The Case for the Steam Locomotive

Improved Efficiency a Possible Alternative to Railroad Electrification

By Charles Frederick Carter

IT seems to be generally accepted today that the age of the steam locomotive is drawing near its close, and that the immediate future will witness electrification on a scale that can only be characterized as general. We suppose that no partisan of the steam engine will deny that there are places where the conditions of traffic, grades and water supply combine to make electric railroading cheaper than the use of steam. But Mr. Carter calls our attention to the fact that in the general case, apart from any such extraordinary circumstances as dictated the St. Paul electrification and the use of current in the suburban territory adjacent to our large cities, a very good brief may be put in for the steam locomotive. We are glad to give him the space in which to develop this brief, and to tell why he does not believe that electrification on a nation-wide scale is either imminent or necessary or even advisable.—THE EDITOR.

HAS the steam locomotive reached the limit of economic development? Is it about to be superseded by electricity?

Taking the last question first because it is the more easily disposed of, the fact must be borne in mind that electrification of the railroads would involve the building of immense power plants, transmission lines, conductors, shops, machinery and locomotives—practically the rebuilding of existing facilities. Statistics compiled by the Bureau of Railway Economics show that in the fourteen years from 1921 to 1934, inclusive, debts aggregating more than ten billion dollars will fall due and must either be paid by the railroads or refunded. As the railroads are prohibited by law from earning returns equal to those yielded by other forms of investment, refunding is not likely to be simple or easy. If it is going to be difficult to meet outstanding obligations, how are the railroads to raise the enormous sums which would be required for electrification of even the principal lines, superadded to financial requirements for other and urgent improvements?

Fortunately for the country railroad managements are not called upon to face this problem because the continuous improvement of the steam locomotive which has effected economies to offset so much of increased operating costs in the past still offers attractive possibilities.

A great many mechanical engineers and other scientific specialists have been, and are still, devoting all their time to the study of locomotive problems. The results achieved are truly remarkable. Only a few years ago locomotives were built as large as clearance limits would permit with boilers of fifteen hundred horsepower. Clearance limits have not been increased but the capacity of boilers within those limits has been doubled. It may be of some help in appraising this truly remarkable feat of compressing great power into small space to bear in mind that a stationary steam power plant of 3,000 horsepower would have half a dozen standard water tube boilers which, with the engines and auxiliaries supplied with steam, would occupy a ground area of ten thousand square feet or more and a height of forty feet as compared with the locomotive's length of 100 feet, extreme width of 10 feet 3 inches and extreme height of 15 feet.

The average locomotive of 1,500 horsepower limit in size burned from six to eight pounds of coal per horsepower hour; representative types in large numbers are in service today developing a horsepower hour on three pounds of coal or less. Some of the best designs use as little as two and a half pounds of coal per horsepower hour. These results have been made possible in part by the perfection of the feed-water heater which, by utilizing waste heat for raising the temperature of the water as it enters the boiler, to that extent decreases the amount of heat to be supplied by burning coal. Other factors are the superheater and the more liberal design of the boiler made possible by the trailer truck. Brick arches and other details have so increased the efficiency of the boiler that 70 per cent of the heat units in the coal burned in the firebox are transformed into effective power in the boiler.

One of the possible future developments is in fuel and its efficient stoking. Fuel involves not merely quality and the means of handling and burning but also the problem of supply. If there were an unlimited supply of oil it would be a simple matter to transport and store supplies, to transfer from the storage tank to the tender and to pipe from the tender to the firebox and thus solve the problem of stoking and efficiency of combustion. But the world's oil supply is too scanty to permit its use as locomotive fuel except in a temporary and strictly limited way.

It is, therefore, necessary to consider what can be done with coal, which varies so greatly in physical and caloric attributes. It would greatly simplify matters if all coal for locomotive use were of the highest quality, free from sulphur and other impurities. But it would not be economic to use the finest grades of coal for locomotive fuel exclusively and thus deprive other consumers whose requirements are more exacting.

It has been suggested that the inexorable necessity of conserving the supply of fuel will compel us to develop on a commercial scale a process of treating coal which will provide a standard quality of fuel and save the other intrinsic values for other commercial uses. The gases ordinarily freed in burning coal as fuel may be distilled and put in solution for use in automobiles and other internal combustion engines, while the coal tar products can be saved for their myriad uses in industry. It has been alleged that the intrinsic value of a ton of ordinary Pennsylvania coal is $25; and that its value for fuel is only one-fifth of this price. The four-fifths irretrievable lost when the coal is burned as fuel, if properly conserved by processes already understood would yield the producers a handsome profit and provide locomotive fuel at a small fraction of present prices.

The automatic stoker has not yet attained perfection. By providing a combustible of the type indicated the difficulties in the way of efficient mechanical stoking will largely disappear.

