Solution of the Railroad Problem

By HERBERT QUICK

THE new factor in energy which has made most changes in the industrial and social life of the world in the past quarter of a century is electricity. We have installed in the United States in the past thirty years more than twice the electric power which would be required to operate all the railroads of the United States; but the railroads themselves have been the least affected by this revolution in all our great industries. Other business is living in the Age of Electricity. The railroads yet dwell in the Age of Steam. The Age of Steam cannot haul the tonnage of the Age of Electricity.

Yet we have made a fine start in railroad electrification. Based on single-track mileage we are operating, it is asserted, more than 5000 miles of railroad with electricity. By this statement, electric street, suburban and interurban lines in which the cars carry their own motors, are eliminated. We are now actually operating more than 5000 miles of regular railroad on which trains are hauled by electric locomotives in the place of steam locomotives. On these railroads ordinary passenger and freight trains made up into ordinary trains are hauled by electricity, and it is such operation that is referred to in this article as the solution of the railroad problem.

Electrical Economies

IN FORMER articles I have shown how completely we are dependent on the railroads for our continued national prosperity and, so far as that goes, for our continued national existence as America has existed in the past. I have shown how the railways have failed us and must continue to fail us whenever we are prosperous, because they cannot haul the load of tonnage prosperity imposes. I have shown the reason why, in the failure of the steam locomotive to develop with the needs of the nation. The solution proposed is electrification. The proposal is based on the performance of electrified railroads already in operation. It is based on engineering knowledge.

We have several hundred miles of main-line electrification on the Chicago, Milwaukee & Puget Sound. Use of electricity in mountain-grade work and in making up trains, negotiating sharp curves and operating through tunnels with heavy freight trains has been a wonderful success on the Norfolk & Western. Terminal work, as well as a good deal of main-line operation, has been completely tried out on the New York terminals and on the New York, New Haven & Hartford, as well as in other places. Every problem in American railroading has been met by electrification by the systems now in operation.

If electrified by beginning where the greatest need exists the process might be carried forward rapidly enough to solve the problem of our next railway crisis, which will be upon us within five years. Electrification will enable the railroads to handle with ease the heaviest traffic we have ever had, on the same tracks and with the same terminals we now possess. It will put off the necessity of double-tracking, reducing grades, and otherwise extending our present facilities, for at least twenty-five years, and greatly reduce that necessity when it comes upon us if it ever does. The cost will be very great, but probably no greater than would be the making over of the roads along the lines demanded by steam traffic, and the results would be certain of success, while the ability of the roads to handle the growing tonnage with the steam locomotive with any conceivable expenditure of money is more than doubtful when we consider the growing problems of huge terminals and the definite limits of the steam locomotive under multiplying burdens.

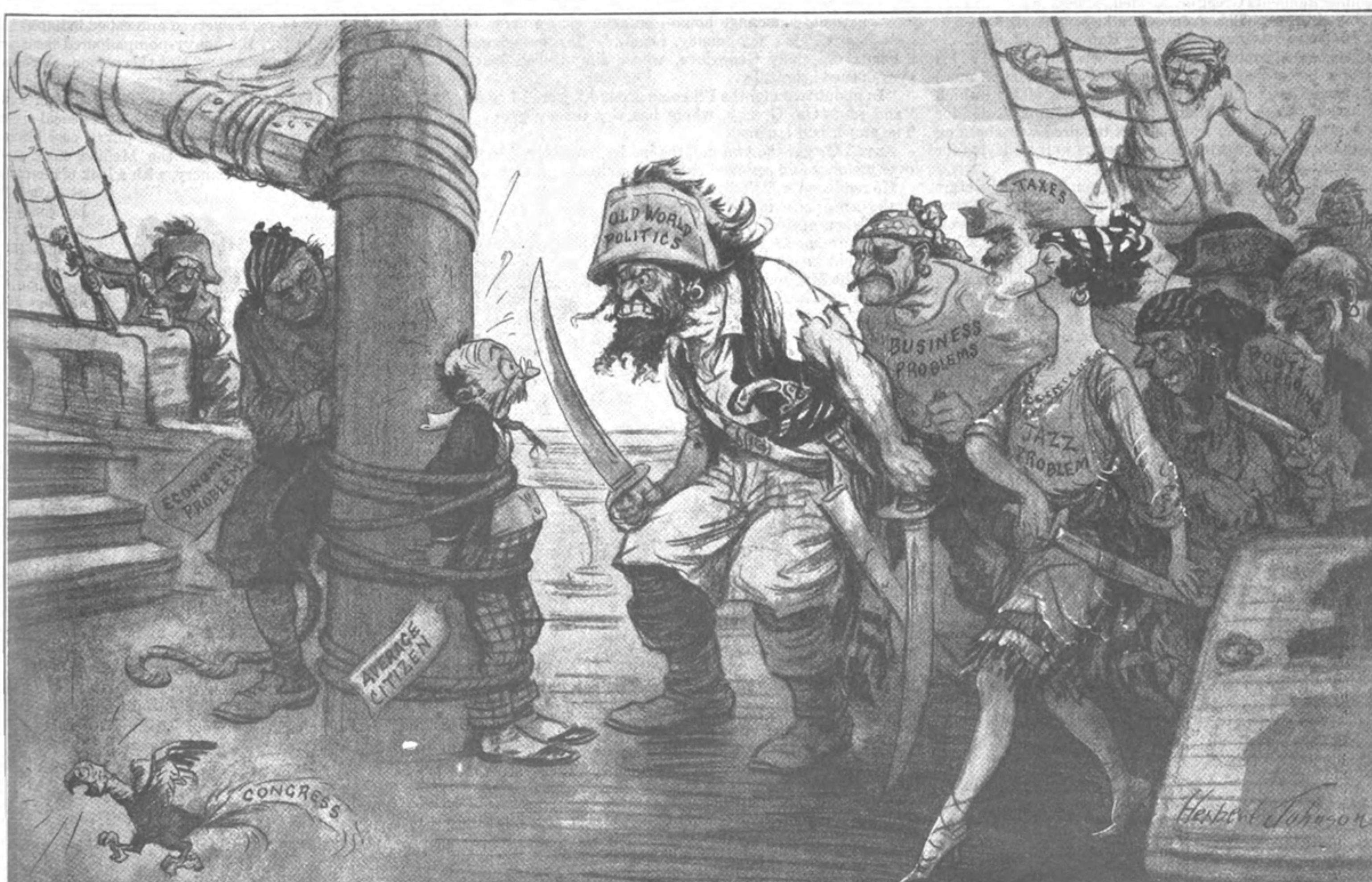
The railroads have resorted to electrification in the past just as they must resort to general electrification in the future, to solve problems that steam could not and cannot solve. The Norfolk & Western after a receivership ending in 1898, faced a grave problem that it could not solve with steam, in its physical obstacles, in the form of a single-track tunnel and its heavy grades in the West Virginia coal fields, where on a stretch of thirty miles there originated daily more than 2000 carloads of coal.

