A Belgian Engineer's Ideas of Heavy Electric Traction in America

Recently Returned from an Inspection of Important Electrifications in the United States, Prof. J. Carlier, of the Faculty of the University of Liége, States That High-Tension Direct Current Is Now Leading and Compares It with Single Phase

JOSEPH CARLIER, assistant professor of railways at the University of Liége, Belgium, recently returned to England from a trip through the United States, where he studied particularly the progress of steam railroad electrification. He has contributed his impressions to *La Lumière Electrique*, Paris, in the form of an article under the caption "Single-Phase Traction and High-Tension Continuous-Current Traction." This contains the results of conferences with a number of railway engineers and observation of several steam railroad electrifications. His comments upon the tendencies in this country are, therefore, based upon first-hand information.

"MONOPHASISTES ET CONTINUISTES"

Referring to the difficulties which American engineers have had to meet in applying electric traction on steam roads, Professor Carlier says that the American engineer knows perfectly well that each time he embarks on a new enterprise uncertainties must be expected, but he is not discouraged by difficulties and solves his problems one by one. As examples the professor cites some of the difficulties which have been met in developing the single-phase system. He refers humorously to the division of opinion among American engineers as to the best system, denominating the extremists on one hand as "monophasistes" and on the other "continuistes." He says that we must admit with the former that excellent progress has been made in reducing the weight of single-phase equipment and in making it flexible. For example, it has been possible to operate three-phase and d.c. motors from a single phase line. This, however, results in greater complication, and the sole advantages which a combined system yields as compared with the high-tension d.c. system are that a line voltage higher than 5000 can be used and dynamic substations are unnecessary. On the other hand in most cases there is no economic advantage in having a very high line voltage and the mercury vapor converter promises simplification of substations to the advantage of the d.c. system.

ELECTRIFICATION SYSTEM ECONOMICS

Taking up the general situation, Professor Carlier says that while the two systems of traction are in use and developing in this country the high-tension d.c. system is making most rapid progress for two reasons. The first is the preference of engineers connected with the companies, and the second is the matter of relative total expense. The last-named item, however, has less weight than in Europe. The American railway man is primarily concerned in developing traffic and he is not so much concerned with the cost of the motive power. In his mind the essentials are to secure simplicity and low capital cost. The consumption of coal or electrical energy in the locomotives is secondary. An example of this is seen in the lack of compound steam locomotives, the powerful ones of the Pacific type of the Pennsylvania Railroad having but two cylinders. While it is true that coal is cheap in the United States, on the other hand labor is expensive, and it is the latter which particularly concerns the engineer. The result of this state of things, which may change later with increase in the price of coal, is that the greater consumption of electric energy in the single-phase system as compared with the d.c. system does not interest the American engineer to the same extent as it does those in European countries. On the other hand he appreciates the greater simplicity of the equipment as a whole and the non-existence of dynamic substations which require constant attendance. His attitude toward the single-phase system for long-distance lines is sympathetic because its principal advantages lie in the net cost factors which interest him most.

Summarizing the qualities of single phase as compared with direct current, Professor Carlier gives the following: the energy consumption is greater; there is less labor required (in substations); it is simpler, and the required investment is less. But when the traffic is considerable the extra expense of electrical energy exceeds the reduction in capital and labor cost, to the extent that the advantage rests with the direct current. Since high-tension direct current (3000 to 5000 volts) has become practicable the single phase has less interest. It is significant that the Westinghouse Company, which has virtually monopolized the single phase, has for more than a year been experimenting with 5000 volts direct current, from substations equipped with mercury vapor rectifiers.

SINGLE PHASE STILL ACTIVE

The two systems operate very well in the United States and in spite of special difficulties which the New Haven Railroad, the first important single-phase electrification, encountered in the early years, there appear now to be no special operating difficulties. The Philadelphia-Paoli line has shown very regular operation. That the single phase still enjoys great favor is evident from the fact that the Pennsylvania Railroad is planning to electrify a section of its main line between Altoona and Pittsburgh at 11,000 volts single phase, with an overhead contact line similar to that between Paoli and Philadelphia. This part of the line is quite broken and it carries an important freight and passenger traffic. Increase in capacity of the line rather than economy in cost is sought in this case. This railroad is also considering the electrification of the New York-Philadelphia line at 11,000 volts. The New York terminal of this has been electrified since 1900 at 600 volts direct current, with third-rail, and has operated admirably.

ADAPTABILITY OF ELECTRIFICATION

Professor Carlier considers that the Pennsylvania Railroad, which is considered as in the forefront of progress, has taken up the electrification problem resolutely. He quotes J. T. Wallis, general superintendent of motive power, to the effect that while electric traction on heavy lines is still in the experimental stage, the systems available are in such a state that there is

no risk in adopting them for a period of twenty years at least. The Pennsylvania does not consider its selections final, but expects to apply the latest developments in electric traction. Professor Carlier points out further that progress is to be expected, but it would be ridiculous to delay electrification until the realization of this progress, for the same situation exists and has existed with respect to the steam locomotive.

