Relative Advantages of Modern Steam and Electric Locomotives*

A Railroad Man's Analysis of Statements Made in Papers Presented by A. H. Armstrong and J. E. Muhlfeld Before Joint A. S. M. E. and A. I. E. E. Meeting in New York on Oct. 22

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A NOTABLE gathering of mechanical and electrical engineers interested in railroading was held in New York City on Oct. 22, under the joint auspices of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, to hear discussed the relative merits of the steam and the electric locomotive in modern heavy traction work. The principal papers presented, respectively by John E. Muhlfeld (steam) and F. H. Shepard and A. H. Armstrong (electric), were abstracted in the issue of this paper for Oct. 23, page 866. The discussion was largely covered in the issue for Oct. 30, page 923, and in that for Nov. 6, page 970, the closing remarks of George Gibbs were printed. A. W. Gibbs requested that the report of his remarks be withheld pending an amplification that he desired to make. This is now complete and we are able to publish a summary this week. As this paper gives the point of view of a railroad man who has had much experience with electric locomotives, it will be of value both to steam and electrical locomotive enthusiasts.—EDS.

THE papers by John E. Muhlfeld and A. H. Armstrong indicate that both of the writers have been a bit too enthusiastic. Both steam and electric methods of operating have their advantages and both have decided limitations.

COMMENT ON MR. ARMSTRONG'S PAPER

Mr. Armstrong's data are largely derived from mountain electrifications, where the electric locomotive is undoubtedly at its best and the steam at its worst, and he has compared with the electric a type of steam locomotive whose coal and water rates are more than double those of locomotives especially designed for such service. Then on the basis of this mountain performance he reasons from the particular to the general application of electric motive power. It is not at all certain that the speed advantage claimed is obtained where the steam locomotive is designed for the work.

Mr. Armstrong gives a comparative statement of the performance of two steam and one electric locomotive. (See ELECTRIC RAILWAY JOURNAL, Oct. 23, page 872.) To this exception can be taken because the steam locomotives do not represent the last word as to those available and the electric locomotive is on paper.

The accompanying table gives data for a 2-10-0 type steam locomotive, of which more than 100 are in regular service and of which fortunately very full information is available from the locomotive testing plant. These locomotives were expressly designed to do all of their work within the economical range of steam distribution, the required power being obtained by increases in size of cylinders and steam pressure. While I have given the power at nearly the speed mentioned by Mr. Armstrong, the performance is excellent at double the speeds given, but the sacrifice in drawbar pull—from nearly 60,000 lb. at 14.7 m.p.h. to about 43,000 lb. at 25.3 m.p.h.—would not be justified. The figures given are within the range where stoker firing is as economical as expert hand firing. The additional advantage of the stoker is that it does not get tired.

The Mallet performance given in Mr. Armstrong's paper is evidently that of one of the large compound locomotives. In all of these locomotives there is a tendency to choke up with increases of speed, due to increase of back pressure.

DATA FOR 2-10-0 TYPE STEAM LOCOMOTIVE

Weight in working order, lb	371,000
Weight on drivers, lb	342,050
Weight on engine and tender, lb	523,000
Drawbar effort at 14.7 m.p.h., 45 per cent cut-off, lb	58,900
Gross tons (2 per cent grade)	1,280
Trailing tons	1,019
Coal per developed horsepower at this speed and cut-off, lb	2.8
Tractive effort at 22 m.p.h., 40 per cent cut-off, lb	43,500
Gross tons	923
Trailing tons	662
Coal per d.hp., lb	3.2
Tractive effort at 25.4 m.p.h., 45 per cent cut-off, lb	43,600
Gross tons	948
Trailing tons	687
Coal per d.hp.	3.8

The same arrangement of limited maximum cut-off used in the 2-10-0 locomotive already described has been embodied in a simple Mallet now running. This locomotive has the same speed elasticity as the 2-10-0 type. Unfortunately, this Mallet, which has a tractive power of about 130,000 lb., cannot be tried out on our present locomotive testing plant. Its drawbar pull is also above the capacity of our dynamometer car, so that no definite figures can be quoted until new recording springs have been applied and the machine calibrated.