The N. & W.'s Experiment

IT HAD the first 100-ton coal cars ever put in service, the best and most powerful Mallet steam locomotives it could get, and a wonderful steel pier at tidewater, on which these huge cars may be run loaded, and dumped by being capsized bodily into bunkers from which a 5000-ton cargo ship can be loaded in two hours. A physical obstacle existed in the heart of their system. The steam locomotives could not handle the traffic through the tunnel and on the grades. The trouble through the tunnel was ventilation, while on the grades and curves it was lack of power and speed.

The company decided to electrify. They made many mistakes by which, and by the mistakes of others on other systems, the electric locomotive has been perfected to an extent that makes it a safe and dependable engine, though

(Continued on Page 98)



LASHED TO THE MAST

SOLUTION OF THE RAILROAD PROBLEM

(Continued from Page 23)

with electricity, unlike steam, further great improvements may be looked for. The electrification solved the problem. Even with electric locomotives in an experimental stage the tonnage over the road increased by one-third in the first three months. After that their success was increasingly triumphant. Years ago, so complete was it, the Elkhorn Grade and Tunnel ceased to be obstacles to the success of the Norfolk & Western. "The outstanding and pertinent facts are," says the Railway Electrical Engineer for January, 1921, "that a new type of locomotive was made to perform a service never before performed, and was put into service practically without experiment. Difficulties have been surmounted as they appeared, and at no time have the electric locomotives been unable to handle the business that came over the division. Electric operation has made it possible to handle the ever-increasing traffic that is originated on this division. The farsighted policy of adopting it has been profitable to the Norfolk & Western, and the working out of the problems involved has been a service to all other roads confronted with similar problems."

A Notable Performance

Mr. A. H. Babcock, consulting electrical engineer for the Southern Pacific Railroad, made a report on this in January, 1917, in which he said of the Norfolk & Western electrification: "It is safe to say that the average train loading has been increased approximately 33 per cent, and the average train movements practically the same amount; in other words the track capacity has been very nearly doubled." I like to quote the careful and conservative statements of these disinterested engineers and technical writers, most of whom would rather lose a month's salary than make anything but an understatement. Mr. Babcock notes calmly the following fact: "Last May, trouble in the power house cut down the electric locomotives available from six to two in service, of which only one could be used on the hill at a time. As a result sixteen of the largest Mallet steam engines had to be brought in from other divisions in order to maintain the traffic." But I should like to have the reader note that when five electrics were for a short time out of business it took sixteen of the best steam locomotives in existence to take their places.

I shall dwell somewhat on the Norfolk & Western lesson for several reasons: First, it has not been much advertised; second, it has been so successful, in which it is like all the electrifications we have had, so far as I know; third, it is so complete, covering as it does main-line work, tunnel work, switching work and the making up of trains; fourth, it takes in work on steep grades and sharp curves; and fifth, it is so typical of the problem of our whole railway system and so illuminating as to its solution.

