and control apparatus, a few of the major instances being as follows: (1) Standard motor for freight and passenger service; (2) universal blower motor, applicable to all classes; (3) universal compressor motors; (4) standard pantograph; (5) standard line switch, and (6) many detail parts of control apparatus and switch groups not interchangeable as a whole.

Mr. Bean divided the multiple-unit cars into two groups; those operating on 11,000 volts, single-phase only, and those operating on both single-phase and direct current. There are six motor cars of the former and twenty-one of the latter types. Each can pull two trailers. There are fifty-two trailer cars. Of the twenty-seven motor cars but two are now equipped with automatic control, although originally eight were so equipped. The six cars built for alternating current only have straight alternating-current motors, the control being arranged to change the connection of the motor as the speed varies to obtain best commutation. Four of the first motor cars were equipped with a flexible drive

similar to that used on the gearless locomotives. Fourteen later ones came with the helical-spring drive. The last four cars were built with flexible gears, and all motor cars were later changed to these gears. The flexible gear produces easier riding and a simpler design and conduces to easy maintenance. The development has been toward replacing existing apparatus with that of larger capacity, so that an increased tonnage rating can be secured or a greater daily mileage.

The installation of larger units involves rearrangement of apparatus so that a considerable change in appearance results due to but a small modification in design.

THE ONLY THREE-PHASE ELECTRIFICATION IN THIS COUNTRY

William Kelly, general superintendent of motive power Great Northern Railroad, described the electrification of the Cascade Tunnel and Tye Yards, commenced in 1908 and completed in 1909. There are here four three-phase locomotives, power being taken from two overhead contact wires at 6,600 volts and transformed on the locomotive in two three-phase transformers to 500 volts. All motors are of the three-phase induction type and the control is of the Sprague multiple type.

The locomotives weigh 115 tons each, all driving wheels being traction wheels and each motor being coupled to its axle like a street car motor. The motor shaft has a pinion on each end, with nineteen teeth, the driving gears having eighty-one teeth. Although the gear is not cushioned to equalize tooth pressure, both pinions wear evenly, the tooth pressures appear to be uniform and the wear to date has been almost negligible.

The four motors are of 250 nominal horsepower each, but can carry 50 per cent overload for the short periods that the railroad is able to use them continuously. The regenerative control is used, but this feature, Mr. Kelly said, has proved of practically no value to the Great Northern.

As to maintenance, the railroad has a one-stall locomotive shed, where periodical inspections are made as well as all repairs except turning of tires, which is done at the Delta shop, 76 miles away. A crew of four electricians is necessary, but this same crew could take care of much more equipment.

Mr. Kelly gave the following data on cost of operation: Repairs per locomotive-mile, \$7.53; wages, \$27.39; lubrication, \$0.20; supplies, \$0.33; total \$35.45. The mileage per pint of cylinder oil is 313; per pint of car oil, 19; the average gross tons per engine-mile, 345; the average tonnage per train, 1,035, as three locomotives are used; the total passenger-car miles, 48,096; the total ton-miles, 8,461,770. These data are for the year 1918.

ANOTHER SINGLE-PHASE ELECTRIFICATION

The Hoosac Tunnel electrification was covered by L. C. Winship, electrical superintendent. This 7.9-mile tunnel electrification was undertaken primarily to increase the capacity of the tunnel and to eliminate smoke. With electric operation, which began in May, 1911, four Mallet locomotives used for helper service were diverted to other uses and electric helping locomotives were provided for all trains. The original electrical equipment comprises five a.c. locomotives of the 2-4-4-2 type, developing 51,000 lb. tractive effort as a maximum—20,500 lb. continuously—working under a trolley pres-

sure of 11,000 volts. Two similar locomotives were added in 1917. These handle 1,750 tons behind the steam locomotive.

ELECTRICAL OPERATION ON THE B., A. & P.