Another promising field for improvement is in thermal efficiency; that is, the ratio of heat units converted into steam in the boiler to the total contained in the combustible burned in the firebox. At present the best practice transfers 70 per cent of the heat units in the coal into the steam in the boiler. Present progress encourages the hope that the standard may be raised to 80 per cent.

In this connection it must be borne in mind that there is a marked difference between the thermal efficiency of the boiler and of the engines of the power plant. Disregarding the small amounts of steam used by accessories such as the air pump, stoker engine, etc., and confining the comparison to the main power plant of the locomotive, the ratio of work done at the drawbar in terms of energy compared to the heat units delivered in steam at the top of the valve chest is 10 per cent. A part of this loss is inevitable, regardless of whether the steam engine is mounted in a stationary plant or whether on the frame of a locomotive. Mechanical friction is necessarily greater in a locomotive because of the limitations in weight and dimensions. The average steam locomotive loses about 17 per cent of efficiency because of friction and its own weight.

By far the greater loss is the latent heat of vaporization. It takes one heat unit to raise a unit of water one degree in temperature from 211 to 212, and one heat unit to raise temperature from 213 to 214, for instance. But it takes 700 heat units to change water into steam. When the steam is exhausted from the locomotive and is condensed into vapor about 700 heat units are surrendered to the atmosphere. About 40 per cent of this latent heat of vaporization is literally thrown away because no way of recovering it now exists on the locomotive. In stationary power plants where abundant ground area and water supply are available to build condensing plants and even on shipboard it is possible to recover a large part of this latent heat. A locomotive with similar facilities would probably be as long as an ordinary suburban train and of course, entirely impracticable. Present knowledge affords no way to recover this very large amount of wasted energy, yet it is within the bounds of future possibilities that a way may be found. The suggested possibilities of increasing thermal efficiency from 70 to 80 per cent are to be realized by the proper combination of known resources, such as improved superheaters, feed water heaters and perfected combustion.

Great mechanical improvement has been made in recent years. Electric welding has practically abolished the trouble from leaky flues. Firebox surfaces are now stayed with flexible staybolts. Outside valve gear readily accessible for repairs is now the standard. Ingenious devices for taking up wear in crossheads, wedges and other parts have come into extensive use. Mechanical stokers have made possible the introduction of locomotives too large for efficient firing by hand. There are pneumatic firedoors, electric headlights and many other devices unknown a few years ago. Still, the limits of possibility in mechanical development do not appear to have been reached.

One of the most recent improvements is known as "The Booster," which by utilizing the idle weight of the trailer truck and the surplus steam in the boiler at starting adds 20 to 35 per cent to the power of the locomotive at starting and enables it to "pick up" a heavy train very much more rapidly than would otherwise be possible. There are numerous other mechanical devices now in process of development which, when perfected, will still further enhance the efficiency of cylinders and machinery.

Mechanically the tendency in the last twenty years has been to increase the weight of locomotives very greatly. This tendency, however, has its limitations and this introduces the factor of capital efficiency; that is, the ratio of capacity for doing work to the amount of investment. Weight has a direct reaction upon the investment in track, structures and all facilities with which the locomotive comes in contact. There is a point beyond which it ceases to be economical to strengthen bridges and increase the weight of track structure. A locomotive materially heavier than a given standard might be theoretically far more economical than the standard but if its adoption involved the reconstruction of the whole railroad to stand up under the increased weight it would hardly be deemed a wise investment.

By mechanical refinements already in process of development and increased thermal efficiency known to be attainable it will be possible to increase the capacity of the steam locomotive enough to take care of the increasing volume of transportation for the immediate future. The question of electrification will then be thrown back where it belongs—it will rest on the ability of electricity to compete with steam, in capital expenditure and in operating economy. There will be less talk of electrification to meet the "breakdown" of steam.

Wireless Telegraphy at Danzig

ACCORDING to the Danzig press, the Danzig telegraph office has recently installed a wireless press receiving station. These receiving stations, of which there are said to be about 120 in Germany, receive, for transmission to newspapers, press news distributed by wireless by the press services. In addition, the stations receive commercial news of the Bureau of Foreign Commerce in Berlin, intended for chambers of commerce, and also weather reports. News is sent out by the main station in Königsmusterhausen.

The Danzig telegraph office is now operating four wireless stations: A station for the domestic telegraph service of the German wireless system; a coast station for communicating with vessels; the wireless press receiving station referred to above; and a special receiving station maintained by the *Danziger Zeitung*, a local newspaper, for its own messages.

The Polish authorities also possess their own wireless station, situated in the port district at Danzig-Neufahrwasser and used largely for communicating with vessels bringing government supplies. According to the press, the Polish station was specially authorized by the high commissioner and is subject to certain regulations in order to prevent interference with the operations of the Danzig, German, and British naval stations. For instance, the Polish station may communicate with Warsaw only between 1 and 3 A. M., and its conversations with vessels at sea must be confined to 10 minutes.