Developments of the Future in Electrification

The Electrification of Steam Railroads Is Discussed by Engineers Prominently Identified with this Phase of the Electric Railway Industry from the Standpoint of Commercial Possibilities and of Impending Technical Developments in the Electric Locomotive and in Power Distribution

THE following series of articles deals with future possibilities of heavy electric traction from both the commercial and the technical sides. In regard to the former, the author who discusses it, A. H. Armstrong, writes in a distinctly optimistic vein, and is expectant of a considerable degree of activity in the immediate future in mountain-grade electrification. This field is considered the most promising not only because of the opportunity for attractive returns on the investment involved in electrification, but also because of the fact that here the physical limits of the steam locomotive have already been reached. On the technical side, an article by E. H. McHenry calls attention to the opportunities for improvements in the electric locomotive, this possibility of evolution, in fact, constituting one of the important indications of the extension of electric operation on steam railroads. The most important fundamental feature that is cited wherein the electric locomotive possesses an inherent advantage is that of its ability to handle heavy trains on fast schedules, and the author considers that but a very small part of the penalties now paid to attain express-service speed for freight trains apply to electric operation. On the subject of power distribution for heavy electric traction F. H. Shepard makes the important announcement that the present maximum contact-line voltage of 11,000 is likely to be subject to an increase in the near future, and outlines also some of the possible future considerations that have been brought to the front through experiences with the 5000-volt direct-current installation that was made last summer. In the following series of articles, therefore, each general phase of electrification has been discussed, and from the views expressed by the several authors there is ample evidence that the immediate future is going to see important changes as well as constantly increasing activity.

Some Aspects of Heavy Electric Traction

BY E. H. MCHENRY
McHenry & Murray, Consulting Engineers

It has been stated that when an art reaches a stage of development at which no further progress is possible, it does not remain stationary but disappears and is replaced by some other form or method which possesses greater inherent qualities of continued evolution. If the steam locomotive has now reached this stage, its ultimate replacement by some new form of motive power is certain, and with our present knowledge we must assume that this will be some form of electric traction.

In past years the steam locomotive has several times appeared to have reached the ultimate practical limits of growth in horsepower and tractive effort, but each time some new development in design or method has made further advances possible, and it would be too bold to predict that the limit has even now been reached. Nevertheless, there is good reason to believe that it is close at hand, if not already here, as indicated by the present tentative experiments with electric traction in practical operation and the increasing difficulties and cost of adapting steam traction to the ever-growing requirements. Further development of the steam locomotive is so severely handicapped by the space and weight limitations, which appear to be inherent in any form of prime mover, that it does not seem likely to survive in the end in competition with a simpler and more convenient form of motor, in which energy supplied from an outside source is simply converted into work at the point of application. This is more particularly the case under conditions which permit large reductions of dead weights and the distribution of the present excessive concentrations of weight and pressure over more space and points of support.

In current practice higher steam pressures, compounding and superheating have greatly extended the horsepower capacity of the steam locomotive, but until recent years a corresponding increase in tractive power has only been gained at a cost of very high concentrations of weight and pressure within the restricted limits afforded by the rigid wheelbase. Axle loads of 30,000 lb. in 1880 have risen to 60,000 lb. and 65,000 lb. in 1915, with an extreme maximum of 73,000 lb., making necessary great changes in track standards and corresponding increases in the cost of track and track maintenance.

In the same interval the weight of rail sections have been much increased, but the rails have not kept pace with the increasing axle loads in either strength or quality, with the result that economy has been sacrificed and the margin of safety has almost disappeared.

The development of the Mallet and triplex locomotive types affords a partial relief from the restrictions imposed by the rigid wheelbase by distributing the weight of the locomotive over more driving axles, but the evil effects of the precedents already established still survive and in the later engines of this class the newly-regained margin of safety is again nearly absorbed.

All of the above considerations tend to the conclusion that the possibilities of future growth of electric traction are much less sharply limited than in the existing steam service.

With electric traction the weight and space limitation of the steam locomotive are largely avoided, as it is not necessary to overload the driving axles nor even to assume that all driving axles must be concentrated into locomotive units, as the possibilities of multiple unit control now utilized in passenger service can obviously be also extended to freight service, and it is altogether probable that in future the motive power will be distributed in the length of the train in order to avoid excessive draft strains and concentrated stresses in bridge members.