The selection of contact system, overhead line or third-rail, and form of current (he evidently eliminates consideration of three phase) is a perfectly simple problem and there are numerous solutions. It is possible to pass from one form of current to another and from one kind of contact system to another, as in the case of the New Haven operation into the New York Central terminal in New York. In the future it will be necessary to remodel an existing steam road electrification from time to time, introducing new types of rolling stock and contact system and changing the form of current. Electrical equipment is well adapted to this process.

MERITS OF HIGH-TENSION DIRECT CURRENT

Summing up the situation the professor admits that the reliability of the systems of electric traction in present use is such that the future holds great possibilities. In the light of the experience with the traction systems in use in the United States and in Europe, for railroad lines now operated by steam and approaching the limits of capacity and which are not of considerable length, the direct-current system at high tension (3000 volts or even 5000 volts) with aerial equipment is most economical. The General Electric Company has equipped in the United States a number of lines with direct current at high tension, including an important road which has been operating regularly at 3000 volts for many months.

While it is true that the high voltage has its place, it is also true that the more intense the traffic the lower can the voltage be. Thus for underground roads in cities, with close headways, the use of third-rail with the moderate voltage of 600 is quite economical. But to the extent that the distance increases and at the same time the traffic diminishes, the contact line voltage must be raised. If the traffic becomes comparatively light, the advantage of very high tension, and therefore of single phase, appears.

Between the two limits of contact line voltage, 600 and 11,000, there is an economically mean tension corresponding to a traffic sufficiently intense on relatively short lines, namely, 3000 volts to 5000 volts, permitting the use of direct current with all of its inherent advantages.

THIRD RAIL AND AERIAL LINE

Third rail electrification of the New York Central Railroad (32.3 miles) and of the Pennsylvania Railroad at New York (9 miles), as well as of the subways, the Hudson & Manhattan Railroad and the elevated railroads in New York has been successful for many years. We must look also to the electrification over long distances with third-rail at higher tension, 2400 volts. Up to the present this line of development has not progressed very far, but such progress is desirable, and great improvement must be made in the future in this direction.

Unfortunately the economical voltage is not always compatible with the use of third-rail. Under these conditions, in spite of the sentiment of the railroad engineer for a system in which there is no clumsy and complicated superstructure, he must accept the aerial equipment. In time the third-rail with 2400 volts and even 3000 volts will become practical, but to use third-rail at this tension economically, a certain density of traffic will be necessary. It should be added also that in certain installations, such, for example, as that of the Philadelphia-Paoli line, the overhead construction has been made more sightly than that of previous installations through the use of cross supports and posts which are comparatively light while still sufficiently strong. The railroad engineer is thus partially satisfied.

It should be emphasized, however, that both high-tension direct current and 11,000 volts single phase are entirely practical and operate with entire reliability. While the former seems to be in more favor, the single-phase system is still developing, although, as explained, the trend of progress tends to render competition with the direct current more difficult.

MECHANICAL FEATURES OF ROLLING STOCK

In the United States the locomotives most favored are those with jackshafts geared to the motors or connected with them by rods and cranks. The Pennsylvania Railroad has combined these drives in a locomotive for heavy freight train service from Altoona toward East Pittsburgh. This locomotive consists of two similar units each with three driving axles connected to a jackshaft, which in turn is driven by two motors through connecting rods. Between the electric motors and the jackshaft is an elastic coupling containing powerful springs which absorb in part the variations in the driving force.

The locomotives used at the Pennsylvania Railroad terminal in New York, from Manhattan Transfer to New York, contain jackshafts driven by the motors through connecting rods and cranks. They are very stable at high speeds, and Professor Carlier was able to state from personal recent observation that the stability and other operating characteristics were absolutely perfect at a mean speed, including starting and stopping, of 45 m.p.h. and a maximum speed of nearly 70 m.p.h. The railroad management is justly proud of these locomotives, which, it appears, are also able to operate on long runs satisfactorily. However, there is as yet little experience along the latter line and further information as to the durability of electric locomotives on long runs at high speed is desirable.

The New York Central locomotive with motors mounted directly on the axles, and the New Haven locomotive with motors driving the wheels through elastic couplings are giving regular service with important trains. It seems, however, that the New York Central plan with armatures mounted directly on the axles requires a track perfectly constructed and maintained, a condition which appears to exist on the electrified section between New York and Harmon. Nevertheless this installation furnishes valuable data for reference, and it must be admitted from an inspection of the motors after long use that they have surprising mechanical as well as electrical qualities. This example, however, has not been followed by other companies. In this arrangement the center of gravity of the locomotive is low with a corresponding tendency to strain the track, and the gyroscopic effort developed on sharp curves at high speed is apt to produce a reaction inimical to the stability of the railway.

In the United States the tendency on the whole is to use multiple-unit cars when possible, wherein the motor equipments are arranged under the cars to provide the maximum passenger space. Locomotives are only employed for through trains and freight trains. There is as yet little experience with these cars at high speeds, say 75 m.p.h., or more on long runs. The use of steel passenger cars is extending very rapidly. In the case

of motor cars this has been brought about to secure absolute insurance against fire.