This railroad was partially paralyzed by a gorge of traffic at what is called by traffic men the neck of the bottle, and its efficiency was limited by what could pass through this neck. That is exactly the case with the railroad system of the country. There are numerous necks in the bottle in which congestions take place which destroy the business of the nation, not to mention that of the railroads, whenever business becomes prosperous.

The business prospects of this road were rosy for the future, and its traffic capable of indefinite expansion—if it could equip itself to carry the load. This is exactly the case with the railways of the United States generally; only in the latter case, cities, states, the whole business fabric of the nation must dwindle and decay unless the peak load of traffic is carried, instead of the business of a small region in the Appalachian coal fields.

The Norfolk & Western could not extend its facilities for steam-locomotive traction. It could not lay its tracks along a new route. By reason of physical conditions it could not lay additional tracks without prohibitive expense. It had to use the tracks it possessed—and it had to use the Elkhorn Tunnel, the sharp curves and the steep grades.

If we look at the railroad system of the whole country we see similar situations. We must use the tracks we have. We must use the terminals we have. We cannot relocate, or to any basic extent replan our railway system. The bottle necks exist, and the physical properties must be used. The peak load of American business must be hitched to something that will have the speed and the power and the reliability to haul it over the grades of our mountains, through and around what we may term the tunnels and curves of our great terminals and freight yards, and down to our docks. The problems of the bottle necks must be solved, and can be.

Let us start with a 3250-ton train of freight over the Norfolk & Western as it now goes. It stands on a 2 per cent grade. At the front end is an electric locomotive, and at the rear another and a similar locomotive used as a pusher. The heavy train starts very easily, with no slippage of wheels. The engineman in the cab watches his instrument closely and can govern this matter of wheel slippage very accurately. It used to be very different with the start of the same train with the huge Mallet steam engines. Then they had to use two great engines at the head of the train, and another at the rear as a pusher. The train started with much slipping of wheels and jerking of the whole train. The force in the electric is continuous, but with the steam locomotive it was not, and there was a lot of buckling and much damage to the rolling stock.

Don't think this unimportant. How much of the trouble in times of transportation crises is due to train breaks? Congestions grow out of such troubles to a great extent. And 42 per cent of the train breaks are caused by starting under steam. Tests made with a dynamometer have shown a stress as high as 800,000 pounds on the drawbars of cars over and above the normal pull of the train. Enough power can be applied under electricity to pull any train in two; but where, as on the Norfolk & Western, the trains hauled are those turned over to the great steam engines which haul them on, such is the control exercised and the steadiness of pull that train breaks have been for years practically unknown under electricity. Inquiry of men engaged in this work for years showed that they had never known of a train-break under electricity.

Weight and Speed

The train is of the proper size to be handled by the steam locomotives when the electrics turn it over to them; but it might be much longer if conditions made it desirable. Longer trains cannot be hauled by steam, because the engines are as heavy as the track and the bridges and curves will permit, and they cannot be made more powerful without being made larger. But as many electrics as might be desired might be put at the head of a train and operated by one crew. Electrics can pull any train of any length—provided that the drawheads and the general construction of the cars will permit.

Length and weight of trains has long been a subject of controversy among railroad men. There is the dominant school, which we may call the Hill school, who believe in the economy of making the trains of the maximum weight and moving them at what may be called the minimum speed. Opposed to the heavy-train, slow-speed doctrine there is what may be called the Harriman school, who believe in trains somewhat lighter but moved at a higher speed. One great revolution which must be wrought by electrification will arise from the fact that heavier trains than Hill ever advocated may be hauled by the electric locomotive at speeds never dreamed of by Harriman for freight trains. Freight trains of immense weight can be electrically operated at a speed as great as that at which local passenger trains are run. I do not know how to state the importance of this fact. It means that under electrification the advantages claimed by both schools may be combined, and not only combined but carried further than their most enthusiastic advocates have ever hoped for under steam. This will make for enormous economies

(Continued on Page 100)

(Continued from Page 98)

and efficiencies. But let us return to our Norfolk & Western freight-train excursion.

We start the train easily up the 2 per cent grade, and in a single minute we have reached a speed on this upgrade of fourteen miles an hour. Having attained this speed we hold it constant. It was not thus with the best and most powerful steam-drawn trains at the same place. The three great engines got the same train up to seven miles an hour, which was as fast as they could run. They were made for power and not for speed, and were not expected to make more than seven miles. It took these three engines twelve minutes to get up to seven miles an hour. In a minute our two electrics get the train to fourteen miles.

We pass through the Elkhorn Tunnel in three minutes. The old steam-drawn train was often half an hour in making this passage.