The Butte, Anaconda & Pacific Railway was electrified during 1912 and 1913. In the symposium it was covered by F. W. Bellinger, electrical superintendent, his contribution being the same paper as that read at the Pasadena convention of the N. E. L. A. on May 21. As this paper was fully abstracted in the issue of the ELECTRIC RAILWAY JOURNAL for May 29, page 1101, it will not be necessary to repeat the abstract here. Mr. Bellinger concluded his paper with the significant statement: "For our service the electric locomotive is in every respect far superior to the steam engine."

EQUIPMENT FOR HEAVY TRACTION ON THE NORFOLK & WESTERN

John A. Pilcher, mechanical engineer Norfolk & Western Railway, described the equipment on the portion of the Pocahontas division familiarly known as the Elkhorn grade. The conditions here, he said, were favorable for electric traction because there was an entire short operating division on which electric power could be substituted for steam between engine terminals without shortening or interfering with adjoining operating divisions. In addition there were heavy grades where power requirements were great, and the large volume of traffic taxed the capacity of the line because of physical limitations and slow operating speeds. In this case the primary objects of electrification were the increased capacity of the line, and economy and increased efficiency of the service generally. The present electrification extends from Vivian to Bluefield. For information beyond that contained in his paper Mr. Pilcher referred to the issue of the ELECTRIC RAILWAY JOURNAL for June 5, 1915, and to papers before the New York Railway Club on March 19, 1915, by George Gibbs and on March 16, 1917, by C. H. Quinn.

Comparing electrical operation with steam, Mr. Pilcher said that it was customary under the latter to make up a train to a maximum weight of 3,250 tons behind the engine and to handle it by a Mallet road engine and a Mallet helper over the division, with a Mallet pusher in addition at the 1½ per cent and 2 per cent grades, or three engines per train. In cold weather and under adverse conditions the trains were reduced to about 2,900 tons. The engines were of the latest compound type, fitted with mechanical stokers and superheaters, weighing about 370,000 lb. on drivers and 540,000 lb. total, including tender, with a tractive power of about 85,000 lb. Tonnage trains were handled normally at speeds of 7 or 8 m.p.h. on the grades, but on account of the ventilating conditions the speed was reduced to 6 m.p.h. in the Elkhorn tunnel.

The decision to electrify, arrived at about seven years ago, followed a careful study by the officials of the road of the actual steam operating costs on this particular division. Twelve electric locomotives were provided for the service, replacing thirty-four Mallets. Alternating current at 11,000 volts with an overhead contact wire was selected for the installation, with the locomotive equipped with three-phase motors, a phase converter being used on the locomotive to change the single-phase current into three-phase current. The drawbar pull of the locomotive varies from a maximum of 114,000 lb. during acceleration to the 14-mile speed to 86,000 lb.

and operating at this speed uniformly on a 1 per cent grade. The valuable characteristic of this type of electric locomotive is its capacity of safely exerting full tractive effort for a considerable time while standing.

Mr. Pilcher said that electric operation has been in service too short a time to give data as to performance, but the estimates of increased capacity have been fully met. The acceleration of one of these heavy trains is impressive as regards the amount of power required. Preliminary tests indicate that getting a train in motion up the grades requires as much as 11,000 hp. (electrical), and that running at uniform speed up the grade requires 8,000 hp.

There are twenty coal trains hauled eastward daily and six time-freight and passenger trains are helped up the grade. The daily coal-train tonnage eastward is 65,000.

DATA REGARDING THE C., M. & ST. P. RY. ELECTRIFICATION

The general superintendent of motive power of the Chicago, Milwaukee & St. Paul Railway, H. R. Warnock, contributed to the report a synopsis of the results of electrification of sections of that road. The railway was first interested in electrification at the time of its extension from the Missouri River to the Pacific Coast. The reason for its consideration was to lessen the fire hazard, as the line was building through a very extensive forest reserve of the government. The consulting engineers first decided upon a single-phase trolley system, but the plan was abandoned owing to insufficiency of power available on the St. Joe River. In the meantime the road secured a site for power development on Clark's Fork of the Columbia River.