It may be added that the uniform turning moment of the electric motor permits a higher utilization of the available adhesion, which also tends to a reduction of the present axle loads. The available horsepower capacity will also be very much enlarged, as the source of primary power may be regarded as unlimited so far as the requirements of any one train are concerned, and this will have the practical effect of eliminating many of the present limitations on train load and train speed.

Under favorable conditions, in which density is the chief factor, electric traction is already most economical in operation, but the general substitution of electric for steam traction will not depend so much upon its comparative economy under similar conditions as in its inherent and latent possibilities of future development and in its ability to occupy wider fields of usefulness. This point is strikingly illustrated in the development of electric street railways, in which the comparative cost and economy of electric versus animal traction were at first compared under similar service conditions, but in which the character of the service soon changed so greatly that no one to-day would even think of them as equivalents upon which economic comparisons could be based. Similarly, in the operation of standard railways it is probable that electric motive power will find applications in new fields still undeveloped in which the steam locomotive could not meet the requirements.

It is the writer's opinion that electric traction will find no rival in at least two fundamental features of high commercial importance. In light passenger service, the higher rates of acceleration, reduced weights and lower cost of train wages, fuel and repairs afford opportunities for more frequent train service than would be economically possible with steam traction, collaterally accompanied by higher gross and net earnings.

In freight service, the ability to operate heavy trains on fast schedules has a commercial value which is but little realized and which it would be difficult to overestimate. The higher rolling friction and wear of track and equipment form but a small part of the cost of high speed in freight service, which is principally due to the fact that the steam locomotive can rarely generate sufficient horsepower to utilize its tractive rating at speeds higher than 10 m.p.h. or 15 m.p.h., and only attains higher speeds at a sacrifice of train tonnage. This sacrifice is disproportionate to the gain in speed and may greatly increase the number of trains required to move the same tonnage, and as about one-half of the cost of operation varies directly with train mileage, it is evident that the cost per ton-mile will be much greater. In one case in the writer's experience, 4.6 trains were required to move the same tonnage at 35 m.p.h. as compared with one train at 18 m.p.h., thus more than doubling the ton-mile cost. This is not an unusual condition and it is safe to say that the train load of a great majority of all freight trains in the United States is less than that fixed by the resistance of the maximum grades.

The additional cost of high speed in express service and time-freight service is supposed to be compensated in the freight rates, but there must always be some rate of speed in each particular case above which a rate sufficiently high to compensate for the reduced train loading cannot be obtained, and below which a loss in traffic rates may be suffered. With electric traction but a very small part of this penalty for high speed need be paid, as the armature speed of the electric motor is almost independent of its weight and tractive effort, thus affording an opportunity to maintain full traction ratings at higher speeds than permitted by the limited horsepower capacity of the steam locomotives in common use. This is a fundamental distinction in favor of electric traction, as it is apparently possible to earn the higher rates now paid for fast service without added train mileage, with the result that the net earnings per train-mile will be much increased. In general, the commercial value of speed is less than that of its tractive equivalent, provided that it is sufficiently high to meet the requirements of the time schedules established for each particular class of service, and any available horsepower capacity in excess of such requirements may usually be converted with greatest profit into equivalent tonnage rather than into speed.

The fullest utilization of the inherent advantages of electric traction will not be obtained until the motor capacity can be more flexibly extended over a wider variable range of speed and tractive effort, in which respect the present motors of the series types are quite deficient. Their characteristics are such that the motor horsepower and speed rise and fall almost together, with the unhappy result that the available horsepower becomes less as the need for it grows greater.

In the operation of engine districts of relatively low resistance, with local sections of high resistance, which is the most common condition, the motors will be too heavy and too slow on the level sections; or, alternatively, too light to meet the tractive requirements on the sections with heavy grades. Under these conditions the electric motor is at a disadvantage when compared with the steam locomotive, which can always develop its full "adhesion rating" at lower speeds and constant horsepower without regard to the time or distance over which the maximum effort is exerted. This disability has already been overcome in some measure by special types of induction and series motors, which afford two or even more "steps" in speed at equal horsepower, and there is every reason to believe that a fuller development along the same lines will extend the range of practical application and afford a more nearly continuous gradation between the extremes of speed and tractive effort. The difficulty could also be met with the aid of some practicable form of mechanical gear changer, but the present prospects for such a development do not appear to be very encouraging.

