

The Abandonment of Electric Operation
by the Chicago, Milwaukee, St. Paul &
Pacific Railway Company

By Gordon W. Rogers and Michael Sol

Northwest Rail Group
Everett, Washington
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THE ABANDONMENT OF ELECTRIC OPERATION

BY THE CHICAGO, MILWAUKEE, ST. PAUL AND PACIFIC RAILROAD COMPANY

A Report Prepared by The

Northwest Rail Improvement Committee

THE PIONEER OF ELECTRIC RAILROADING

In 1906, the Chicago, Milwaukee & St. Paul Railway undertook construction of a new transcontinental railroad line, from its existing midwestern lines to the north Pacific coast. The company laid out the grades of its Pacific extension across the Belt, Rocky and Bitterroot Mountains and the Saddle and Cascade Mountains of Washington with the intention of eventually operating the line with electric power generated from the abundant nearby sources of hydroelectric power.¹

In 1914, the company began constructing the most advanced railway electrification system of that day, using the highest direct current voltage ever attempted for railway purposes - 3,000 volts. The DC system of electrification was chosen after a great deal of study showed its superiority for the heavy-duty service under adverse mountain conditions.

By 1920, about 600 route-miles had been built - the longest electrified line in the world - but still only 75 per cent complete. Pressing economic conditions of the company prevented completion of a section of 226 miles from Avery, Idaho, to Othello, Washington. Otherwise, from Harlowton, Montana, to Tacoma, Washington, the Milwaukee Road was an electrified railway, free from the expense and difficulty of steam operation over five major mountain ranges.

So excellent was the performance of the new system that it was eventually copied on some 41,000 route-miles of railroad in 26 nations, in preference to any other system.²

To the surprise of railroad economists, the new electrification paid for itself by 1930, returning nine per cent annually on the investment, in savings over comparable steam operation.³

The original system had 22 substations on the Rocky Mountain and Coast divisions, with 84 electric locomotive units of the boxcab type. In the early 1920's, the company added five gearless "bipolar" electric passenger locomotives and 10 geared passenger electrics. The company also had four 3,000 volt DC steeple-cab switching locomotives. One 1,500 volt DC steeple-cab switcher worked 7 miles of electrified tracks in the Great Falls terminal, not connected with the main line electrification.

In the late 1930's, several of the boxcab units, which had been operated in pairs, were modified to operate as three and four unit locomotives. Later the motors of many of the units were rewound for

greater power and speed, controls were revamped for increased flexibility, and many of the smaller components were changed to modern designs.

The original system endured virtually intact until 1950 when the railroad acquired twelve 5,500 horsepower electrics.

During the early 1950's, several projects were undertaken to upgrade and modify the electrification system for more efficient and economical operation. Several substations were automated, providing for operation from other substations by supervised remote control, eliminating the need for two or three operators at each substation. The trolley voltage was increased from 3,000 volts to 3,400 volts to increase the operating speeds of trains and overcome voltage drop problems between substations. Equipment was installed in the modern 5,500 h.p. "Little Joe" electric locomotives, and later in several boxcab units, for the remote operation of diesel locomotives from the cab of the electric, allowing multiple-unit operation of electric and diesel locomotives.⁴

After 1960, few improvements were undertaken and electric locomotives began to be retired in increasing numbers.

In 1971, electric operation on the Coast division was terminated except for occasional extra runs, and in February 1973, the Milwaukee Road announced the termination of the entire electrification, to take place over a period of several months. Finally, on June 15, 1974, the last mainline electric operation took place on the Rocky Mountain division and at midnight on June 16, 1974, the electrification era on the Milwaukee Road officially ended.

THE TERMINATION

When the Milwaukee Road announced on February 20, 1973, that it was planning to terminate its electric operations, it surprised not only railfans but railroad employees and professional engineers alike.

David P. Morgan of Trains magazine wrote that "Sure, the electrification was always 'under study', but to us that study implied a decision on whether to 'close the gap' between Avery and Othello, not on whether to lower all pantographs for good."⁵

It had always been a foregone conclusion to observers and employees that the electric operation of the Milwaukee Road out-performed, in every respect, the modern high priced and short lived diesel motive power that moved most of America's freight.

"From a dollar and cents point of view, the railroad had no alternative....," the company claimed, stating:

"When first installed, the Milwaukee's electrified system was vastly superior to steam operation, and even to the diesel power of several years ago. It served us extremely well. Given 1973 facts, however, with highly efficient and versatile diesel locomotives available for both main line and branch line service, compared with aging electric locomotives confined to the main line only, the decision was inevitable."⁶

However, available evidence indicated overwhelmingly that the claims of the Milwaukee were not true. The company's stated reasons for abandonment did not make sense either from an economic or an engineering standpoint. As one member of the Northwest Rail Improvement Committee pointed out, the Milwaukee's claimed advantages of diesel operation generally violated the laws of physics.⁷

About 26 nations in the world have electrified their railways with systems copied directly from the Milwaukee's. Many of those countries, when the systems became inadequate for increasing tonnage, found they had three alternatives: extending and supplementing the existing DC system, conversion to high voltage AC, or dieselization. Almost without exception, DC systems were retained as the most efficient and economical alternative. Of the three alternatives, dieselization is generally considered the most expensive and the least efficient. Only where large sections of new electrification were to be built were the more cheaply constructed AC systems used; for existing systems, AC held no advantages over DC.⁸

In consideration that the electric system was being abandoned for apparently spurious reasons, a group of professional engineers and technical writers from the states of Montana and Washington formed the Northwest Rail Improvement Committee. The members of the committee had studied motive power on railways for several years, especially the Milwaukee's electric system, with the conclusion that it was one of the most efficient means of rail transportation ever devised, even when compared with "modern" diesel power.

This committee made strenuous efforts to prevent the abandonment. This report is the story of that effort.

THE EVIDENCE

One of the most striking pieces of evidence against the Milwaukee abandonment decision was contained in the Milwaukee Road's own Annual Reports to the Interstate Commerce Commission and the state public utilities commissions. The company claimed that the electric locomotives were suffering from high maintenance costs because of advanced age, yet the reports indicated that, on an equivalent horsepower basis,

the electric locomotive maintenance costs were about 20 to 40 per cent of the costs for equivalent diesel horsepower.* Further, the electric figures were for locomotives confined to the rugged environment and operation of mountain operation, whereas diesel costs were for much newer locomotives, whose maintenance costs were averaged over the entire system - much of which is relatively undemanding flatland operation. Yet the diesels came out a poor second in maintenance cost. Even when the cost of maintaining the power supply system is added to the electric locomotive maintenance cost, the total electrification maintenance was still about 40 to 60 per cent of the cost of diesel per available horsepower at the drawbar in mountain service.⁹

Another compelling argument against the company's abandonment reasoning was delivered by a study calling into question the entire range of claimed advantages of diesel operation.

In the late 1950's, British railway officials wishing to improve their railway lines were beset on one hand by the observation of American railroads exchanging steam locomotives for diesel and on the other hand by the continental European countries favoring electric motive power. Seeking guidance, they asked one of the world's most renowned authorities on railroad motive power to prepare a research paper on the economic results of railroad electrification and dieselization in the United States. That authority was Harry Farnsworth Brown, then a consulting engineer with Gibbs & Hill, Incorporated.

In his effort to verify several claimed advantages of diesel locomotives over steam, Brown found all of them spurious, having been based on invalid comparisons, faulty statistical methods, incomplete and biased data, and various forms of misinterpretation. His results and conclusions were presented before the Institution of Mechanical Engineers of London on November 30, 1960, in a paper entitled "Economic Results of Diesel Electric Motive Power on the Railways of the United States of America". Mr. Brown's conclusions were devastating:

*In comparing diesel and electric locomotives, it is necessary to compare them on an equivalent horsepower basis, since diesels in road service do not deliver their full rated horsepower at any time. The ratings are based on maximum horsepower at the engine under SAE ambient conditions. Under operating conditions, with frictional losses and conversion to electricity for the traction motors, drawbar horsepower is usually a maximum of about 80 per cent of rated h.p. Under mountain conditions, further losses of output are experienced due to altitude, tunnels and severe weather, according to Southern Pacific Railway, reducing drawbar h.p. to as little as 60 per cent of rated h.p. By contrast, electric locomotives deliver more than their continuously rated power under the same operating conditions, and traditionally the electric locomotives of the Milwaukee Road operated near this hourly rating on the steeper grades, which is 110-120 per cent of their continuous rating. A valid comparison between diesel and electric locomotives must use their actual output under the severest conditions.

This study simply states that the all-embracing economies claimed for diesel motive power on the class I railways of the United States, as a whole, do not appear in the statistical record.

The diesel locomotive has not 'revolutionized' American railway economics. In road service, diesel motive power has added to the financial burden of the railways.

The comparative analysis made in the paper showed the economic performance of diesel motive power to be about on par with that of steam on its overall application on the United States railways - no better, no worse... In line haul, or 'road' service, the paper showed it to be more expensive than equivalent modern steam might have been... The capital costs had just about cancelled the operating savings.¹⁰

The Milwaukee Road readily admitted that its electrics were vastly superior to steam. It is an inevitable conclusion that they must be superior to diesel.