SUMMARY AND CONCLUSIONS

In Professor Carlier's opinion we shall see in the United States before many years the electrification of a truly high-speed line with heavy traffic on which the electric locomotive and also possibly the multiple-unit car will be subjected to speeds of 75 m.p.h. or more for an hour or two. The Pennsylvania Railroad, always in the forefront of progress, seems to desire to undertake an electrification of this kind on the New York-Philadelphia Line.

Summing up in résumé the results of his observations in the United States, Professor Carlier says that this country affords abundant and instructive examples of the electrification of railroad lines in which complete success has been achieved. It is important for European countries to investigate these, although to copy directly the practice in this country is not advisable. It is necessary intelligently to adapt American systems and methods to European conditions. The choice of system with all of its possible variety must depend upon the numerous and complicated characteristics of the railroad to be electrified.

The Future of the Street Railway

New England Street Railway Club Hears Address on Regulation, Valuation, Fares, Public Relations and Other Future Factors

AT a meeting of the New England Street Railway Club in Boston, Mass., on Nov. 23, with President C. V. Wood in the chair, Edwin F. Jones, counsel Manchester Traction, Light & Power Company and allied electric railways recently concerned in fare increase proceedings before the New Hampshire Public Service Commission, delivered an address on "The Future of the Street Railway," which was received with unusual enthusiasm. After a comprehensive survey of street railway development, the penalties of early overconstruction and financial mistakes, the influence of electrification upon traction expansion and the increasing demands of the public, Mr. Jones took up the points of regulation, valuation, fare units, tax abatements and jitney competition.

THE FUTURE OF REGULATION

Regulation, in Mr. Jones' opinion, is probably more essential to the future welfare of public utilities than to the public itself, for it includes governmental protection to the properties and to the securities issued under public authority. Provided good judgment has been used in selecting the locality in which to operate and the community has need of the company's service, the security holder of the future under regulation may rely upon the fact that in the end such charge for the service rendered as will make his investment reasonably profitable will be sanctioned by the authorities. A commission cannot under the law authorize a stock issue by a street railway for money actually invested in the plant and then afterward refuse the company the right to charge such a fare as will assure a reasonable dividend upon that stock. The necessary increases in fare may come step by step, one at a time, but in the end the desired result is bound to be attained. Utilities, Mr. Jones said, must realize that the public service commissioners generally represent the average public opinion, and that they desire to be fair to the companies as well as the public. If they make mistakes in the law, the courts will afford a remedy.

Mr. Jones stated that the determination of the value of the property devoted to the service of the public is the first and fundamental requirement for future business. Every street railway ought immediately to welcome and prepare for the official determination of the value of its property devoted to the use of the public. Fares cannot be raised on any road until the supervising commission is satisfied that the increase is necessary to afford a reasonable return upon the value of the property after the payment of all allowed charges against revenues. A certain value is better for the security holder than a higher estimated one. When once fixed by a commission, the valuation is not likely to be reduced, as under official regulation provision for renewals will be required and all future additions will perforce be accurately recorded. In future rate hearings or in refinancing, therefore, the difficulties of the present situation will be avoided. To Mr. Jones' view it would be better for the business to start over with a clean balance sheet approved by the public authorities to be used as a basis for all future operations. It would be better to have securities scaled and be able to charge rates which would give at least a 6 per cent dividend, whose permanence might be relied upon, than to go on with existing uncertainties as to value and income. A small certainty is a better basis for business than a doubtful proposition of estimated but undetermined larger value.

SEVEN AND EIGHT-CENT FARES ARE PRACTICABLE

The public, Mr. Jones averred, ought constantly to be reminded of the advantages that American street railways afford as compared with those in foreign countries. The length of ride for a single fare, the system of free transfers, the speed of the cars and the higher wages paid should all be kept constantly in the public mind by judicious advertising or otherwise. More important than almost anything else, the public must be taught that there is nothing sacred about a 5-cent fare. A 6-cent fare is just as pure, just as holy, if the investment needs of the railway warrant the increase. Since the recent increases from 5 cents to 7 cents and 8 cents were granted on lines outlying the Manchester and Nashua districts, the public has seemed to ride as freely as before and no great complaint has been registered. With the great rises in wages and in operating and construction costs generally, street railways are justified in raising the selling price of their product. Every increase thus authorized will help in every other application for the approval of fare increases. The public, Mr. Jones believes, will be reasonable when all the facts are before it.

BETTER PUBLIC RELATIONS SUPREMELY IMPORTANT

Continuing, Mr. Jones stated that every effort ought to be made by street railway managers to mold public opinion so that some of the undue burdens and restrictions now imposed by law may be eliminated. There is no fairness, for example, in requiring an electric railway to maintain street paving between its tracks and for a distance of 18 in. on either side. The reason for the requirement vanished with horse cars. Besides, a street railway pays its proper proportion of the cost of building and maintaining highways when it pays its taxes.

Moreover, the unjust and damaging competition of jitneys must be curtailed if street railways are to have a cheerful future. Here again only a change of public opinion can bring due relief. The public must be made to realize that within the last twenty-five years street railways have been one of the greatest factors