We reach the top of the Elkhorn Grade at a speed of fourteen miles an hour. When we ease over the crest of the hill we do not apply the brakes. We never apply the brakes except when we desire to stop. We increase our speed from fourteen to sixteen miles an hour—and we hold that speed without applying the brakes. You wonder why the heavy train does not go faster and faster on this steep hill until it is wrecked. Something has happened; but what? Simply this: The motors have become generators and are holding the train back by the simple process of making current for the line. At sixteen miles an hour they put as much electricity into the line as one of the locomotives took out coming up at fourteen. That is, a train of sixteen cars coasting down grade will pull half of a similar train coming up the same grade. This is called regenerative braking. Since the system was put in operation, in 1915, more than 50,000 trains have been taken over the electrified section without a single failure of regenerative braking. Now it was not thus with the steam-drawn trains. They struggled with the weight of the train, burning coal all the time. Often the brake shoes grew red-hot with wasted energy. One of the most common causes of accidents is found in taking heavy trains down steep grades. This seems to be eliminated by regenerative braking, and much equipment damage is saved as well. Besides this, the electricity generated by the train itself is just as valuable as if it were produced by the burning of costly fuel.

The Power for Zero Weather

Just how much this bottle neck of traffic had to do with putting the Norfolk & Western into a receiver's hands I cannot say, but it has been a prosperous road since it solved its problem of the traffic jam. According to Mr. Babcock it began its electric operations in May, 1915. At the end of June, 1915, it showed for the year a decrease of net operating revenue of 3.73 per cent. The next year this was converted into an increase of 4.41 per cent with an increase of 14.49 per cent in maintenance-of-way expense, and a reduction of nearly 25 per cent in the number of cars and locomotives awaiting repairs. During the year before Mr. Babcock's examination the operating revenues had increased 37 per cent over the year before, the net operating revenues increased 69 per cent, and the net income 96 per cent.

The Norfolk & Western electrification covers only a small portion of the system. The significance of this lies in the fact that though it does not, on account of its limited extent, permit the economies that a more extensive application of the system would do, it has up to this time solved the problem of the breakdown of the steam locomotive. It widened the neck of the transportation bottle. It works in switching, make-up of trains, and imparting speed to main-line traffic.

On the Milwaukee there are several hundred miles of main-line electrification with current derived from water power. It is straight railroad operation. Its adoption was not a necessity, for though there are heavy grades in this portion of the line the work could have been done by ordinary means as well as on other lines. Electrification was adopted probably because of the availability of the water power. It has worked as well here as on the Norfolk & Western, and we glean some vitally important lessons from it.

It effects a reduction of 22½ per cent in the number of trains, and cuts down the time of trains 24½ per cent. It has so improved conditions that 30 per cent more tonnage can be handled in 80 per cent of the time. This means an increase of at least 50 per cent in the capacity of the track, and probably more. But it means more than this, for this added efficiency is in the ordinary operations. When the pinch of a crisis comes electricity shows its merits. It works better in cold weather than in hot, since the trouble with the electric motor, when it arises, is from overheating. Thus when the steam engine freezes up and dies the electric motor is better than ever. In 1917–18, when the weather was bitterly cold and steam engines could not make steam, when the chief apology of the railways all over the country was that they were paralyzed by the cold, when passengers were subjected to suffering, danger to health and financial losses, when tracks were blocked by frozen engines and trains, and tonnage was cut down to the point of actual danger, industries were shut down with great losses, and normal business was prohibited, the electrified division of the Milwaukee ran on schedule time. Often trains running over this division made up two hours of the time lost elsewhere by steam.

Handling Emergency Overloads

Other roads with electrified divisions did quite as well. The Norfolk & Western did, though at times their trolley wire was merely a string of icicles. Instead of going dead if not taken to a water tank or a coaling station every few hours, and being babied in a roundhouse half the time, these Milwaukee electrics often run twenty-four hours continuously, and have made 766 miles in a day. Instead of lying down when the load limit is increased beyond a certain point, as the steam locomotive does, the electrics can handle an overload of 100 per cent in hard starts and unusual pulls without injury—for they are drawing not on their own power but on a huge power house. All the Milwaukee electrics have ever had to do has been to increase the capacity of the road 50 per cent in normal times; but in crises they can more than double it. In crises they can do the work when steam will not operate the line at all. And this is the thing we must have. Steam works well on its stated load and under good conditions; but we must have a system that, as Artemus Ward once said, can rise to an emergency and cave in the emergency's head. This is where electricity excels. It rises to emergencies. It can carry overloads. It flourishes on bitter cold weather. And it caves in the emergency's head.

On the New York, New Haven & Hartford similar results have been noted. According to A. L. Ralston, mechanical superintendent of that road, there is one failure in every 21,000 miles run by electric, and one for every 4000 under steam. Thus electricity is several times as reliable as steam. Fuel consumption in passenger service averages twice as great under steam as electricity. In freight service it is two and a half times as great. In switching service it is much more than twice as great. Last year the partial electrification of this railroad, according to Mr. Ralston, was saving the road $755,000 annually in its fuel bill.