The release of Brown's study touched off storms of rebuttal from all of the appropriate sources, especially the people who built and marketed diesel locomotives. However, after the smoke cleared, it became apparent that his results and interpretations were nearly unchallengeable: the diesel locomotive had improved the overall economy virtually none over modern steam operation. Several years later his conclusions were confirmed by a study by S. Graham Hamilton of the General Electric Company, who compiled comparative data on the economics of steam, electric and diesel motive power in several European countries.¹¹ The overall comparison between steam and diesel was remarkably close in both Brown's and Hamilton's estimation.

Soon after Brown's study, General Motors redesigned its locomotive products, adding new shells, and making the locomotives larger with several internal modifications. The new models were supposed to be "phenomenally improved" over the older diesel models. Yet it is interesting to note some facts. In the early 1950's, the Internal Revenue Service estimated, for depreciation purposes, the life span of a diesel locomotive to be 20 years. A study for the Chesapeake & Ohio Railroad, by Gibbs & Hill in 1954-55, demonstrated the actual economic life to be 12-14 years. As a result of that study, the IRS reduced the depreciation period for the C&O diesels in 1955, and for the entire railroad industry in 1962, to 14 years.¹²

However, since then diesel locomotives have been altered considerably, possibly affecting their useful economic life. Whereas the older GP series diesels, which were the main mainline motive power on most American railways, when they became unreliable for mainline work, were light enough for yard, light industry and branch line work; the new diesels are powerful, heavy machines, of such great weight that when they become unreliable

for mainline work, there is no other useful work they can perform. With no life-extending service possible, the new diesels will necessarily have shorter life spans than their predecessors.

It stands to reason on the basis of General Motors' historical record of sales policies that it would not deliberately improve its locomotives so as to last substantially longer than the established 14-year life, because to do so would reduce the future replacement market. Unless the price of new locomotives should be substantially reduced, improvements are not economically realistic unless they prolong the time between replacements.

It is becoming apparent to many railroaders that the claimed economies of diesel locomotives are false economies.¹³

Speaking to a 1972 Railway Systems and Management Association seminar on electrification, Canadian Pacific Railway Senior Executive Officer Keith Campbell spoke of the future of diesel motive power:

There is a question mark concerning future development of the diesel locomotive... In hauling fast freights, the needs of the market dictate that to maintain competitive schedules we should use four, five or even six locomotives of 3,000 hp or more. Where bulk freight is concerned, the need to minimize costs has led many railroads to operate very long trains sometimes requiring as many as 12 such locomotives. There is nothing inherently wrong in this - yet somehow, such an inelegant solution suggest that we have reached a technical plateau from which some new technical departure is overdue.¹⁴

It may be noted here that one available technology that overcomes the many problems of diesel operation operated on the Milwaukee Road for 89 years.

Campbell saw no future for the diesel locomotive:

...efforts to increase locomotive output by using more than one low-speed engine per locomotive have not been sufficiently successful to obtain wide-spread acceptance... The way ahead for the diesel locomotive is not readily apparent, and the demand to generate more and more horsepower from it seems to have resulted in high maintenance costs and a level of dependability that some of us... would no doubt call to question.

As diesel locomotive operators, we are the prisoners of a single fuel, a fuel that is fast becoming a pawn on the chessboard of international politics. It is a fuel, too, for which many users - truckers, for example - have no alternative at the present state of technology. One does not need sophisticated techniques for predicting the future to form the view that, whatever else happens, its price is bound to rise. And I fear that the problem

of scarcity is not the kind of problem that goes away if you ignore it. In the generation of electricity, by contrast, almost any fuel may be used...

...the high and increasing cost of labor for locomotive maintenance adds to the attractiveness of making an investment in fixed equipment and in locomotives which, once made, will require little further capital expenditure over a period of 30 or more years - during which potential escalations in the price of both fuel and diesel maintenance labor remain unknown but rather frightening factors.¹⁵

Campbell cited only one major obstacle in electrifying railways - the high initial cost. The Milwaukee Road was already 75% past that hurdle for an 882-mile continuous system.

That diesel maintenance costs are far greater than the costs for equivalent electric traction are confirmed by most foreign railways according to "Performance of Electrified Railways", Conference Publication No. 50, 1968, by the Institute of Electrical Engineers (London).

More recently, in a paper presented at the Quality Control Conference on January 25, 1972, S. G. Hamilton of General Electric confirmed in his "Trends in Motive Power Reliability" that the maintenance costs for straight electric motive power are about one-third that for comparable diesel operation.

There is no doubt, as verified by the Milwaukee Road Annual Reports, that electric motive power - even as old as that which operated on the Milwaukee - is far cheaper to maintain per horsepower, all things considered, than equivalent horsepower of the "modern" diesel locomotive. By implication, as well as by the testimony of at least two dozen trainmen, supervisors and maintenance personnel, the electrics are more reliable to operate, contributing to cheaper operating costs in general, faster schedules, greater percentage of on-time arrivals, and less disruption due to in-service breakdowns.

Further, due to the combined effects of high altitude, tunnels, and severe weather conditions, diesel locomotives may put out less than 60 per cent of their rated horsepower, whereas electric locomotives under the same conditions put out at least 110 per cent of their rated capacity for one hour, or even 150 per cent or more for shorter periods. Hence, an electric locomotive can virtually always climb a hill with its fully rated tonnage even if it has to plow snow and fight subzero cold in addition, while a diesel locomotive will lose power and stall under the same conditions.¹⁶

The most nearly valid criterion of comparison readily available for assessing the operating capabilities of the two forms of motive power is the measurement of the available horsepower for negotiating the severest operating conditions, which in the case of the Milwaukee Road, included

the electrified sections of track. Overall, in any comparison of maintenance and fuel cost comparisons of the two motive power forms, the correction factor for nominally-rated diesel power will be approximately .7 and for electric power 1.1. In addition, one can add at least 10 per cent for the longer operating time of electric locomotives and subtract at least another 10 per cent for the larger horsepower of diesels needed - all because on the long-term average, electric locomotives spend that much less time in the shop than diesels.

THE PROBLEMS OF ELECTRIC OPERATION ON THE MILWAUKEE ROAD

There can be no doubt that the evidence was, up to the last, in favor of continued electric operation on the Milwaukee Road. Yet the railroad, in public and private statements, indicated that there were problems associated with continued electric operation that were too great for the railroad to overcome economically.

The primary problem, according to the railroad, was money. The enormously high initial capital investment involved in undertaking new electrification projects has long been a deterrent to railroads considering electrifying. Most railroads seem to feel, with some apparent justification, that it is better to absorb the greater costs of dieselization only because they can be spread over the longer term, or because the initial investment required for electrification cannot be returned fast enough to attract the necessary capital. In this respect the Milwaukee was at an enormous advantage over non-electrified railroads in that it had a perfectly viable system that had paid for itself many times over. Its system, except for the gap between Othello and Avery, was complete. It was built, tested, modified and enormously efficient. Only supplementation, at a relatively small cost, was necessary.

Although the system was built to handle lower tonnage trains than those characteristic of modern practice, it had been modified at relatively small expense to handle modern tonnage with little difficulty. With further upgrading, it could have handled the traffic of the foreseeable future with considerably less cost than replacing it all with diesel motive power. In 15 years, the system and its locomotives would have still been available for further modification, if necessary, at the relatively low costs that have characterized past modifications, instead of being in the scrap heap along with the diesel locomotives which were purchased to replace the electric system, as they will then require total replacement.¹⁷

It was suggested by the railroad that, for maximum efficiency, the entire apparatus of electrification would have to have been replaced by alternating current system technology, where the Milwaukee to remain electrified.¹⁸ This committee considers that notion completely ridiculous.

Most studies comparing the cost of AC vs DC railway electrifications find that the only real economic advantage that AC has over DC is that the AC costs from 10 to 30 per cent less to construct, as it requires less complicated conversion equipment and lighter catenary. There is no significant operating cost difference.¹⁹ For an existing DC system, such as the Milwaukee had, there was no rationale for conversion to AC operation.

Indeed, foreign countries which have standardized on the DC system are retaining and augmenting it, even though new AC systems are being built in addition. The Soviet Union and Italy are experimenting with 6,000 volts DC for railway operation, while Italy recently converted several three-phase AC systems to 3,000 volts DC. Algeria and South Africa are purchasing new direct current locomotives, while the latter also builds a new AC system. South Korea has just finished constructing a new railroad electrification which uses DC in the cities and AC between cities, with dual-voltage locomotives. Spain recently inaugurated service on about 160 miles of new 3,000 volt DC electrification using solid-state automatic substations, and is planning to build 1,713 more miles of the same kind of system in the next three years, because even if the electricity is generated by burning oil, 13 per cent less oil is required than by comparable use of diesel locomotives, in addition to other economies. Manufacturers in Japan and England are producing DC locomotives with electronic chopper controls which are similar to the thyristor controls of modern AC locomotives and offer the same technological and economic advantages. It can be concluded that advancements of electrical engineering have made the DC systems more viable than ever, rather than making them obsolete, as the Milwaukee claims.²⁰

The great age of the system has been cited as the primary obstacle to continued operation. Although the Milwaukee system was the oldest 3,000 volt DC system in existence, having been the first at that voltage, the age of it had very little to do with the economics or efficiency of the system. A Milwaukee Road electrical engineer, anticipating the criticism, wrote in 1956 that "age is not a suitable criterion" to judge the Milwaukee electrification.¹⁶

Indeed, the original boxcab units, built in 1915, operated effectively into the several million mile class until their first extensive overhaul in the 1950's gave them considerable years of additional service. Spare parts were never a problem since most of the needed parts were produced without great expense in the railroad's own shops.²¹

The railroad complained that the newest electric locomotives on the line, the 1950-vintage "Little Joe" locomotives, were nearing the end of their life expectancy.²² Yet most observers, professional engineers, and company employees agreed that the engines were good for at least 40 years. The "life expectancy" then may have been only their depreciation period, but certainly not their economic service life.