The time factor is such an important element in the tractive rating of electric motors, that measurements of motor capacity in terms of continuous and hourly horsepower become almost valueless for practical use, and some method of service rating which recognizes the relation between horsepower capacity and the coefficient of adhesion of the weight on drivers would be most desirable.

In ordinary switching service, an electric locomotive can effectively utilize its full tractive weight on drivers with but one-fourth of the rated horsepower capacity in motors required to utilize the same tractive weight in service extending over much time and distance, as in the operation of long inclines. A rating of the kind suggested would simply express some time relation between the maximum and average values of the root-mean-square current as determined by the physical characteristics of the particular division or engine district to be operated, and would doubtless take the form of a coefficient to be applied to the continuous horsepower rating of the motor capacity. Means for correcting the lower power factor of systems using induction and single-phase motors, in order to reduce line losses and the first cost of apparatus, would be particularly desirable, and the possibility of accomplishing this result by locally supplying magnetizing current from the locomotive auxiliaries has been under consideration for some time past. A further extension of the same principle would apparently also afford local voltage regulation at the motors, which would be even more desirable and valuable than simple power factor correction.

Reference has already been made to the opportunities afforded by electric traction for reducing axle loads, which is necessary both in the interests of safety and economy. Under the old rule of the Baldwin Locomotive Works, and the more refined rule submitted by Gustav Lindenthal before the New York Railroad Club on May 21, 1915, which takes the modulus of the rail section into account, the safe axle load for rails of 100-lb. section does not exceed 45,000 lb., as compared with the higher loads previously noted. A further and more comprehensive investigation of safe loads for the different rail sections in common use should afford valuable results. Better methods will doubtless be devised for cushioning impacts arising from the heavy motor weights, which is an important feature as the destructive effect of uncushioned impacts on motors, gears, wheels and rails is very large.

That these aspects of electric traction have not been more generally recognized is not surprising, as they occur more particularly in heavy freight service which as yet is but little developed in the field of electric operation.

Opportunities for Electrification

BY A. H. ARMSTRONG
Chairman Electrification Committee General Electric Company

The striking economies resulting from the electrification of the Butte, Anaconda & Pacific Railway, which constituted the first practical demonstration that electric operation of steam railroads could be made to pay direct profits on the investment involved, have had a far-reaching effect. Prior installations had been undertaken only because of considerations which, like those of the smoke nuisance or improved suburban service, were entirely aside from the question of profit, and in consequence electrification was very generally regarded more as a costly luxury than as a means for decreasing operating expense. But now it is being recognized by the various railroads of the country that there are a great many instances wherein the investment involved by electrification will prove to be thoroughly advantageous upon financial grounds alone and will produce an attractive return in the direct form of operating economies. This makes it certain that a material increase in electrified mileage is going to take place in the immediate future.

Some of the increase will undoubtedly come from the electrification of large railroad terminals. The popular demand for smokeless operation is very much in evidence at present, and where the proper conditions exist, such as the opportunity to take advantage of multiple-level stations and increased capacity of individual tracks, the work is going to be carried out. It is probable, however, that in urban districts from which the steam locomotive is banished there will be considerable trackage on which the traffic is too light to warrant the economical installation of an electrical contact system, and for work under such circumstances the use of electric units that are capable of self-propulsion when necessary, seems likely. Obviously, the cost of the equipment of sidings such as house tracks that are used but once or twice a week constitutes a heavy and quite unnecessary burden upon electrification, which is, primarily, a means for delivering large amounts of energy to moving trains.

Because of this, in fact, mountain-grade electrification appears to be a more important field of opportunity at the present time than terminal electrification. Indeed, steam railroad operators are turning at last to electric operation for the very good reason that their growing demands for tonnage and speed have gone beyond the maximum physical capacity of the steam locomotive, and it may be safely said that there is hardly a heavy trunk-line mountain grade in the country where electrification is not being seriously considered. This does not mean that electrification of every grade will be undertaken at once, because there are numerous factors, notably the difficulty of raising funds, that have always to be considered before actual construction can commence. Nevertheless, there are to-day a number of very active grade electrification projects in view, and there seems to be good reason to expect that several will be actually authorized within the coming year.