In brief, the improvements in the steam locomotive, if properly availed of, have much narrowed the field of economical electrification.

SOME SALIENT TOPICS TAKEN UP BY MR. ARMSTRONG

Stand-by Losses.—While stand-by losses are actual and large it is very difficult to fix their value, as they are so much affected by the use made of the locomotive. Where the average monthly mileage is low the stand-by loss is presumably high, and it is a part of good operation to have the average mileage as high as possible. When all is said the electric locomotive has still an advantage with respect to stand-by losses, provided there are sufficient trains in motion to smooth out the total demand on the power plant, which is assumed to be steam-operated.

Weather.—The independence of the electric locomotive of severe weather is another undoubted advantage, not so much because of the performance of the motors

*Abstract of remarks made at joint meeting of railroad section A.S.M.E., metropolitan section A.S.M.E. and New York section A.I.E.E., held in New York City, Oct. 22, 1920.

but rather from the avoidance of losses and delays due to ashpit work and to frozen pipes and other parts, incidental to the presence of water on the steam locomotive. Where cold weather is a "steady winter diet," this is usually better handled than where cold spells are spasmodic.

Liability to Interruption.—Electric operation is dependent on uninterrupted connection with the source of power. In the event of breakage of the line, especially of the overhead construction, the trains in the section involved are dead and cannot get themselves out of the way of the repair trains. On large systems it is customary to make great changes in the assignment of locomotives to clear up congestion at any point on the system, also to avail of diversion routes on which steam trains may be moved around obstructions on the main line. The fact that the steam locomotive is a self-contained power plant is an immense advantage in this respect. In electric operation there is not this freedom of movement.

Speeds.—The question of speed is evidently treated from the freight standpoint, for there has never been any question as to the speed capacity of well-designed passenger locomotives. This is far beyond that permitted by the rules. In this connection it may be said that many of the electric locomotives could be very much improved by closer adherence to steam standards as to distribution of weights and in the adoption of wheel arrangements which will not set up resonant disturbances at high speeds.

While Mr. Armstrong treats the question of speed from the meeting point of view, it is probable that electrification will have its greatest application on roads where the traffic is dense, probably on multiple-track roads. As I see it, the feature of high speed of trains is of less importance than uniformity of speeds of different trains. If tonnage trains had the same speed as preference trains, and could thus avoid the great delay due to sidetracking of trains of inferior rights, far more would be accomplished than the mere saving in time over the division due to the increased speed. With steam trains at 25 m.p.h. water may be picked up from track troughs. Coaling stops will, however, still be necessary. Delays due to the train itself, such as those caused by hot boxes, burst hose, broken coupler knuckles, etc., would occur equally with steam or electric operation.

I fully agree with Mr. Armstrong that the 1,000-ton-mile has absolutely no value as a method of comparison for different roads and it should not be used except possibly for comparing the same division at different periods. His Table VIII (see ELECTRIC RAILWAY JOURNAL, Oct. 23, page 873) contains a fixed tractive coefficient which may or may not be obtained. The only comparison which has any value is the record of an accurate dynamometer car.

Cost of Maintenance.—Mr. Armstrong gives maintenance cost per mile for different electric locomotives. Any post-war data are so clouded by the abnormal labor and material costs as to be very doubtful. These locomotives have not run long enough to reach a general level of costs, as it will be noted that the average annual mileage is low except in the case of the Milwaukee locomotive. Besides this, there is no evidence as to the maintenance costs of the rest of the outfit, including power plant, transformers, transmission lines, converters or transformers, trolley or third rail, and track circuits, all of which are essential to the operation of electric locomotives, and are just as much a part of the electric locomotive as the boiler is of the steam locomotive. If power is purchased the purchase price, of course, includes the cost of maintenance of the power plant and of the transmission line to the point where the current is received on the road. If it is generated by the using company the cost of maintenance of the power plant should be included with the cost of maintenance of the locomotives. The renewals of parts of the power plant and transmission lines do not occur in the early stages of operation, but they are certain to come and when they do are heavy. From experience, I must deny that the back shop can be dispensed with with either class of locomotive, though it is admittedly more essential in the case of the steam locomotive.