The substation electric power conversion machinery was almost entirely of 1915 design, yet maintenance of that machinery had kept it in virtually perfect condition. The machinery was generally acknowledged to have many more years left of useful life. Although solid-state rectification equipment is more economical and efficient to operate than the Milwaukee's rotating apparatus, the condition of the rotating machinery did not warrant the expenditure necessary to replace with solid-state equipment, except as supplementation to the existing equipment.²³ Also the existing machinery provided for recovery of power by regenerative braking, which requires special apparatus with solid-state electronic equipment.

With electrifications in general, one of the significant items of maintenance expense is the structural support system for the catenary. On the Milwaukee Road, this system consisted primarily of wooden poles, most of them of pre-1920 vintage. A stubbing program in the 1930's gave the poles an estimated life expectancy lasting into the 1970's.¹⁶ In the last years of the electrification's existence, a logical program of gradual replacement was not undertaken. Under normal circumstances poles were replaced a few at a time each year where needed; hence the annual cost was very low.

The railroad complained that if the system had been kept operating, it would have required a great deal of money all at once, just to keep the system running because of the need for immediate measures such as pole replacement. Yet the railroad, in not undertaking a replacement program when it could have been spread out over a number of years, brought on that condition by calculated policy.

Gradual replacement would have kept the costs down and established a system that, with modern pole treatments, would have lasted well past the year 2010.

As for trolley wire wear, a sample possessed by one of the authors of this report, scrapped from the main line in Montana in 1974, shows that in 58 years of use it was less than half worn out.

In the 1950's, the company began a program of consolidating its 100,000 volt transmission structures with the catenary support poles - creating a system where a single pole supported the catenary, the high voltage transmission line, and the railroad's communications equipment (otherwise carried on catenary support poles).¹⁶

This improvement, had it been extensively done, would have significantly reduced the number of poles to maintain. However, this committee considers that pole maintenance, even without money saving improvements, was a small cost for the railroad.

The catenary structures normally carried the railroad communication and signal lines, for which poles would normally be maintained anyway,

with or without the electrification, although the cost was charged to the electrification. Rental of the high voltage lines to electric power utilities actually would make them a revenue producing portion of the system, and the Railroad's transmission lines actually were used by the power companies for transmitting their own current.²³

The use of Milwaukee high voltage lines by the commercial power companies had benefits for all concerned. Use of the Milwaukee right-of-way as a power transmission corridor avoids the cost and unpleasantness of a power line cutting a vast swath across public and private lands and forests. The presence of the direct current lines nearby added a benefit by acting as a ground for the alternating current lines and reduced lightning damage on the AC line, which spanned five mountain ranges.

A major stumbling block for the electrified system has always been the existence of the gap between Avery, Idaho, and Othello, Washington. Although the electrification operated more efficiently than comparable diesel service, even with the gap, there is no doubt that savings could be increased considerably with a complete electric system on the 882 miles of transcontinental line between Harlowton, Montana, and the West Coast. At \$70,000 per track mile, the gap could have been electrified for about \$15,000,000.²³

There can remain little doubt that the Milwaukee Road was not candid in its decision to terminate the electrification. There is no foundation to claims that the system was obsolete, inadequate, or too old. The public relations releases of the railroad stated that the termination decision came only after a series of "exhaustive studies" over several years. What the releases failed to note was that some of the most exhaustive of those studies recommended keeping the electrification as the most economical and efficient way to go.

A 1963 study found that at the very low levels of traffic then prevailing, the electric operation was breaking nearly even with comparable diesel operation. But much of the costs of the electrification were fixed as salaries and fixed plant maintenance and taxes, which had to be paid whether the trains ran or not. Since traffic has since increased nearly four-fold on the Milwaukee, it can only follow that the electrification became increasingly cheaper to operate relative to the diesel operations.²⁵ The fuel crisis during and after 1973 reduced any argument of diesel economy and efficiency to absurdity. In fact, the former official of the Milwaukee Road who conducted the 1963 study wrote in personal correspondence in April, 1972 (emphasis his):

"We made many cost studies. You can't get any active figures account of railroad policy, but you can know this: that with the business of the times (early 1960's) the margin was very thin, usually in favor of the electric. You could throw it either way by how you handled depreciation. Now today, with business the best it has ever been in electrified territory, the study would show a big saving in favor of electric."

A later study indicated that if the gap were electrified, 40 electric locomotive units would have been required to handle the tonnage, whereas converting to diesel operation would have required 105 diesel locomotive units. Direct current locomotives as used on the Milwaukee Road have been priced by company personnel to cost about the same per rated horsepower as diesel locomotives, which makes the initial cost per electric locomotive about 2/3 the cost for diesel when corrected for drawbar horsepower. The much longer life of the electric locomotive makes the cost about 1/3 the cost for equivalent diesel power over a 30-year period. Inflation effects on the cost of replacing diesel power put the cost benefits even further in favor of the electric locomotives.²⁶

The Milwaukee Road has refused to release the studies that it says support the abandonment of the electrification, or even back up its published reasons with documentary evidence. In view of the thought that such publication might quell the opposition to the abandonment and satisfy the many employees who were disheartened by it, the only rationale for that refusal would be that the reports and studies do not support the abandonment, or else are not sound or accurate in engineering analysis.

Projected maintenance for the two fleets provide a startling contrast. It is generally recognized that maintenance of electric motive power costs about one-third of that for equivalent diesel power, which requires a larger and more diverse labor force. The cumulative differences of maintenance and labor requirements of diesel and electric motive power are substantial.^{11, 14}

To gain a modern, efficient motive power system, the Milwaukee would need 40 electric locomotives to electrify the gap, or 105 diesel locomotives, according to the aforementioned study.²⁶ Assuming 3,000 nominal h.p. per diesel and 5,000 per electric locomotive and applying the aforementioned correction factors, both fleets work out to about 220,500 rail h.p. However, 12 Little Joes need not have been replaced, so their 66,000 h.p. may be deducted, leaving 154,500 new electric h.p. to be purchased, and the same amount of diesel rail h.p. would be released for sale or use elsewhere. Allowing 20% reduction in value for depreciation and correcting the h.p., the value of the released diesels would be about \$21,000,000, at the price per reference No. 27.

The 66,000 rail h.p. of diesel locomotives needed for replacing the Little Joes cost about \$12,000,000, which added to the value of the diesels on hand totalled about \$33,000,000 as the total cost of dieselization in 1973. However, this does not count about \$6,000,000 credited to diesel depreciation which was properly part of the original cost of replacing electric locomotives and which had to be set aside for replacement funds. Hence \$39,000,000 is the actual total cost of the diesels that replaced electrics.²⁷

Traditionally, electric locomotives had cost about 82% as much as diesel per nominal h.p.,²⁶ and production cost improvements should apply to both types, so it seems safe to assume the same differential in 1973.²⁸ Hence, new electric locomotives should have cost about \$92 per available h.p., or about \$15,000,000 for the fleet needed.

By a somewhat involved process of itemized estimates the salvage value of the electrification is found to be about \$9,000,000.

If we assume that the aforementioned \$15,000,000 for electrifying the gap was for power distribution only, and add \$5,000,000 for substations, it comes to \$20,000,000 which is close to the figure given in a letter from Milwaukee Road Chairman William J. Quinn to U. S. Senator Warren G. Magnuson in November, 1973.

The foregoing estimates may now be summarized as follows:

Electrifying the gap	\$20,000,000
Augment existing power supply	4,000,000
New electric locomotives	<u>15,000,000</u>
Gross cost of modernizing electrification	39,000,000
Less value of diesels released	<u>21,000,000</u>
Net cost of modernizing electrification	\$18,000,000
Cost of diesel locomotives, total	\$39,000,000
Less salvage value of electrification	<u>9,000,000</u>
Net cost of dieselization	\$30,000,000

Hence it cost the Milwaukee Road about \$12,000,000 more to de-electrify (or 1.67 times as much) than to modernize the electrification. On top of that, when the diesels are replaced about 1988, assuming 7½% interest on the \$39,000,000 cost of the 1973 diesel fleet, and a 5% per year inflation rate on replacements of the same diesel h.p., the 30-year cost of de-electrifying will rise to \$183,000,000. If the annual inflation rate is 10%, the 30-year cost will be about \$314,000,000.

Inflation would not affect electric investment costs for the same period because there would be no replacements. At an interest rate of 7½% on the gross cost of electric modernization, the 30-year total investment cost would have been about \$63,300,000. Hence over the next 30 years, the cost of dieselization will be about 3 times as much at 5% annual inflation, or 5 times as much at 10% annual inflation.

It is interesting to note that by applying only the h.p. corrections to the numbers of locomotives quoted, the total h.p.'s come out approximately equal. If another correction were added for availability,

the differences in cost would be greater, making diesel about twice as much as electric, initially.