The railway, in its operation, to secure terminal facilities at Butte and traffic for its new road, established relations with the Amalgamated Copper interests in Montana and acquired a substantial interest in the Butte, Anaconda & Pacific Railway, which was owned by the Amalgamated company. About this time the Great Falls Power Company, which was also controlled by the copper interests, was seeking a market for power from its important development and to that end acquired the Madison River Power Company and the Butte Electric Company, which were controlled by C. A. Coffin, president of the General Electric Company and affiliated interests, the combination being called the Montana Power Company.

For the purpose of developing a market for power as well as to develop electrified operation and to secure the savings therefrom the B., A. & P. was electrified, the contract being made with the General Electric Company. The engineering work was done by the Montana Power Company and the General Electric Company. The result of this undertaking was successful financially as well as technically.

About this time a representative of the General Electric Company made a report on the electrification of the Rocky Mountain division of the C., M. & St. P., based upon duplication of the locomotives and substation apparatus in use on the B., A. & P. No consideration of regeneration or control of peaks was contemplated. Based upon this report the contract was made with the Montana Power Company for a nominal sum of 10,000 kw. for the Rocky Mountain division, with options provided under certain times for an increase to a maximum of 25,000 kw. The contract further

provided that apparatus would be secured by the railroad capable of regulation of power factor, and that the minimum monthly charge would be equivalent to an average of 60 per cent of the nominated maximum power.

The road entered into a similar contract for the extension of the electrification to include the Missoula division from Deer Lodge, Mont., to Avery, Idaho. It was concluded that the topography of the road was particularly suited to regeneration and that this would be required. Another conclusion was that automatic means should be provided for the limitation of the maximum demand for power.

The Westinghouse Electric & Manufacturing Company submitted an analysis, including an estimate on the cost of electrification, based on a single-phase trolley, split-phase locomotives for freight service, series commutator motors for passenger service and substation apparatus to convert from 60 cycles and to reduce automatically both voltage and frequency when the demand exceeded the predetermined peak setting. Each locomotive and each dispatcher's office was to be equipped with frequency meters so that at all times those interested in the condition of power demand would be able to function advisedly.

Analysis of the probable load condition with 2,500-ton trains led to the conclusion that a voltage higher than 2,400 was economical, and supporting this was a demonstration by the Westinghouse Company of a high-voltage car equipment, which was operated at 6,000 volts, direct current. The voltage of 3,000 was therefore decided upon and contracts were made with the General Electric Company for the electrification of 440 miles from Harlowtown, Mont., to Avery, Idaho. The execution of this electrification has been unique in the perfection of its details. The technical result of the electrification has been quite a success, and the financial result, due particularly to fuel and labor conditions, and the indirect value due to the publicity of this operation have been equally satisfactory.

Mr. Warnock also described the additional electrification of the Columbia and Coast divisions, which has been covered in detail in recent issues of the *ELECTRICAL RAILWAY JOURNAL*.

In regard to operating organization, Mr. Warnock said that the two divisions, Rocky Mountain and Missoula, are under one superintendent, who had two assistants, one for each. Train dispatching is done from Deer Lodge by telephone, one set of three dispatchers handling the Rocky Mountain division and another the Missoula division. Under steam operation there were two division superintendents, one at Three Forks and the other at Missoula. Each of these points had two sets of dispatchers operating in either direction, which made a total of four dispatching districts.

Electric locomotives run from Deer Lodge through to Harlowton and Avery, respectively. Under steam operation locomotives were changed at the intermediate engine points, Three Forks and Alberton. The radius of the locomotive has, therefore, been doubled. The locomotive repair shop is at Deer Lodge, two men being located at Avery and Harlowton respectively, to attend to light inspection. The master mechanic at Deer Lodge has general charge of substations, a supervisor being in direct charge of the latter. Three operators, each working on an eight-hour shift, are provided at each substation. Maintenance of the trolley and transmission lines is under the charge of a general foreman of

maintenance, reporting to the superintendent of the two divisions. In general, three maintenance crews are used, each consisting of a foreman, two linemen and a helper, provided with suitable work train.