The reason for classing mountain-grade installations as the most profitable field, and the one in which the greatest activity is imminent is, in general, because of the relatively high speed at which the electric locomotive can exert its full tractive effort and the economies that are consequent thereto. The limitations of the steam locomotive involve a material loss in hauling power when the speed is increased above 8 m.p.h. or 10 m.p.h., and there is, in addition, an indirect loss that is especially important on heavy grades because the great weight of the machine cannot be utilized for adhesion at higher speeds, thus acting as dead weight which must be deducted from the revenue train-load behind the tender. For example, the recently developed "triplex" type of steam locomotive is capable of even greater tractive efforts than the latest designs of electric engines, and it is obvious that speeds of say 15 m.p.h. could be obtained with it on ruling gradients by reducing the tonnage of the trains that it was called upon to handle. However, when this is done the tractive effort becomes only some 10 per cent of the adhesive weight and the result is a most inefficient hauling machine.

To make electricity a commercial competitor of steam it is necessary only for two favorable conditions to apply—(1) sufficient tonnage, and (2) available power facilities. For the latter it may be said that a straightaway feeding distance of 200 miles is reasonable for synchronous machinery and up to that limit hydroelectric or other foreign power may be purchased; otherwise power stations must be built for the individual use of the railway, and this is always a serious handicap.

Regarding tonnage, a very approximate minimum limit may be set on roads with heavy grades, amounting to 15,000 tons daily in one direction. With traffic of this order it will generally pay to electrify, and where there is more than this on single-track roads the proposition should become very attractive. For double-track roads the minimum should not be appreciably different because, whether a line is double or single track, no more copper need be installed, and the power facilities and number of locomotives required are dependent upon the schedules irrespective of whether they are maintained on one track or two. Clearly enough, this minimum makes electrification a practical possibility on every Eastern trunk line that crosses the Alleghenies and on practically every road crossing the Continental Divide in the Western States.

Included in the latter are the Transcontinental systems, and in the case of these roads there are considerations due to location and character of traffic that make electric operation particularly advantageous. In the first place, steam fuel is generally high in price and poor in quality, and at the same time the mountain rivers provide an adequate supply of hydroelectric power at well situated points. The consequent saving, which is the largest single item in the list, should normally run to fully half of the entire cost of steam locomotive fuel. Repairs constitute another very important item, these frequently exceeding 20 cents per mile for a steam engine having only about

60 per cent of the tonnage-moving capacity of the electric machine and making 35,000 miles per annum under the most favorable conditions. Electric locomotives of a size similar to those now in service on the Chicago, Milwaukee & St. Paul Railroad, and having 450,000 lb. on drivers, should cost about 10 cents per locomotive-mile to maintain, making an annual mileage of at least 60,000. The average increase in train speed to be expected under electric operation brings with it reductions in other operating expenses that are obvious, and this constitutes a third item of importance.

These considerations apply with special emphasis, of course, directly to those divisions where heavy grades are encountered, but as a measure of the mileage thus involved may be cited the fact that the mountain country extends for 800 miles on the Chicago, Milwaukee & St. Paul Railway, or nearly twice the length of the very extensive electrification now nearing completion.

Logically, electrification should be made continuous, and all of the sections with heavy grades could profitably be coupled together even though this might involve the electrification of an intervening low-grade engine division, thus eliminating the disadvantage of maintaining a steam engine division that is placed between two electric engine divisions, and here it may be said that, on the Chicago, Milwaukee & St. Paul Railway, it is the intention to combine two steam divisions into one electric engine run totaling 220 miles in length.

The extent of the savings from this source can hardly be estimated at the present time, but that they should be important cannot be doubted. Even in the light of present experience there is no longer any question but that in mountain-grade electrification the whole division that includes the grade should be equipped and the steam locomotives eliminated completely. Combined steam and electric operation does not pay, except under extraordinary circumstances, and such installations are made entirely from motives of expediency rather than because of the direct return upon the investment.

Regarding opportunities for profitable electrification other than mountain-grade installations there should be mentioned the possibilities inherent in low-grade freight lines and in large switching yards. Both of these general fields look exceedingly promising, but the expression of any opinion as to the extent of the available economies or the probability of their exploitation in the near future would be speculative, because of the existing lack of definite data upon which to base conclusions. Electric yard service would have every thing in its favor from an operating standpoint and should show excellent returns, provided that fixed charges are not made prohibitive by having to equip tracks that are used comparatively seldom.