It may also be noted that a good deal fewer than 40 new electric locomotives would have been needed if the boxcab fleet of the mid 1960's had been kept serviceable. Some of those locomotives could have been overhauled and speeded up by changing the gear ratio for a few thousand dollars each. By modern electronic synchronization, six units could have been connected in multiple control. (A method had been worked out by one of the Road's electrical engineers). Thus, only the priority time freights would have required new locomotives, while the "drag" runs could have been handled by the boxcabs. At an overhaul cost of \$25,000 per unit, which should be generous, all 77 boxcab units which were on hand in 1964 could have been overhauled for \$2,000,000. This estimated price of \$12.20 per hourly h.p. is about 10% of the price of new electric locomotives, and only about 7% of the cost of equivalent diesel h.p. Even though their construction was considered to be archaic, their maintenance cost was only around half that of equal diesel power at the drawbar, according to the Annual Reports.

If the Milwaukee Road were really as short on financial resources as its management has claimed it to be, then how could it finance, let alone justify, a change of motive power costing so many more times as much as an improvement and augmentation of existing facilities?

In addition to this, the maintenance cost comparison shown in the Appendix to this Report indicates that the projected electric system between Harlowton and Tacoma, locomotives and power system combined, would cost about 42% as much to maintain as equivalent diesel locomotives. At the aforementioned 220,500 h.p. for operating that territory, the saving in motive power maintenance by electrification would have been at least \$2 million per year at 1973 prices.

Several other factors must be considered in any discussion of railroad electrification. The electrification, once installed, insulates the railroad company from the ravages of inflation for its equipment and much of its spare parts and repair costs, as has been shown. Diesel power, replaced relatively frequently, makes the road extremely vulnerable to soaring prices.¹⁴

The price and availability of diesel fuel are considerations that the Milwaukee either did not make, or decided to take a risky gamble on. It already doubled in price within a year after the announcement to de-electrify.²⁹

If the Milwaukee electrification, with its high fixed costs, could break even with diesel operation in 1963 at the low traffic levels then prevailing, the economy of the electrification in the 1970's would be startling with the higher utilization of the electric system due to higher traffic levels, and the high diesel fuel prices compared to 1963.

Traditionally, electric locomotives had cost about 82% as much as diesel per nominal h.p.,²⁶ and production cost improvements should apply to both types, so it seems safe to assume the same differential in 1973.²⁸ Hence, new electric locomotives should have cost about \$92 per available h.p., or about \$15,000,000 for the fleet needed.

By a somewhat involved process of itemized estimates the salvage value of the electrification is found to be about \$9,000,000.

If we assume that the aforementioned \$15,000,000 for electrifying the gap was for power distribution only, and add \$5,000,000 for substations, it comes to \$20,000,000 which is close to the figure given in a letter from Milwaukee Road (Chairman William J. Quinn to U. S. Senator Warren G. Magnuson in November, 1973.

The foregoing estimates may now be summarized as follows:

Electrifying the gap	\$20,000,000
Augment existing power supply	4,000,000
New electric locomotives	<u>15,000,000</u>
Gross cost of modernizing electrification	39,000,000
Less value of diesels released	<u>21,000,000</u>
Net cost of modernizing electrification	\$18,000,000
Cost of diesel locomotives, total	\$39,000,000
Less salvage value of electrification	<u>9,000,000</u>
Net cost of dieselization	\$30,000,000

Hence it cost the Milwaukee Road about \$12,000,000 more to de-electrify (or 1.67 times as much) than to modernize the electrification. On top of that, when the diesels are replaced about 1988, assuming 7 $\frac{1}{2}$ % interest on the \$39,000,000 cost of the 1973 diesel fleet, and a 5% per year inflation rate on replacements of the same diesel h.p., the 30-year cost of de-electrifying will rise to ~~\$120,000,000~~. If the annual inflation rate is 10%, the 30-year cost will be about ~~\$205,000,000~~.

Inflation would not affect electric investment costs for the same period because there would be no replacements. At an interest rate of 7 $\frac{1}{2}$ % on the gross cost of electric modernization, the 30-year total investment cost would have been about ~~\$20,000,000~~.³ Hence over the next 30 years, the cost of dieselization will be about ~~5~~ times as much at 5% annual inflation, or ~~5~~ times as much at 10% annual inflation.

It is interesting to note that by applying only the h.p. corrections to the numbers of locomotives quoted, the total h.p.'s come out approximately equal. If another correction were added for availability,

the differences in cost would be greater, making diesel about twice as much as electric, initially.

It may also be noted that a good deal fewer than 40 new electric locomotives would have been needed if the boxcab fleet of the mid 1960's had been kept serviceable. Some of those locomotives could have been overhauled and speeded up by changing the gear ratio for a few thousand dollars each. By modern electronic synchronization, six units could have been connected in multiple control. (A method had been worked out by one of the Road's electrical engineers). Thus, only the priority time freights would have required new locomotives, while the "drag" runs could have been handled by the boxcabs. At an overhaul cost of \$25,000 per unit, which should be generous, all 77 boxcab units which were on hand in 1964 could have been overhauled for \$2,000,000. This estimated price of \$12.20 per hourly h.p. is about 10% of the price of new electric locomotives, and only about 7% of the cost of equivalent diesel h.p. Even though their construction was considered to be archaic, their maintenance cost was only around half that of equal diesel power at the drawbar, according to the Annual Reports.

If the Milwaukee Road were really as short on financial resources as its management has claimed it to be, then how could it finance, let alone justify, a change of motive power costing so many more times as much as an improvement and augmentation of existing facilities?

In addition to this, the maintenance cost comparison shown in the Appendix to this Report indicates that the projected electric system between Harlowton and Tacoma, locomotives and power system combined, would cost about 42% as much to maintain as equivalent diesel locomotives. At the aforementioned 220,500 h.p. for operating that territory, the saving in motive power maintenance by electrification would have been at least \$2 million per year at 1973 prices.

Several other factors must be considered in any discussion of railroad electrification. The electrification, once installed, insulates the railroad company from the ravages of inflation for its equipment and much of its spare parts and repair costs, as has been shown. Diesel power, replaced relatively frequently, makes the road extremely vulnerable to soaring prices.¹⁴

The price and availability of diesel fuel are considerations that the Milwaukee either did not make, or decided to take a risky gamble on. It already doubled in price within a year after the announcement to de-electrify.²⁹

If the Milwaukee electrification, with its high fixed costs, could break even with diesel operation in 1963 at the low traffic levels then prevailing, the economy of the electrification in the 1970's would be startling with the higher utilization of the electric system due to higher traffic levels, and the high diesel fuel prices compared to 1963.

For instance, the average price of electric power used for the electric locomotives in mountain service in the years 1964-73 was approximately 92 per cent of the cost of equivalent fuel costs for diesels in flatland service.³⁰ Assuming that electric locomotives return 15 per cent of their power by regenerative braking, the equivalent differential in mountain service is about 80 per cent at pre-1973 prices. Since the price of diesel fuel has at least doubled since that time period, electric power would now be costing the road about 40 per cent as much as diesel fuel.

It is incomprehensible to suspect that the Milwaukee Road would not take into account that known petroleum reserves will only last about 20 more years, at which time the Milwaukee would be forced to undertake the electrification at much great effort and cost than otherwise. The global political situation may curtail available supplies of fuel, and the Milwaukee would have been able to perform a real service in such a crunch, being the only transcontinental railway able to move freight without depleting, unnecessarily, critical reserves of fuel in a crisis.

For example, in 1972 about half of the locomotive horsepower in the Milwaukee's Rocky Mountain division was electric, and that saved about 8,000,000 gallons of fuel. With full electric operation of both of the railroad's electrified zones, the savings would have been about 24,000,000 gallons. With the gap electrified, about 31,000,000 gallons could have been saved annually.³¹

It is often argued that the rapid turnover in diesel locomotives allows the railroads to take advantage of progressing technology. This is a false argument. The Milwaukee Road electrification was by no means frozen into a 1915 technology. It was continually modified, incorporating technological improvements at much less cost than replacing whole sets of motive power. The Little Joe electrics - made in 1947-48 - were every bit as modern as the latest diesels on the road, especially in the most important characteristics of being more powerful and cheaper to operate and maintain. Any new advances in motive power, especially of the "on-board" type as typified by diesel locomotives, will probably be minimal for the foreseeable future. The great advances and changes will rather be in the types of energy available, as atomic power and other proposed types are developed and commercially applied. The diesel locomotion systems cannot take advantage of these changes at all, whereas the electric systems can use power from any source.