This road recently put in sixteen electric switchers. Operating in the crowded terminals of New York City and vicinity and through the dense industrial belt of New England it faces a most acute terminal crisis whenever business gets good. These electric switchers on many occasions have run twenty-four hours a day for thirty days without interruption. Compare this with the steam locomotive! As I have said, the electric locomotive works best in cold weather. It does not have to be turned around. It runs without the necessary stoppages of the steam engine. Its inspection is on five times the mileage of the steam engine. Trains run at a uniform speed and can be dispatched on a close margin. Freight trains can be run at a speed approximating that of passenger trains, and thus keep out of the way. Train crews make fewer delays. Division points on a fully electrified road should be at least 500 miles apart instead of about 100 as at present, and thus a part of the 5 per cent of the train crews' time lost in these division yards would be saved.

Six electric switchers on the New York, New Haven & Hartford take the place of ten steam switch engines. This is important as justifying the confidence of this road in electrification in view of its ample experience. The great terminals are the

Gordian knot that must be cut in times of crisis. To cut it requires the speed, the ability to work in all weathers, the reserve of power, and the constant service of the electric. Electrification is the solution of terminal jams.

On the Philadelphia, Paoli and Chestnut Hill electrified divisions of the Pennsylvania Railroad, the schedule is made with such regularity as to amount to 10,000 train miles to every detention. On the Long Island Railroad 532 schedule electric trains are now operating. On the Erie Railroad between Rochester and Mount Morris the line has been electrified for thirteen years. It has been tied up only once on account of storms, and then for only four hours. Steam tie-ups of ten hours to three days had occurred on several occasions.

In the St. Clair Tunnel the Grand Trunk has been operating electric locomotives for twelve years at a fuel cost of half that of steam locomotives, and delays of even a few minutes have been practically unknown.

Thirty-three electric locomotives have handled the passenger traffic in and out of the Pennsylvania terminals of New York for eleven years. They have made more than 7,000,000 miles with a record of 64,437 miles per detention on account of the locomotives. They have made 11,456 miles for every minute of detention, including electrical, mechanical and man failures! The maintenance of these locomotives over all this long time has been just about one-sixth of that of equivalent steam locomotives.

The care and upkeep and inspection of the electrics are matters of interest. They may be judged from the experience of the Boston & Maine on their Hoosac Tunnel electrification, where seven electrics are used. They never withdraw these locomotives from service for general overhauling; and, so far as I know, this is true with electrics generally. The Boston & Maine inspect their locomotives on the basis of every 1800 miles, when the main motors are blown out, brushes are replaced if necessary, clearances taken, switch groups overhauled, auxiliary motors overhauled and oiled, and other light repairs made. This is all.

Many of the above facts are taken from a paper read in March, 1921, before the Providence Engineering Society by Mr. C. C. Whittaker, of the Westinghouse Electric & Manufacturing Company, and reprinted in the Railway Review, which says editorially: "Mr. Whittaker's address cannot be taken as an exhaustive analysis of the relative advantages of the two systems of operation, although presented without bias; nor will it be found to embody technical details with which every well-posted engineer is not already familiar."

Mr. E. M. Herr's Testimony

The electrified terminal is an entirely different thing from the one operated with steam locomotives. Contrast the electrified terminals of New York, for instance, with the old-style ones of Chicago. The steam-operated terminal is a nuisance. It is constantly crowded farther and farther from the center of business. But in New York electrification makes it possible for great and elegant hotels and businesses of the highest and most exclusive class to exist right alongside a great terminal. There is little noise, no smoke or steam, no hooting of engines, no human suffering and destruction of property from soot and gases. Enormous values are added to property by this close proximity of fine business property to the very center of transportation. I should not be surprised to learn after Chicago's terminals have been electrified, that the cost of the change will be found added to the value of adjacent property.

But the benefits to the railways are equally great. The huge terminal is really the graveyard of cars. Let me quote on the application of electricity to the solution of the terminal problem, a man who has been an engineer of tests, a superintendent of telegraphs, a division superintendent, a division master mechanic, a general superintendent of a locomotive works, and who has held many other important positions in the railroad world, who is an airbrake specialist, and an electrical and mechanical engineer, now connected with the electrical profession, and whose railway experience in official positions dates back to 1886, Mr. E. M. Herr.