Extent of Electrification.—Where electrification is contemplated a very serious question is: What shall be its extent? Naturally the desire would be to wipe out as many as possible of the extensive accessories to steam operation. If, however, it becomes necessary to operate steam trains over the electrified section, it will obviously be necessary to retain water stations and possibly fuel stations, provided the electrified section is sufficiently long. This operation of steam locomotives under their own power over electrified sections would be necessary in case of redistribution and possibly in case of diversions where the electrified section formed part of the diverted line. Therefore, the claim for economy in doing away with these features of steam operation would probably not be realized.

COMMENT ON MR. MUHLFELD'S PAPER

In my judgment Mr. Muhlfeld's enthusiasm has carried him too far in minimizing the advantages of electrification. The operation of the electrified roads has undoubtedly been good, whether it be terminal or road operation. The reduction in the number of engine terminals alone is a great advantage, to say nothing of the absence of fuel and water service with the stops that they entail, the way to get trains over the road being to keep them moving.

He also ignores the fact that the modern improvements which have so added to the performance of the steam locomotives are potential only. For instance, it is possible and common by indifference so to carry water in the boiler that the superheater becomes merely a steam drier and its value disappears. In many cases, because of neglect of damper mechanism or from dirty flues, little benefit is derived from improved appliances. Modernizing of steam locomotives calls for intelligent use of the devices, which will come when the old spirit of loyalty returns.

MR. GIBBS' CONCLUSIONS

The electric locomotive, or electric operation, has in many cases undoubted operating advantages because the power is generated in quantity at few sources and the power on any one train is not limited by the capacity of a self-contained portable power plant; sustained speeds are possible due to independence of fuel and water stations and, as a result of both these conditions, better use can be made of a given stretch of road.

Electrification does not at all obviate the numerous delays due to the train itself, such as hot boxes or other of the numerous derangements which when combined so much retard the movement over the road.

Electrification does not obviate that class of delay arising from necessary classification on line of the road to meet terminal requirements. Where the terminal conditions limit the capacity of the road as a whole electrification is not the remedy.

On level grade roads, where the existing steam locomotives will handle all the cars that can be safely moved in one train, the value of electrification will be principally the absence of stops and probable reduction in overtime.

The claims for fuel saving have been greatly overstated because the comparisons which are made are not with the potential performances of the best steam locomotives.

Of course, with steam locomotives the maintenance or the indifference of those operating them, both on the road and elsewhere, may to a large extent nullify the savings possible.

Stand-by losses must exist probably with both classes of operation, but especially with steam, and may be any percentage of the total consumption, depending on the actual use of the locomotives.

The relative cost of repairs of both classes of equipment cannot be fairly stated at the present time because maintenance conditions are so abnormal and because the most modern locomotives of both classes are too new to have reached a stable condition, this being especially true of the electric one. While the indications are that the maintenance of the electric locomotive will be less than that of the steam, it must be remembered that the electric locomotives are dead affairs without the necessary electric generating, transmitting, converting and track appliances, all of which are an added expense, due solely to electrification; hence the cost of maintenance of all of these, in addition to that of all of the locomotives, divided by the locomotive mileage, is the real treasury cost of maintenance per locomotive-mile.

If the operating current is purchased, obviously the cost of maintenance of generating apparatus and of all appliances to point of delivery of current is covered in the rate, but in any event it is ultimately paid in some form by the user.

Personally, I believe that many roads now operated by steam will be operated in whole or in part electrically, but that this will not be decided in the offhand manner advocated by some.