Indeed, as energy becomes a more restricted quantity as certain fuels begin to run out, it will be increasingly important that motive power be efficient movers of freight and passengers. It is notable that the Milwaukee electric system was over 72 per cent efficient in the use of energy it received from the power companies, about 90% of which was generated by water power.³² A diesel locomotive is only 23 per cent efficient in using the energy potential of diesel fuel.³³

Financing has been cited as a major problem for electric equipment. However, in a letter to Senator Warren Magnuson of Washington, Milwaukee Chairman William J. Quinn made no mention of this as an obstacle, writing as though the Milwaukee, in its studies, had found financing - or even leasing of both facilities and locomotives - to be no problem. He even wrote of a 6 per cent rate which the Milwaukee had apparently found available for the electric equipment.³⁴

Some sources suggested that the commercial power utilities were willing to cooperate on construction of the electrification of the gap between Avery and Othello at almost no immediate cost to the railroad.³⁵

The company claimed that it had to "conserve capital" and that it therefore had to go diesel. It should be noted that many developed and developing countries, which must strive mightily to conserve capital, generally prefer electrification as the best way to do it as far as their railways are concerned. The Milwaukee Road, rejecting the experience of the rest of the world, chooses to "conserve" its capital by committing itself to a long term policy whose investment, maintenance and operating costs have been shown in this Report to be several times those of the equipment it scrapped.³⁶

THE COMMITTEE PROTESTS

After the Milwaukee's announcement of the abandonment of electric operation, the Northwest Rail Improvement Committee undertook an effort to prevent the abandonment and to make known the consequences of such abandonment. News releases of the Committee's statements and positions were sent to appropriate newspapers in Montana and Washington state. Generally, however, the newspapers preferred to accept the railroad's versions and arguments without question, ignoring any other side of the issue. Only three newspapers attempted any kind of fairness at all in their coverage. The Great Falls (Mont.) Tribune and the Missoula (Mont.) Missoulian made note of the Committee's efforts and position in feature articles on the abandonment. The Tribune followed up with an article on the Committee. The Missoulian gave extended editorial space on two occasions for commentary by a Committee member. The Aberdeen (Wash.) Daily World was generous with coverage of the Committee's efforts on several occasions.³⁷

As part of its efforts, the Committee also undertook a political lobbying effort on behalf of the electrification system.

With support from the Committee, Representative Joe Brand introduced into the Montana Legislature a bill requiring all railroads to electrify in Montana by 1978. The bill was not reported out of committee, as it was found both economically unfeasible and unpassable. Subsequently, bills were introduced into both the Montana and Washington Legislatures requiring electric railroads to continue using electric

power and prohibiting the abandonment of such facilities. The Montana bill was killed in committee because most of the members felt it was an infringement on the rights of private industry. Private industry's infringement on the public was apparently not considered. The Washington bill got buried in higher priority legislation and the committee did not have time to consider it.

The public regulatory commissions of the states of Montana and Washington were not only reluctant to take any action, but in some cases actually defended the railroad's decision.

Governor Daniel Evans of Washington cited conclusions by the Washington Utilities and Transportation Commission that supported virtually all of the railroad's contentions about continued electric operation.³⁸ A rebuttal from the Northwest Rail Improvement Committee detailing objections to those arguments was met by a reply from Washington Assistant Attorney General Edward Mackie.

Mackie maintained that all of the arguments were fine, but that as a regulatory agency, the Commission had no authority to dictate kinds of motive power to railroad management.³⁹ He appeared to forget that New York, Cleveland, and other municipalities forced the railroads to electrify their city terminals many decades ago.

The position of the Northwest Rail Improvement Committee was that the action of the railroad would lead to a degradation of the environment through increased emission of diesel pollutants, whereas maximum electric operation would have a beneficial effect by reducing the amounts of those pollutants emitted.

Further, it was felt that in the midst of an increasingly serious energy shortage as of late 1973, the railroad was inflicting a serious hardship on the other users of such fuels by increasing its consumption unnecessarily at a time when other users, who did not have the luxury of an alternative source of energy, were faced with shortages and rapidly increasing prices of those fuels. The Committee's position was that the short and long term effects of such action were something that could be remedied politically, especially during rationing when it was felt that those who had other alternatives should be required to cut their use of fuel.

It was felt that the actions of the railroad could be demonstrated to be to the long term disadvantage of the railroad, its security holders, and the general public which depends on the railroad transport system for much of its needs. Therefore, the public regulatory agencies, charged with acting in the public interest and for the public benefit, would be compelled to take remedial action, encourage other agencies to take remedial action, or at least make a motion of opposition.

Not one of these courses of action was undertaken by any state agency with regard to the abandonment of electric operation by the

Milwaukee Road. It is the opinion of the Northwest Rail Improvement Committee that this inaction of the state regulatory agencies was contrary to the spirit of their creation and contrary to the long term interest and welfare of the public.⁴⁰

In Montana, the Public Service Commission flatly refused to have anything to do with preventing the abandonment, and the Governor of that state, Thomas Judge, referred communications on the matter to his Lieutenant Governor as Chairman of the Montana Energy Advisory Council.⁴¹ The Lieutenant Governor and the Energy Advisory Council did not respond in any way to Committee proposals.

By contrast, the Governor of Pennsylvania announced his state's policy to seek electrification of the Penn Central line across the Allegheny Mountains in that State.⁴²

At the national level, government agencies were no more willing to take action. Senators Warren Magnuson and Henry Jackson and Representative Julia Butler Hansen of Washington requested several agencies of the government to look into the matter, but obtained nothing in the way of results.⁴³

Representative Richard Shoup of Montana strongly opposed the abandonment. Milwaukee President Worthington Smith met with Shoup in Shoup's office, and the congressman argued strongly against the abandonment. After that meeting, Shoup wrote to the Environmental Protection Agency, the Department of Transportation, the Federal Railroad Administration, the Federal Power Commission and others. "Not one of these agencies had anything significant to contribute", Shoup reported.⁴⁴

The Northwest Rail Improvement Committee also undertook efforts to obtain federal action, mainly through the Interstate Commerce Commission. The Commission refused to take any action, claiming that "nothing in the Interstate Commerce Act or the other Federal laws administered by this Commission would support or even suggest I.C.C. intervention..." Echoing the Washington State regulatory agency, the I.C.C. maintained that conversion from electric motive power to some other form "is a matter wholly within the discretion of a railroad's management".⁴⁵

The Committee maintained, however, that it was not so much just the replacing of electric operation by diesel that was the complaint, but rather that doing so, in this case, was so demonstrably irrational that it deserved investigation. The long term effects, as the Committee calculated them, would lead to a weakening of the Milwaukee Road and its ability to serve the public and would therefore interfere, in a most direct way, with interstate commerce by effectively removing a major transcontinental railroad from competition. An investigation was urged on these grounds; if the Committee were wrong in its assumptions and conclusions, no harm would come as a result of an investigation.

If, however, the Committee were at least partially correct in its interpretations of the situation, the public would suffer, and an investigation was in order to determine this and prevent it.

The Interstate Commerce Commission refused to undertake or even consider any such proceeding in spite of the fact that the Interstate Commerce Act specifically makes it the duty of the Commission to monitor and investigate such matters even without being asked to do so.⁴⁶

Finally Congressman Shoup introduced House Resolution 1178 to prevent the abandonment of any electric railway in the United States until federal studies could be undertaken to determine the possible effects. The bill was reported to committee and was not reported out.⁴⁷

Likewise, the Department of Transportation defended the Railroad in several attempts on the part of the Northwest Rail Improvement Committee and congressmen to persuade the Department of Transportation or Federal Railroad Administration to intervene. The following wording was included in several of the DOT's replies:

"An investigation has been made regarding the railroad's decision to convert the present electrified operations to diesel operations. We were advised that the present system is outdated and would require a large capital investment to modernize which the railroad does not feel financially able to undertake...

"As to the energy crisis and the environmental aspect, diesel electric locomotives operating at capacity are extremely efficient in terms of energy consumption and are relatively pollution free."⁴⁸

These quotations were brought to the personal attention of FRA Administrator John W. Ingram in a letter by the Northwest Rail Improvement Committee dated March 13, 1974, which reminded him that a 12-page memorandum had been sent to him previously and to other officials of the DOT explaining that the quoted statements were false. The letter continued:

"It is well known through the revelations of organizations such as Consumers Research and Consumers Union and of individual writers such as Ralph Nader that the information put forth by Big Business is not always truthful. Therefore, what ground have you for accepting what a spokesman for the Milwaukee Road says about the alleged obsolescence of its equipment or what a spokesman for General Motors says about the alleged high efficiency of his company's diesel locomotives, in preference to information from an obscure individual who is so bold as to call these spokesmen liars? If for any reason you may doubt the word of the obscure individual, it is not only your privilege to ask him for supporting evidence; IT IS YOUR DUTY TO DO SO. Otherwise how can your staff obtain the information needed for properly carrying out the functions of your Department?"

Mr. Ingram's reply, dated April 9, 1974, completely evaded this and every other question raised by the Committee. It discussed the Government-Industry Task Force's report A Review of Factors Influencing Railroad Electrification, which was enclosed, and which incidentally strengthens rather than weakens the arguments in favor of retaining the Milwaukee Road electrification. His letter ended:

"Until an objective program of analysis is undertaken, no one can know with certainty that the abandonment of certain electrified rail operations is a bad decision on the part of railroad management."

Thus Mr. Ingram himself admitted the need for investigation, but did nothing to promote one at the time of need. That he subsequently took a job as President of the Chicago, Rock Island & Pacific Railroad might suggest a clue as to his attitude. That the Rock Island went bankrupt a few months later is a peculiar continuation of the story of Mr. Ingram. One wonders what interests he really serves.

CONCLUSIONS

The conclusions of the Northwest Rail Improvement Committee with regard to the abandonment of electric operation by the Milwaukee Road are clear: the controllers of the railroad have undertaken a course of action detrimental to the long-term good of the railroad and the public it serves. The reasons given by the railroad are plainly spurious and contrived.

Why then, does the railroad invent reasons for abandoning an electric system that has proved itself more economical, efficient and reliable than any comparable system? Certain members of the Committee have spent several years of research on this question, only to discover that the reasons are as astounding as the conclusions themselves.