"The electric locomotive," says he, "enables the capacity of a terminal to be greatly increased, owing to the greater rapidity of its movement over that of a steam locomotive, and the fact that the electric locomotive does not have to be turned, coaled, watered, have fires cleaned or its boiler washed. . . . In addition to the advantages mentioned above, in large terminals the use of electricity on wharves, in freight houses, and properly designed auto trucks for delivery of freight to consignees and collecting freight from shippers, must not be overlooked. On wharves, in freight houses, and other places where freight is temporarily stored or stopped in its movement from one kind of carrier to another, electricity, by its wonderful adaptability to subdivision and use in either small or large motors, is most advantageous. By a system of telpherage, properly designed and adapted, all kinds of freight can readily and economically be taken from car to freight house or wharf or the reverse, and what is of very grave importance, the entire space covered by this system can be economically used. The statement has been made that the cost of moving a ton of freight from the point at which it originates to the railroad car which is to carry it by rail to the railway terminal at its destination, added to the additional cost of delivering it from car to the consignee's store, factory or warehouse, is as large as the entire charge for rail transportation for a large proportion of freight handled by rail which has to be delivered and collected by dray or truck. Why then should not the railways themselves arrange to collect and deliver freight at terminals? Here again electricity can be of great service in furnishing the power to drive the telpherage for loading and unloading cars and supplying the motive power of a fleet of auto trucks and drays so handled as to cause the minimum delay of freight cars at terminals and the promptest delivery of package freight at the lowest cost."

The Price of Organization

This moderate statement of a recognized expert strikes at the heart of the railway problem—terminals. It warrants the belief that with electrification the great terminals will cease to be not only the graveyard of cars but the graveyard of prosperity in America.

I have not stated half the case for electrification, but I think I have stated enough for present purposes. There is, of course, a case against it. For one thing, it would more completely integrate our transportation system, and render each part to an extent more dependent upon every other part. That is the price paid all through Nature for the higher development and the more complete organization. This penalty in the higher animal is death, instead of the everlasting life of bacteria. I can conceive an electrified transportation system completely paralyzed by the destruction of its power houses. But integration has already gone so far with the present railway system that it, too, staggers and falls down when it fails in one of its members. The peril through the complete integration by electrification is no greater. The paralysis of steam is on us. We must dare the remoter dangers of electrification, which can hardly come upon us except through the collapse of our civilization itself.

Besides this there are objections made by men wedded to steam. For a quarter of a century railway men have been spurred up by one interest or another, and by their native conservatism, to a false confidence in the steam locomotive. They had to believe in it or they could not have devoted themselves so completely to the task of making it do the work of the nation. There are business interests involved. But once the matter is taken up as it should be, that public interest which is warranted by the vital nature of the subject matter will stimulate investigation and thought to the end that the world will see that the case of electrification versus steam is complete.

Electricity might be demanded in the place of steam even at increased cost of carriage, in a case of life and death; but we have no such choice to make. Electrified railroads can do the work more cheaply than steam railroads, even at the present price of coal, and with every rise in coal the advantages of electrification are increased. According to the annual report of the Norfolk & Western the cost of haulage by steam locomotive per million tractive miles is \$29.90. The cost of doing the same work with the electric locomotive is \$26.20. This is without any doubt an attractive saving.

When Mr. Babcock was looking over the Norfolk & Western for the Southern Pacific, he said: "It is significant, however, that the general manager of the line refused to give me any operating costs per ton-mile, because, as he said, such figures as were available would not be fair for electric operation." As a matter of fact the above figures understate the case for electric operation. They include for both steam and electric operation the following items: Interest and depreciation, repairs, fuel of electric power at the locomotive, lubricants and waste, supplies, engine-house expenses, water and wages. But the power house charged against electricity is large enough to operate 33 per cent more locomotives. The repairs were calculated on a basis that the engineers agreed was unfair to the electrics. The accounting included the central power house in the calculation as a charge against electrification, but did not reckon in the roundhouses, machine shops, coal facilities, water stations, turntables and the like, against the steam locomotives. On a basis of strict accounting the financial returns on the traffic handled were more than 15 per cent better by electricity than by steam. It is only one case anyhow, though a very typical one. Results in other cases of electrification are, so far as I am informed, parallel.

No one suggests that all the railroads should be electrified at once. No one can indicate what proportion should be electrified, or whether they should all ever be electrified. In any case it will take a considerable term of years to carry the plan out, no matter how soon it is undertaken. During this time the engines replaced by electrics would increase the power plant of the lines still under steam, and whenever there should develop a surplus of steam engines there ought, in a world short of locomotives, to be a market for them abroad.

The economies which effected a saving of 15 per cent on the line just mentioned are nothing like what might be realized with complete electrification by divisions. Divisions under electrification should be 500 miles or more in length, and on them the old steam-engine facilities would not be needed or kept up. This would increase savings still further.

The Ideal Condition

The first electrifications should be on the mountain grades, where present facilities are inadequate, and in the dense industrial regions about our cities, and especially in New England, which suffers from lack of coal. The great superpower zone on which Mr. Murray has made a report should be included. This would give us electrification from Boston to Washington, through the great New England industrial belt, all around New York City, all of Eastern Pennsylvania and New Jersey, Delaware, Eastern Maryland with Baltimore, and the vicinity of Washington. But this is not enough for even the immediate future. The railways from this zone to Pittsburgh should be included at once. Also the electrification should be carried west through all the region between the Ohio and the Great Lakes, including Southern Michigan. It should sweep up on the west of Lake Michigan at least as far as Milwaukee, and across Illinois to the St. Louis trade basin.