It is to be noted that practically all of the electrifications on steam railroads so far have been based on local conditions. In the electrifications in and around cities a moving cause has been the elimination of smoke and other objectionable features incidental to steam operation and the possibility of increasing the capacities of the passenger terminals. On the Milwaukee road it was the utilization of available water power. On the Norfolk & Western it was to secure increase in capacity on a congested mountain division with tunnel complications. It is fair to assume that other electrifications will be similarly governed by local conditions.

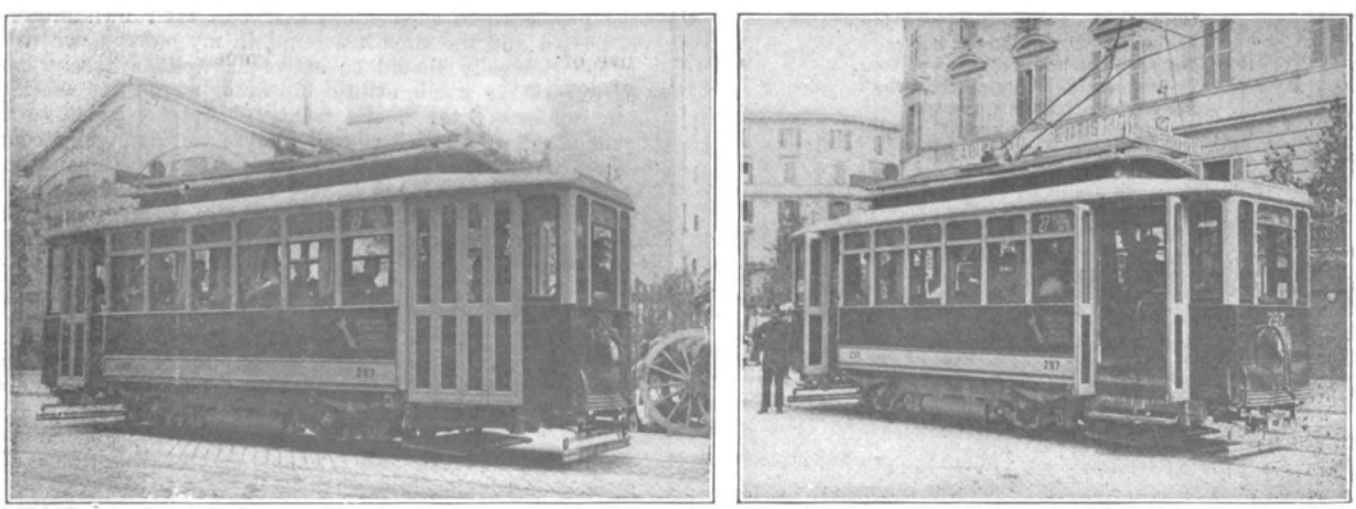
Question Largely One of Economics

If, after careful consideration of the road, based on actual train sheets for the heaviest actual or probable congested operation, the capacity and number of active and available locomotives required, crediting the operation with incidental savings which may be effected, and eliminating expenses peculiar to steam operation, it appears that there would be economy in electrification, either from actual savings or better operation, or both, it still remains for the management to decide whether the money required can be spent to better advantage for electrification than for some other features of the general operation.

In this connection it must be remembered that on originating roads a considerable part of the locomotives' assignment is devoted to service on the branches feeding the main line and forming part of it, and that in this service they make little mileage. If these branches are electrified, their operation will be a decided drag on the economies of the main electrification, for the reason that each of the steam locomotives will have to be replaced by an electric one, with its greatly increased first cost with small use to justify. If they are not electrified and the operation of the district is part steam and part electric, locomotive terminals, organizations and all that go to make up steam operation must be retained to an extent.

Prepayment Cars in Rome

FROM a report received from F. Cusani of Milan, Italy, it appears that the prepayment plan of fare collection has met with approval in Rome. Mr. Cusani has sent the accompanying pictures of a short, double-end prepayment car as used in the "Eternal City."



FRONT AND REAR OF PREPAYMENT CAR USED IN ROME, ITALY