The Milwaukee's abandonment of electrification is remarkably parallel to the abandonment of every other major electric traction abandonment in this country. In the late 1950's, for example, the New York, New Haven and Hartford Railway abandoned its electrification for reasons similar to those given by the Milwaukee Road. A subsequent Interstate Commerce investigation revealed that dieselization of the electrified territory was one of the causes of the New Haven's financial embarrassment. The abandonment had been inspired by a General Motors study which was nothing but idealistic salesmanship. The management of the New Haven realized its mistake before it was too late, and the electrification was reinstated.⁴⁹

The Great Northern mysteriously decided to abandon its 75-mile Cascade Mountain electrification in 1955 and then engaged a consulting

firm to make a study justifying that decision. The engineering study was so inexpertly done that it justified nothing but the conclusion that the consultants were doing as they were told. A previous study by the road's own engineers demonstrated attractive economies by extension of the electrification.⁵⁰

The Norfolk & Western Railway abandoned its electrification because it relocated its tracks and went back to steam. The Virginian abandoned its electrification because of a merger with the N&W, and its electrified portion was made a one-way track. The evidence indicates that the abandonment was hasty and ill-advised. Eventually the N&W was forced to dieselize and to go into debt for the first time in that company's history. The debt became perpetual because as soon as the diesels were paid for, they had to be replaced and a new fleet had to be financed.⁵¹

The Butte, Anaconda & Pacific Railroad abandoned its electrification because a reduction in ore traffic reduced the traffic levels to about one-sixth of former levels. A study showed that the combined costs of taxes and maintenance and operation of the electric supply system outweighed the economies. The road could handle the reduced traffic with the diesels already on hand. However, BA&P's president recently stated privately that on account of inflation and rising fuel prices, the electrification would have been more economical than diesel operation for the future.⁵²

Dozens of electric traction systems in city transit have been scrapped and dieselized for virtually the same reasons as those published by the Milwaukee Road. But ridership decreased and profits plummeted until the city governments were forced to purchase the systems to insure any public transportation system at all. Recent testimony and charges in the United States Senate indicate that this evolution was planned to (1) create a market for diesel busses, (2) promote the sale of automobiles by discouraging the use of public transit, (3) promote the sale of outlying property near cities beyond the reach of transit systems for freeways, shopping centers and other expansion, (4) to profit by selling depreciated transit systems to cities, and (5) to profit by financing the new equipment for public transit systems to upgrade the systems. Obviously, the public has been swindled.⁵³

It is difficult to make any firm conclusions about the reasons for the Milwaukee's abandonment, except to make the following observations:

(1) Since its bankruptcy in 1925, the Milwaukee Road has been under the control of its creditors and bankers, whose profit is made from the interest on debts and the fees for marketing securities. The Road's stock has paid but little in dividends. Much of the profit involved in railroad operation is taken from the financing of equipment. Far more money is to be made in this way from the short-lived, high cost diesels than from the long-lived electrification systems. The Milwaukee Road electrification did not make a dime of profit for

the financial controllers of the railroad in 54 years, since no new equipment was purchased in that time, except the extraordinarily good deal the railroad got on the "Little Joe" electric locomotives.⁵⁴

(2) That the Milwaukee announced a desire to merge with the Burlington Northern shortly after the de-electrification announcement, and has continued to press for more trackage rights over the BN and sharing of its markets in lieu of merger, offers evidence that scrapping the electrification removed an obstacle to consolidation. Several eminent authorities have shown that railroad consolidations are pushed by the financier-controllers for purposes of eliminating competition and centralizing their power to control large regional or industrial blocks of economy.⁵⁵

(3) General Motors is now committed to build railroad electrification equipment, making its shared monopoly with General Electric complete in the American railroad motive power market.⁵⁶

(4) The Burlington Northern is seriously studying electrification.⁵⁷

(5) A monopoly of one railroad serving the area from the Great Lakes to Puget Sound would provide a justifiable market for a very large new electrification which would be quite lucrative to the suppliers and financiers.

These observations support the suggestion that the abandonment was instigated by the Road's financier-controllers for their own aggrandizement at the stockholders' expense.

That these situations are not discussed in the press is attributable to a simple reason: the press lives on advertising, and to investigate railroad financial arrangements would be to offend the most powerful economic groups, and therefore the influential powers of advertising, in the nation.

The Northwest Rail Improvement Committee can only speculate about the actual reasons for abandonment of the electrification system. But whatever the reasons, the evidence strongly suggests that the Milwaukee Road has lied to the public and abandoned one of the finest transportation systems ever devised, to the ultimate public harm. If no harm to the public were likely to accrue from the abandonment, then what would be the point in justifying it by the apparently spurious explanation that has been revealed in this report?

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14. "Tomorrow's Power: Will It Be Electric?" RAILWAY AGE, Oct. 8, 1973, p. 10; excerpted from "Electrification - a Time for Re-appraisal?", The Railway Management Review, Vol. 74, No. 2, 1974, pp. A1-A5.

15. Ibid.
16. Laurence Wylie, op. cit. reference No. 4.
17. The standard policy of American railroads is to replace diesel freight locomotives every 14-15 years, as per reference No. 12. Also see RAILWAY AGE, Jan. 19, 1970, pp. 33-38, 92, 101.
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19. Per a 1952 study of the Joint Committee on Railroad Electrification of the American Ry. Engineering Assn., the operating expenses of 25,000 v., 60-cycle single phase a.c. were estimated to be 99.3% of those for 3,000 v. d.c., (AREA Bulletin No. 583, Jan. 1964). Even if modern electronics have improved locomotive maintenance by 10 times, the differential is still less than 10%.
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21. Per interviews with three Milwaukee officials in motive power departments, and two supply officers. These interviews indicate that if the alleged parts shortage existed at all, it had been caused by the railroad's policy of ceasing to order parts during the era of locomotive cannibalization.
22. "The Milwaukee Electrification - A Proud Era Passes", MILWAUKEE ROAD MAGAZINE, July-Aug. 1973, special supplement.
23. Motive power officials interviews.
24. According to an electrical engineer closely acquainted with officials of the Puget Sound Power & Light Co., the power companies offered to purchase the MILW's 100,000-v. transmission lines, since they are used partially for their own transmission anyway. The proceeds from such sale would have practically covered the cost of electrifying the "gap". This was not denied by the MILW's own electrical engineer when he was questioned about it in March 1973 by a member of the N.W. Rail Imp. Committee. He said the money was more sorely needed for other purposes.
25. Interviews with officials of the Milwaukee Road familiar with the 1963 study.