A WORD FROM A C., M. & ST. P. MASTER MECHANIC

The division master mechanic of the C., M. & St. P. Ry., E. Sears, reported that comparing his experience with maintenance of equipment under 3,000-volt and 600-volt operation, the former is affected more by weather conditions; that is, all resistance units have to be kept freer from moisture. Also experience has shown that it is poor policy to try to break heavy currents at 3,000 volts, except through resistance, for the vapor and fumes formed by the copper will cause the current to jump as far as 6 ft. A number of contactors were burnt out, due to the facts that there were no circuit breakers on the locomotives and that the main motor currents were broken through twin contactors. This trouble has been eliminated by the insertion of a small amount of resistance ahead of the contactors when arcs are broken. The new locomotives are equipped with high-speed circuit breakers.

Mr. Sears has not found any special difficulty in keeping insulators clean to prevent creepage at 3,000 volts. There has been no trouble with the "freezing" of the contactors, which require very little attention. Under normal operation there is about 600 volts drop between substations, with a greater variation brought about by the power-limiting apparatus. The method of collecting current from the overhead is ideal, being sparkless, with little wear on the double No. 0000 contact wire.

Mr. Sears said that the pantographs are greased with graphite grease at terminals and require no further attention on the road. The average life of pantograph strips is from 9,000 to 10,000 miles. Pantographs can be more cheaply maintained than third rail shoes, but are susceptible to being torn off on account of lack of alignment of the overhead. This is probably due to the method of overhead maintenance, as it appears that the overhead maintenance crew depends upon the pantographs to show where the bad places in the overhead are. In hot weather, when the expansion is greatest, as many as fifteen pantographs have been lost in one month.

ELECTRICAL EXPERIENCE ON THE LONG ISLAND

G. C. Bishop, superintendent of motive power Long Island Railroad, gave an account of electric operation on its lines. As this subject was covered in last week's issue of this paper, it will not be necessary to go into details here. He said that the Long Island still furnishes the most extensive example of multiple-unit passenger train operation. Steam-operated express trains to the eastern end of the island are taken from the Pennsylvania station by electric locomotives to Long Island City, at which point steam locomotives are attached. It is probable that in the near future electric locomotives will haul these through trains to Jamaica. The freight service is still conducted by steam and on some portions of the electrified system steam locomotives are used to operate both freight and through passenger trains.

SOUTHERN PACIFIC ELECTRIFICATION EXPERIENCES

The electrification of the Southern Pacific Company's Oakland, Alameda & Berkeley suburban lines was discussed by George R. McCormick, general superintendent

of motive power. This improvement, he said, was part of the general rehabilitation of the Southern Pacific property carried on by Mr. Harriman. In the fall of 1906 instructions were given to begin electrification. At present more than 900 electric trains are operated daily from the two ferry landings and 32,000,000 passengers are handled annually. He referred to a complete description of the distribution and trolley system given in the *ELECTRIC RAILWAY JOURNAL* for Oct. 21, 1911.

The trains on the O., A. & B. run from one to seven cars, operated on the multiple-unit system, a train unit consisting of one motor and one trail car. On the motor car are four 140-hp. motors. The two motors on each truck are connected permanently in series, so that although the equipment is a four-motor one, the control is of the two-motor type. The car repair shop, located at West Alameda, was designed for inspection and quick overhaul of the entire equipment. Detailed description of these cars and this shop will be found in the *ELECTRIC RAILWAY JOURNAL* for June 17, 1911.

The total single-track mileage electrified on this system is about one hundred and the car equipment comprises sixty trail coaches, fifty straight motor coaches, twenty-nine baggage and passenger motor coaches, two express and baggage motor cars and ten street cars. The system was placed in electrical operation in 1911.