By that time the interests involved could tell how much further the work should be carried, and how soon. If the plan suggested in the work of the superpower survey above referred to were adopted there would be no doubt that it would be found profitable to extend it much further, and as fast as the building could be done.

This plan involves the establishment of a great superpower company which would sell power not only to the railways but to all present producers of electrical power who might find it profitable to buy it. It may be asked, Why not let the railways attend to their own power and thus keep the railway power separate from that of general business? Well, that is a point to be decided, but the answer given is, economy.

The ideal condition, it is claimed, is to have every user of electricity on the same system, so that what is called the load factor may be smoothed out and made more regular, steady and constant. Let me illustrate by the experience of Logan County, West Virginia. Here a few years ago the electrically operated coal mines were maintaining boiler capacity to the extent of 4000 horse power to operate their generators. They decided to put them into one electrical system, and found that a plant of only 500 horse power would do the work—an economy which the nation as a whole cannot afford not to emulate. Seven-eighths of the power plant was saved. Data obtained from the electrified mines of the Pennsylvania district are exhibited to show that if they were operated from one central station the plant used in making their power would not only do its present work but would yield enough surplus to carry the entire load requirement of Greater New York, including the railways.

In the discussion of the Lane superpower plan Mr. Samuel Ferguson, vice president of the Hartford Electric Light Company, said that in his city there is now installed 13,000 superfluous horse power which is idle from one end of the year to the other, but which might be either disposed of or put to work if a general system—a superpower system—were installed to carry the entire load. A superpower corporation to furnish electricity not only to the railways but to the other business of the United States would effect economies similar to those of Logan County, West Virginia, which if not so great in percentage of saving would be on a scale multiplied 20,000-fold.

Distribution of Power Plants

The minds of many, possibly most readers, will at once turn to water power as the agency which would supply current for the railways and the rest of us; but in this I think they are mistaken. Hydroelectric plants except where very favorably located cost three to four times what power plants operated by coal can be built for. Under such conditions power from water represents waste instead of saving. We had far better have three huge steam-operated plants than one of the same capacity using water power. Mr. Buckland in discussing the Lane plan mentioned the production of power from tidewater coal brought to New England ports, and "from unmerchantable coal developing power at the mines in Pennsylvania." This latter suggestion seems to be the one that will be adopted. The Rocky Mountain and Pacific States have most of the water power in the United States. They also have plenty of coal. That third of our area which needs four-fifths of our power, especially for railroad use, is deficient in water power, and its streams are irregular in flow. It must depend for a long time on coal, and will find it actually cheaper.

The moment coal is loaded on cars for shipment to power plants a great part of the economy is lost. We should have a system of great power plants located at the coal mines. We should not use anthracite. It is too limited in supply and is too valuable for other fuel uses. Power from Niagara and from the proposed Great Lakes-St. Lawrence development, and from the New England streams should be utilized if it can be developed promptly and regularly—but we should not wait for it. The easternmost power plant should be in the eastern edge of the bituminous fields of Pennsylvania. Other plants should be located in Western Pennsylvania, in West Virginia, in Virginia, in Ohio, in Tennessee, in Alabama, in the Ozark coal fields, in Kansas, in Oklahoma, in Illinois and the soft-coal fields of Iowa. The immense lignite fields of the Dakotas and Montana and thence west will furnish ample power more cheaply than it can be obtained from water, and will utilize a fuel that is largely unmerchantable.

If it be said that this leaves long distances unprovided with power plants, so that the current will have to be transmitted over longer distances than are now spanned, it is necessary only to cite the fact that the General Electric Company has recently transmitted current at 1,100,000 volts, and that plants are now building for commercial transmission at 220,000 volts. Distance yields to voltage. Expense for conductors yields to voltage. It is stated that at 220,000 volts, which is only one-fifth the pressure attained in the laboratory, 100 horse power could be transmitted through an ordinary forty-watt lamp filament without heating this little thread above its normal operating temperature or shortening its life. Transmission of current over the distances suggested is not difficult.

Texas has great lignite beds that can be used. California has coal fields away from the railways that might be used if the problem of building the plants were once solved.

(Continued on Page 104)

(Continued from Page 102)

Oregon and Washington have plenty of coal. And these states have oceans of water power. Colorado can furnish power from her mines or her streams or both for territory as far east as Omaha, or farther. There is no reason to doubt that the Montana and Dakota lignites can be used to furnish power with incredible economy not only for the Twin Cities and their vicinity, but on to Duluth and Chicago if desirable. Give out the contract and the engineers would start the job to-day.