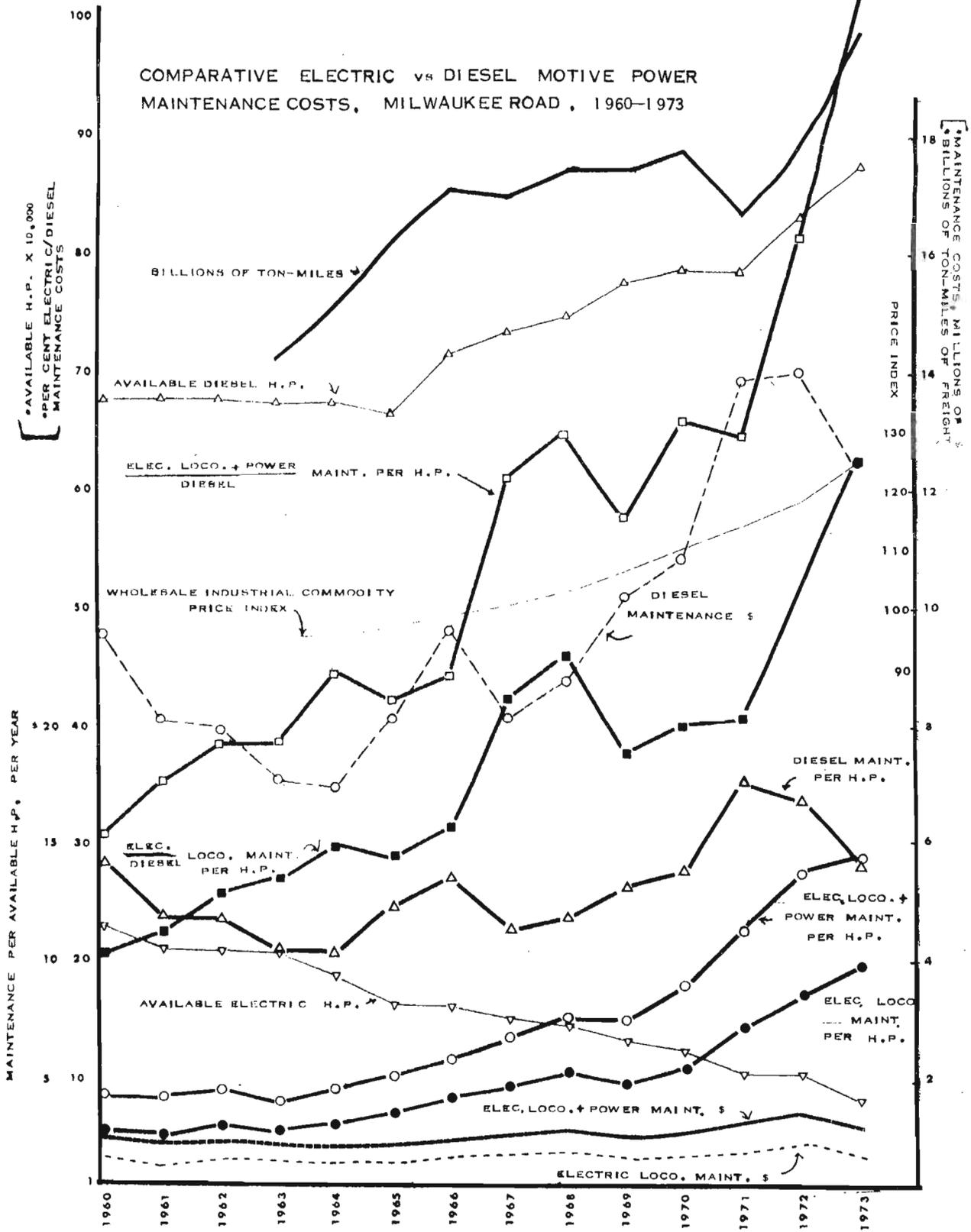
26. Missoula (Mont.) MISSOULIAN, "52 Years Railroading Didn't Sap Coombs' Voltage", Jan. 10, 1971. According to two Milwaukee officials who were personally involved in pricing locomotives in the 1960's, electric locomotives with regenerative braking were about 82% of the price of diesels, per nominally rated h.p. When the aforementioned corrective factors are applied, this reduces to about 52%. In 1973 a report was received that new electric locomotives were priced about \$10 per h.p. higher than diesel, which when corrected reduces to about 68%, according to diesel costs noted in RAILWAY AGE, Nov. 12, 1973. p. 8.
27. Based on figures from the HARLOWTON (Mont.) TIMES, Nov. 8, 1973. Also RAILWAY AGE, Nov. 12, 1973., p. 8.
28. The reduction in diesel locomotive cost per h.p. claimed in General Motors advertising is small and cannot be taken seriously as not being applicable also to straight electric, because the improvements in electrical technology are general, and diesel engine technology had improved but little in ten years. Also the prices noted as paid for diesels by the Milwaukee Road are higher than those paid by some other railroads according to various notes in RAILWAY AGE; hence the differential should have been virtually the same in 1973 as in 1963. Also, some engineering cost of new electric locomotives might have been eliminated by duplicating the Little Joes, which were eminently satisfactory.
29. THE MILWAUKEE ROAD MAGAZINE, March 1974, p. 1.
30. Milwaukee Road Annual Reports.
31. The estimated gallons of oil saved by the electrification were calculated by G. Rogers from the energy content and efficiency of diesel locomotives relative to the amount of diesel horsepower in service on the Rocky Mt. Division in 1972 per a locomotive count of trains passing through Missoula by a member of the NWRIC.
32. Per interviews with a MILW former electrical engineer who had kept records from the watt-hour meter readings of the boxcab locomotives for many years. The Little Joes were said to be a bit more efficient than the boxcabs.
33. Marks' Standard Handbook for Mechanical Engineers, Theo. Beaufmeister, Editor, 7th Edition, 1967, p. 11-30. General Motors claims 25-30% efficiencies for its diesel locomotives; however, this is the nominal efficiency while operating under favorable conditions. In operation over the long term, variations in load, terrain, weather, and idling time reduce the overall practical efficiency drastically. Similar statistics are noted in France, where the nominal efficiency of diesel locomotives

33. (Contd.)
is found to be 27% at the drawbar or 31-32% at the wheelrims, but only 22% in practical service at the drawbar. The 72% efficiency quoted for MILW electric locomotives is the practical efficiency derived from a multiplicity of meter readings taken at the beginning and end of each trip. (See RAILWAY GAZETTE INTERNATIONAL, "Traction Efficiencies", March 1975, p. 117, and May 1975, pp. 199-201.)
34. Letter from William J. Quinn, Chairman of the Board of the Milwaukee Road, to Senator Warren Magnuson, Nov. 13, 1973.
35. Refer to reference 24.
36. Americans often argue that foreign railroads are able to electrify because, unlike American railroads, they are government-supported by plenty of money and not required to operate at profit. A perusal of the technical papers in "Performance of Electrified Railways" (Ref. 20 above) and many articles in RY. GAZETTE INT. soon shows that this argument is false. The administrators of many foreign railways complain that money is very hard to squeeze out of their governments, and they state specifically that electrification is being expanded for purposes of economy. To quote two handy examples, the Rt. Hon. Richard Marsh, Chairman, British Railways Board (whose country is rapidly expanding its railway electrification) says: "British Rail has a statutory obligation to break even financially... It would be unwise, to say the least, for a Government which has a duty to make the best possible use of public funds to permit wasteful competition between modes of transport". (INTERNATIONAL RAILWAY PROGRESS 1972, p. 1). M. Srinivasan of the Indian Ministry of Railways says "While economics is important even in affluent countries, it is an imperative in a relatively poor country like India". (Ibid., p. 10). According to S. K. Kanjilal in "Performance of Electrified Railways" (Op. cit. p. 377) India is doing a great deal of research and development on railway electrification improvements.
37. "Sentimental Journey Sees End to Electric RR Era", Great Falls (Mont.) TRIBUNE, Oct. 20, 1973, p. 9. "Farewell 'Little Joes'", Missoula (Mont.) MISSOULIAN, Oct. 21, 1973, p. 33. "'Deelectrified' RR Under Fire", Great Falls TRIBUNE, Nov. 15, 1973. "Milwaukee Road Shouldn't Dump Its Electrics", MISSOULIAN, April 18, 1974, p.4. "Electrics Should Not Be Replaced by Diesels", MISSOULIAN, July 11, 1974, p. 4. Aberdeen (Wash.) DAILY WORLD: "Railroad Curtailment of electric engines hit", Oct. 8, 1973, p. A-7; "Northwest railroad group raps electric section abandonment", Oct. 26, 1973, p. A-4; "Milwaukee Road Answers Complaint", Nov. 12, 1973, p. A-4; "ICC should resign, says group", Nov. 15, 1973, p. A-4; "Professional engineer sustains Harbor group's view on rail changes", Jan. 13, 1974, p. A-4.

38. Letter from Washington Governor Daniel Evans to Gordon W. Rogers, chairman of the Northwest Rail Improvement Committee, March 25, 1974.
39. Letter from Washington State Deputy Attorney General Edward B. Mackie to G. W. Rogers, April 18, 1974.
40. A professor of history, Dr. Gabriel Kolko, has proved that the Interstate Commerce Commission was established for the purposes of protecting the railroads from the public, among other beneficent services to the interests of the major railroads and Big Business; and likewise with the other Federal regulatory agencies. Apparently the same is true of the state agencies. See his books, "Railroads and Regulations 1877-1916", Princeton University Press 1965; and "The Triumph of Conservatism", The Free Press of Glencoe, Division of the Macmillan Co., 1963.
41. Letter from Montana Governor Thomas Judge to G. W. Rogers, Feb. 19, 1974.
42. Letter from E. L. Tennyson to G. W. Rogers, May 23, 1974. Mr. Tennyson is deputy secretary of local and area transportation of the Department of Transportation of the State of Pennsylvania.
43. Correspondence regarding abandonment of the MILW's electrification was received by 3 members of the NW Rail Imp. Committee, dated as follows: From Rep. Julia Butler Hansen: March 28, April 18, May 11, Oct. 19, Nov. 8, Nov. 27 (2 letters), 1973. From Senator Warren Magnuson: Mar. 30, Apr. 30, Oct. 31, Dec. 6, Dec. 13, 1973; Jan. 18, June 14, July 10, 1974. From Senator Henry Jackson: Apr. 5, Apr. 24, Dec. 17 (2 letters), 1973, Feb. 22 (2 letters), May 31, July 19, July 8, July 29, Aug. 21, 1974. From Rep. John Melcher: Dec. 4 and Dec. 31, 1973. From Rep. Dick Shoup: Dec. 4, 1973, and May 13, 1974. From Senator Mike Mansfield: Nov. 29, 1973, and Feb. 11, 1974. From Senator Lee Metcalf: Dec. 20, 1973, Jan. 2, Jan. 31, July 3, 1974. Several of these letters were accompanied by correspondence from the ICC, DOT, Fed. Power Commission, Fed. Energy Office and the Milw. Rd. in response to the Congressmen's inquiries or requests on behalf of their constituents. In all cases the Government agencies defended the Railroad, repeating the Railroad's own propaganda as justification for the defense and ignoring counter-arguments, or claiming lack of jurisdiction to intervene.
44. Letter from Congressman Dick Shoup of Montana, May 13, 1974.
45. Letter from Robert J. Brooks, Director of the Office of Proceedings, Interstate Commerce Commission, July 5, 1974.
46. Such duty of the ICC is specifically spelled out in Sec. 12 of the Interstate Commerce Act. See 49 F.C.A. 309. See also elaboration at 49 F.C.A. 310-311 under "3. Functions of Commission". It is also implied in the preamble to the Act which