The report abstracted above was presented, in the absence of the chairman, Mr. Quereau, by J. A. Pilcher, who said he would not attempt to read the paper, but in presenting it for consideration he wished to call attention to the great number of different schemes that had been studied in connection with the problem of electrification. This method of operating our roads, he said, now seems destined to become a great factor in the development of the future and is particularly adaptable to all service conditions requiring a heavy power output. Mr. Pilcher referred to the constant speed feature of some electric locomotives as being particularly desirable in order to maintain dependable service.

There was no discussion of the paper.

The chairman of the association, W. J. Tollerton, said he considered the subject of electrification a very important one, especially when viewed from the standpoint of conservation of fuel.

The paper was received and a vote of thanks was extended to the committee for the exhaustive paper that had been prepared.

Mr. Hurley on Trade Papers

EDWARD N. HURLEY, formerly chairman of the Federal Trade Commission and during the war chairman of the United States Shipping Board, has a good opinion of trade papers. In the course of an address on June 8 to the Associated Advertising Clubs of the World at Indianapolis he said:

When I was chairman of the Federal Trade Commission I made it a point to have the principal trade papers in the United States sent to me regularly. These were read not only by myself but by the entire staff, so that we might have a finger on the pulse of the country's industry. Advertising agencies placing national and international advertising could well insist on every man in their employ reading the trade journals of the industries of their clients so that they may keep themselves currently informed on the conditions in the businesses for which they are writing copy. I believe in the business journals. I have been closely associated with the work of many and have made a study of them, and I am firmly convinced of the editorial strength and value of many of these publications.

The Locomotive as an Investment

Author of A. R. A. Paper on This Subject Points Out Some Improvements Made in Steam Locomotives in Recent Years

IN AN individual paper contributed to the program of the A. R. A. Atlantic City meeting by G. M. Basford, president Locomotive Feed Water Heater Company, some information is given as to the steam locomotive in its rôle of rival of the electric locomotive. Mr. Basford said that the locomotive is a big investment and it must be so considered and so treated. In no other branch of engineering development have so much progress and improvement been made in efficiency as has been made in the steam locomotive during the present official generation, and the improvement has just begun. If all new and all existing locomotives are made as efficient as the best, and it is possible to make them nearly so, private ownership and operation of railroads will be put in the way of success, but no matter how efficient the power unit may be as a unit, its operation must be such as to obtain the benefit of the possible efficiency for the maximum number of ton-miles per hour. Among other things this calls for the best locomotives and the best use of locomotives, quick and continuous movement, reduction of idle hours, quick terminal movements, improved dispatching, improved maintenance and repair facilities and repair methods, as well as fuel and labor-saving improvements of every kind. Whatever, said Mr. Basford, we may have in the future, today the steam locomotive is the most vital influence in the progress of civilization. Its possibilities for assisting in meeting the problems of the present and future by reducing the cost of transportation are beyond the imagination of all who have not made a careful study of the improvements now available for increasing capacity. Whenever you wish, he said, you may put on the rails locomotives that, from a performance and particularly from an efficiency standpoint, will hold their own with the best non-condensing power plants on land or afloat. You may at any time produce a drawbar horsepower-hour for 2.25 lb. of coal at the speed giving the maximum power of the engine. The problem is how to make all the locomotives of this country approach the standard already set, how to make the best use of facilities that are already available, also how to keep abreast of future improvements.

Mr. Basford challenges some of the contentions made by proponents of the electric locomotive in these words: "Electric locomotive partisans are propagandists in arguments for electricity vs. steam. They argue, however, on the basis of the steam locomotive as they knew it in the past rather than as it is today. They further weaken their case by absurd claims to the effect that electric locomotives can save two-thirds of the coal burned by all the steam locomotives in the country, and they base their claims on the steam locomotive of ten years ago. The truth is that in five years of this period the economy and capacity of the steam locomotive have more than doubled. The object is not merely to win out against the electric but to pit the steam locomotive against the high cost of everything. Constructive, systematic policy of locomotive engineering and operation is the way to do this and it will do it.

"We are told that electricians are replacing steam locomotives. We do not hear enough about the thirty-eight steam Mikados that replaced twelve Moguls and thirty-eight Consolidations on the Missouri, Kansas & Texas