With regard to low-grade freight lines there are equally great benefits to be secured without encountering the disadvantage of infrequently-used tracks, and there ought to be something done in the near future both on Eastern trunk lines and on the level divisions of transcontinental lines after they have had their mountain divisions equipped. However, the physical need for electric operation is not so great on level routes, even though the traffic may be heavy and the load factor high. Notwithstanding the fact that the returns might be quite as attractive as those from a mountain-grade project there is not the same physical incentive to make the change so long as the less economical steam locomotive is able to meet the requirements of the traffic, and this the steam locomotive seems capable of doing in a satisfactory manner for a number of years to come.

Considerations in Railway Power Distribution

BY F. H. SHEPARD
Manager Heavy Traction Division Westinghouse Electric & Manufacturing Company

The well-defined tendency toward constantly increasing train loads in steam-railroad practice, coupled with the demand for higher speed wherever electrification of freight traffic is considered, makes the problem of delivery of energy to the electric locomotive a continually recurring one. Literally enormous demands for power are being made on existing installations of heavy electric traction, and yet there can be no doubt that these will be exceeded in the immediate future. On the electric zone of the Norfolk & Western Railway, for example, drafts of 12,000 kw. for a single train are of common occurrence, and in the passenger service on the Philadelphia main-line electrification of the Pennsylvania Railroad, as many as four heavy motor-car trains in one section may synchronize their power demands during acceleration, calling for a total input of about 16,000 kw.

Although the distribution and collection of such amounts of power are well within the capabilities of equipment designed according to present standards, the margin for a possible future increase in the train load or in the train speed is by no means unlimited, and of late it has become increasingly evident that provision should be considered for further demands if the utmost advantage is to be taken of the benefits of electric operation. The most obvious step in this direction would be an increase in line voltage above the present generally accepted maximum of 11,000, and in fact, there has already been some definite expression of belief by engineers that such a change should be made.

Undoubtedly there is much to be gained by an increase in contact line voltage even under existing conditions. It is true that the difficulty of insulation increases about as the square of the voltage, and with insulators fouled by exhausts of steam locomotives—a condition which occurs on many electrified track sections—this difficulty is of no mean importance. On the other hand, such troubles are generally more impressive in prospect than in practice, as exemplified by the success of the great increase in contact line voltage that was made when 11,000 volts was introduced ten years ago. As a matter of fact, there is no particular reason, aside from the deterrent effect of present custom, why a trial of 16,000 volts should not be made, and if this turns out satisfactorily, it should be followed by another increase to 20,000 volts on the contact line. European practice has already sanctioned 15,000 volts, and now that the need for a higher tension is beginning to appear in this country, it is safe to say that its introduction is going to be a matter of the future.

For railroad transmission lines, however, a similar increase in voltage is not called for. With the exception of the St. Paul installation, electrifications have thus far covered distances that were too short, in view of the power requirements, to warrant transmission at anywhere near the maximum in use for industrial lines. On the Norfolk & Western and the Philadelphia electric zones, a transmission voltage of 44,000 was found to be ample, and no decrease in copper could have been effected by a higher tension without sacrificing mechanical strength, smaller wires than those used being too subject to breakage. Of course, for longer distances a higher voltage would obviously have been necessary, because with traffic of the importance of that which is involved in both cases, it would have been unwise as well as unnecessary to take liberties with voltage regulation, as evidenced by the relatively short intervals of about 10 miles between transformer stations.

Incidentally, it might be well to call attention here to the origin of the rather unfortunate custom of calling these buildings "substations." The latter term conveys at once the impression of skilled attendants and rotating machinery costing some $35 per kilowatt, because of the familiar application of the term in city and interurban railway work. Yet the transformer stations on the electrifications in question are as foreign to such a definition as the pole-transformers on 2300-volt lighting lines which serve a number of adjacent residences with low-voltage current. The power apparatus involved might, if desired, be installed out of doors, and the cost of the equipment, amounting to some $5 per kilowatt, makes it serve directly as a means for reducing the feeder cost. The term "transformer station" is infinitely more applicable to such an installation, because, unlike the "substation" which acts as an auxiliary to the power station for the production of direct current, it is not indispensable to power operations, but serves instead the dual purpose of voltage regulation and prevention of inductive disturbance. The spacing is not dependent upon power losses.