The power plants must be built at the mines, and the coal taken from the earth and dumped right in the stokers. By this system, as Mr. Buckland suggested, unmerchantable coal can be used. This shift from the best coal, such as is now used in steam engines, to the poorest, is in itself an economy that is most impressive. I know a power company in Pennsylvania operated on this plan. It has a fine body of coal in the midst of which its plant is located. The coal goes right from the mine to the furnace. They have several veins, but they are using only the poorest and thinnest—coal it would not pay to ship.

The plan just mentioned is the Boston-Washington Superpower Zone project expanded so as to take in all the railways that ought economically to be electrified, and to give to the system all the business of the country that might find it wise to buy power so cheaply generated. How far would this extension go? When we consider that we now have in operation twice the electric machinery necessary to run all the railroads, and that very little of this makes its power as cheaply as it would be made by the superpower plants, it is safe to predict that the electrification would go much farther than the business of the railways alone would warrant. It is probable that building would never stop until it reached the Pacific Coast on more than one line, and that it would extend from the interior cities and the Western grain fields to the Gulf at several ports.

I have discussed the electrification of railways through a superpower plan, because that seems to me the best method. It would divide the expense between the transportation system and a general electrification, and thus save overhead for the railways and promote huge economies and efficiencies in other businesses. But it is not the only way. It may not be the best way. It is not the purpose of this discussion to promote it. My purpose is to show the chasm of ruin ahead of us if the railways break down again under good business. For every time the collapse comes it is worse than ever before.

Future Financing

"Yes," the intelligent reader has said long since, "but where is the money to come from?" The necks in the transportation bottle would have been electrified long ago if things had not come to such a pass that money goes into almost any other business more freely than into railway investments. This is, without doubt, the great question. The project of making the railways able to save our business life is so large, no matter how it is done, that the financing of it is a problem as great as that which we met in financing the Great War. Do not ask what it will cost—nobody knows. The thing must be done, no matter what it costs, or the United States is a failure for the future.

It is, in fact, war—war to prevent industrial and agricultural ruin, east, west, north and south, war against continental distances, war against the very forces of Nature, a sort of war that no nation in the world's history has ever won. But see what we gain by winning it! And see what we escape by the victory! It is much more vital to our salvation than the victory against Germany. We could have existed and prospered if Germany had won; but America withers and dies when the railways fail. These recurring crises endanger the very fabric of society.

Once get this fact in the minds of the American people, once get it burned into their consciousness, and the money can be raised. Twice as much money can be raised unless America is busted. I do not believe that America is busted. A newspaper paragraph before me says it is significant that the word American ends in "I can." I like that quip. It tells the truth.

We may as well begin to think about ways to raise the money, for the railways in their present condition, no matter who is to blame for it, cannot raise it. It is a great public question, and not one for the railways alone.

The railways might be conceived as each electrifying itself by its own efforts. That may be the better way. It seems to me, however, that the task is so great that it all should be done as one great job or it will not be done at all. This is as certain as anything can be, that the citizens of the United States must make up their minds to invest as freely in one way or another in the business of making our railway systems what they must be made as they invested in the winning of the war. Not that I mean that it will cost so much; but it will cost enough to make us all dig to raise the money. I have no idea how much it will cost, though I have seen estimates running to $20,000,000,000. It ought to be done in much the way it was done in war—under the spur of impending calamity. And it can be so done if the nation can be inspired to the task.

Four Possibilities

We have been told by the railroads' spokesmen why money will not invest in railway securities now. They charge it to governmental regulations, to the fact that so large a proportion of the activities of the railway officials, the wages the railways pay, the rates they charge, thousands of things, are controlled by law and public officers. If we accept their statements we must believe that these restrictions must be removed and the railways be left as free to control their business as shipowners or grocers, or the roads will not be able to get the money to make them able to do our business. I do not intend to discuss this at all here. It is no part of my message. I content myself with pointing out the fact that if we are to go through the process of repealing these laws before we can begin to see light our case is a dark one. For the next breakdown will be on us before we know it. We shall be in the throes of it within five years, unless this business depression is to last longer than any but the most pessimistic dare to predict.

There is the plan of electrification by each road through its own efforts; there is the plan of a great superpower company which shall take over the work and sell power to the railways; there is the plan for this company to sell power to the railways and also to other users of power. And there is a fourth method which must be faced by both those who believe in it and those who do not. This is electrification through a power system established by governmental action. In one or the other of these ways the thing must be done. Every statement made in this paper as to our peril of future paralysis is justified. When the crisis comes upon us we may be driven to do the most unwise things. The time to act is now, while we have time—if we have time.

"There be three things," said Lord Bacon, "which make a nation great and prosperous: A fertile soil, busy workshops and easy conveyance of men and commodities from place to place." Every word of this is more vitally true now than when and where it was written; but unless we have easy conveyance of men and commodities from place to place we cannot have busy workshops, and our fertile soil will by its very richness tempt people out upon it to their ruin.

Editor's Note—This is the last of three articles by Mr. Quick.