This is not the case with the direct-current substation, where the first cost of the machinery makes a maximum spacing greatly to be desired, and this reason, together with the problem of current collection at the pantograph, provides a definite incentive in railway work to increase direct-current voltages. The step that was made some years ago from 600 volts—so long standard for interurban railways—to 1200 volts, was a marked success. Nevertheless, the imposition of more than about 1500 volts on a single armature involves material difficulties, notably that of commutation.

The practical limit in voltage for motor armatures is analogous in some respects to that which was found in generator design when the first attempts were made to increase alternator voltages. This early difficulty was overcome by the ingenious conception of the stationary armature with a rotating field, and that permitted the extension of generator voltage to the desired point. Yet the original voltage limits for a rotating armature have remained unchanged to this day.

Forward steps in direct-current railway voltage, therefore, have been made by combinations of 1200-volt armatures, and the advance reached a record height last summer with the successful operation of the 5000-volt Grass-Lake line of the Michigan United Traction. This installation has been working regularly since that time, and it has shown very gratifying results. But, of course, it is still no more than an experiment, and its commercial success is subject to a great many factors which are as yet wholly unknown.

In this connection it may be said that the problem of earth current voltages is one of major if not of vital importance irrespective of inductive interferences, and although harmonious co-operation between railroad engineers and the engineers of telephone and telegraph companies has been a conspicuous feature of recent electrifications, definite knowledge regarding all phases of action of extreme high-tension direct-current circuits can come only through practical experience.

Certainly, if direct-current voltages are increased greatly and substations are moved far apart, there is a probability of very great differences in earth potential wherever heavy drafts of current are taken from the line. How these will appear, and what their effect will be can only be determined by the slow process of experiment. In the same way the matter of surges is bound to be important with great increases in voltage. Also, voltage fluctuations in railway circuits, as well as the shorts that are bound frequently to come in, are wholly different from any conditions that are found in ordinary transmission problems, and it cannot be said in advance just what is going to develop. In fact, direct-current installations of extreme high voltage like that at Grass Lake are in just the same place as were the single-phase installations ten years ago. Their problems are before them, and these will have to be worked out by experience before they can reach the condition of a definite and precise art in which single-phase operation is to-day.

Rhode Island Arbitration Award

Increases Granted to Second-Year, Third-Year and Older Blue-Uniformed Employees, but None for Shop, Power-House and Other Employees

INCREASES of wages for blue-uniformed employees in the second, third and subsequent years of their service were granted in a decision handed down on Dec. 23 by the arbitration board sitting in the case of the Rhode Island Company, Providence, R. I. No increases, however, were authorized for employees of less than a year's standing in the car service, for the board regarded these men as apprentices. Beginning on Jan. 1, 1916, the hourly wage of blue-uniformed men in their second year's service becomes 26.5 cents, as compared to 26 cents before the arbitration took effect. The wage of third-year men becomes 28.5 cents, as compared to the former rate of 27 cents, and the wage of men in their fourth and subsequent years becomes 30 cents, as compared to 28.5 cents. Blue-uniformed men in their first six months continue to receive 23 cents per hour, and in their second half-year, 24.5 cents per hour.

No change is made in the wages of shop, power-house and other employees. Under the award, however, extra platform men are guaranteed a wage of six hours per day, the work to be performed within fourteen hours. Allowances are made of 25 per cent extra for the first hour or fraction thereof over fourteen hours and of 35 per cent extra for the second hour or fraction thereof and after, over fourteen hours. All soliciting of runs from other employees is abolished by the finding.

By agreement between the company and the union, the award is retroactive to June 1, 1915, and terminates June 1, 1917. In awarding back pay on the former basis, however, the board sets the compensation of third-year men at 27.5 cents per hour and of fourth-year and later men at 29.5 cents per hour, these two intermediate rates terminating on Jan. 1 in favor of the rates first quoted.

COMPARISON WITH OTHER RAILWAYS

In rendering its decision the board stated that a living wage must be considered in connection with the particular employment concerned and that the test of a fair and reasonable wage was a comparison with the wages received by blue-uniformed employees of other street-car companies. It felt that the wages of carpenters, masons, blacksmiths and painters and the like are not helpful in arriving at the proper wage to be paid motormen and conductors and should not be used in determining such wages. The board held, too, that the financial condition of the company should be taken into account in fixing wages, and it was considered evident that the railway is in poor financial condition. The board's outline of the company's history showed that there is a net of $2,000,000 in stock on which no