46. (Contd.)
states the purpose of the Act to be "fair and impartial regulation of all modes of transportation", to "preserve the inherent advantages of each", to "foster sound economic conditions in transportation", etc. (49 F.C.A. 4. See also "Congressional declaration of purpose" at 527). In spite of such specific mandates, jurisdiction was denied in at least 8 letters from 5 members and staff assistants of the Commission to individuals and congressmen. (Later the N.W. Rail Imp. Committee found out why, per reference No. 40).
47. Introduced into the Second Session of the 93rd Congress. H. Resolution 1178, June 17, 1974, referred to the Committee on Interstate and Foreign Commerce.
48. H. David Crowther to G. W. Rogers, Dec. 10, 1973; John W. Ingram to Sen. Henry Jackson, Jan. 14, 1974; John W. Ingram to Sen. Lee Metcalf, Dec. 20, 1973.
49. Interstate Commerce Commission Docket No. 33332 as supplemented, Dec. 16, 1960 and Aug. 30, 1961.
50. International Engineering Company, Inc., "Report on Economy and Feasibility of Changing Cascade Operation from Electric to Diesel", April 30, 1955, and "Feasibility and Technical Considerations for Operation of Diesel Locomotives Through Cascade Tunnel", June 1955. Also, Joseph F. N. Gaynor, "Comparative Operating Results of Steam, Diesel-Electric, and Electric Motive Power on the Great Northern Railway Electrification", Paper 48-36, AIEE TRANSACTIONS 1948, Vol. 67, p. 231.
51. H. F. Brown, "Economic Results of Diesel Electric Motive Power on the Railways of the U.S.A.", Proceedings of the Institution of Mechanical Engineers, London, Vol. 175, No. 5, 1961, pp. 311-312. Lloyd D. Lewis, "Before the Wires Came Down", RAILROAD, June 1963, p. 27.
52. Personal interviews.
53. Memorandum to Senator Edward M. Kennedy re Antitrust Implications of General Motors' Control of Automobile, Bus and Locomotive Production, by Theodore W. Kheel and Bradford C. Snell, Oct. 1972. Also "American Ground Transport", by Bradford C. Snell, published in Hearings before the Subcommittee on Antitrust and Monopoly of the Committee on the Judiciary, United States Senate, 93rd Congress, 2nd Session on S. 1167, Part 4A Appendix to Part 4.
54. C.M.St.P.&P.R.R. Co. Reorganization, Vol. 257 Interstate Commerce Commission Reports, p. 223. Little Joe locomotives: RAILWAY AGE, Nov. 11, 1950, p. 62.

55. See (a) Gabriel Kolko, op. cit. reference No. 40; (b) Louis D. Brandeis, "Other Peoples' Money and How the Bankers Use It"; (c) Theodore K. Quinn, "Giant Business, Threat to Democracy", or "Giant Corporations, Challenge to Freedom", or "Unconscious Public Enemies"; (d) Bradford C. Snell, op. cit. reference No. 53.
56. RAILWAY AGE, May 12, 1975, pp. 10-12.
57. RAILWAY AGE, June 25, 1973, p. 36. Also RAILWAY GAZETTE INTERNATIONAL, Nov. 1974, pp. 433-436.



COMPARATIVE ELECTRIC vs. DIESEL MOTIVE POWER
MAINTENANCE COSTS, MILWAUKEE ROAD, 1960-1973

by

Gordon W. Rogers

EXPLANATION:

The data shown on the accompanying chart have been compiled and calculated from the Annual Reports of the Milwaukee Road, 1960-1973, inclusive. For perspective on the effect of inflation, a graph has been added showing the Industrial Commodity Wholesale Price Index, from Table No. 570, page 348, Statistical Abstract of the United States, 1973, published by the U.S. Department of Commerce.

The purpose of the chart is to compare the maintenance cost of electric motive power with the maintenance cost of equivalent diesel locomotives in service over the electrified divisions of the railroad. To make the comparison as nearly valid as possible, the two types of locomotives were equated on the basis of equal horsepower available for mountain-grade service. Therefore, certain correction factors were applied to the data depicted by the solid-line graphs. The dotted-line graphs are the actual dollar cost figures given in the Annual Reports, with the exception of a deduction from the total power supply costs to separate out the estimated share of power used for yard switching. This chart applies to road service only.

Horsepower is defined as force times distance divided by time. Hence, locomotives of equal horsepower would pull the same weight of train over the same division of track in equal time. The horsepower available at the drawbar therefore determines the potential performance of a locomotive, regardless of whether all of the available power is used or not. In climbing mountain grades, all of the available power normally is utilized; and such terrain makes the severest demand on the locomotives. Hence, available horsepower is a valid criterion of comparison--assuming in this case maximum utilization of the locomotives inventoried.

Locomotive capacities in the 1968 and thereafter Annual Reports are given in the manufacturer's rated engine horsepower, or in the continuous horsepower of electric locomotives. It is generally recognized that about 80% of a diesel engine's output reaches the drawbar under optimum operating conditions. High altitudes, tunnels, and severe weather combine to reduce the output to less than 60% of the engine rating in mountain service on the Southern Pacific, according to an interview with a motive power officer of that railroad. It is estimated that these conditions are somewhat more severe on the SP than on the Milwaukee; therefore 70% is considered to be a fair estimate for the Milwaukee and to give diesel locomotives the benefit of the doubt. It is also consistent with theoretical calculations. Hence the reported horsepowers for diesel have been reduced to 70% for this comparison.

Under the same operating conditions, electric locomotives traditionally have operated near their one-hour rating, according to a motive power official of the Milwaukee Road. The boxcab units had a one-hour rating about 120% of continuous, and the Little Joes about 110%. Since at least 110% of the rated power is available for hill-climbing by the Joes, the ratings have been corrected by that figure for this comparison.

Prior to 1967 the Annual Reports give the locomotive capacities in Tractive Effort instead of horsepower. Since T.E. is a function of gear ratio as well as h.p., there is no way to calculate h.p. from T.E. by the available information. Hence, it

has been estimated by compiling a table of average unit h.p.'s and retired and acquired units for 1968-73, from which the average unit h.p. for 1967 can be fairly accurately estimated. Dividing the aggregate h.p. derived from this by the aggregate T.E. gives a conversion factor of .0301 which was applied to the T.E.'s for all previous years. (This applies to diesel only; electric horsepower is known from the inventory.) Since there was some change in the number of diesel units of each model from year to year, this factor tends to become less accurate as we go backwards in time from 1967. However, the changes in h.p. probably were small among a large total number of locomotives, so the estimate is believed to be close enough for the purpose of this study.

Maintenance costs of the power supply system are totals of "Power Plants" and "Power Transmission Systems" shown in the Reports, reduced by the percentage of available horsepower of electric yard locomotives. (Thus power system costs have been prorated to road and yard locomotives in proportion to the total h.p. of each. During the period studied, yard locomotives have accounted for only about 2 to 4 percent of the total electric locomotive h.p.)

For insight into locomotive utilization, the system-wide freight handled in billions of ton-miles has been added as the topmost graph, on the same scale as the dollar maintenance costs.

DISCUSSION:

The components of a complex machine such as a locomotive wear out at various rates; therefore the longer it is used, the more parts come due for repair and adjustment. Hence the yearly maintenance cost of a 10-12-year old locomotive is higher than for a 1-2-year old one. Because of a diesel locomotive's much larger number of moving parts, its maintenance cost rises much more steeply with age than that of an electric locomotive. Generally the repair costs of diesel locomotives rise so high in 12-15 years that they are traded in on new ones or completely re-manufactured. At the same age, an electric locomotive's repair costs are a great deal lower, and they continue to rise very gradually for many more years. (Cf. H. F. Brown, "Locomotive Repair Costs and Their Economic Meaning to the Railways of the United States", AIEE Paper 60-599, in APPLICATIONS AND INDUSTRY, September 1961.)

It is interesting to note that the diesel maintenance cost vacillated around an average of about \$8,000,000 per year and the maintenance per horsepower per year likewise vacillated around approximately \$12 until 1968, when they began a steady rise until 1971 that was steeper than the rise of the industrial price index. It must be borne in mind that both of these curves are flattened in that period by the concomitant addition each year (except 1971) of new locomotives whose low maintenance costs partially offset the high costs of the older units. The effect of acquiring a large number of new units in 1966 is obvious in the abrupt reduction of costs in 1967. The same effect is noticed in 1972-73 when a large acquisition of new units markedly reduced the total maintenance costs.

(It must be realized, however, that these curves do not represent the total cost of maintaining motive power. Replacing 100% of the parts of a locomotive by discarding it and buying a new one is but a more drastic version of replacing 10% of the parts each year for 10 years in the repair shop. But the cost of financing the new locomotive shows up in a different account; hence the maintenance account alone as an index to the cost of maintaining motive power is deceptively low.)

The largest portion by far of diesel horsepower was in flatland service. However the maintenance costs have been corrected for mountain service, which probably makes the maintenance per horsepower a little higher than realistic for flatland service.

On the other hand, more wear and component failures are caused by the grueling demands of mountain service than by flatland service. Therefore, diesel locomotives used exclusively in mountain service (i.e., the electrified divisions) would incur higher maintenance costs than the averages shown. Since the comparison applies only to the electrified divisions, the diesel maintenance resulting exclusively from service on those divisions is somewhat higher than the curves indicate.

It may seem surprising that electric maintenance per horsepower rose rather markedly during the period studied, to about double what it was in the early 1960's. This may be attributed to a combination of factors as follows:

1. Prices of materials and labor rose by about 31% during the period, according to the price index shown.

2. In the early 1960's the volume of traffic was low, so not all of the available electric locomotives were always in use. This may have made the maintenance per available horsepower somewhat lower than in the later times of full utilization.

3. Up until the latter years, spare parts were purchased or fabricated in quantity and stored until used. When the phaseout became imminent, parts were ordered for fewer locomotives only when needed; hence they became obtainable only at the high cost of specialty items.

4. Beginning about 1964, parts for the boxcab locomotives were obtained largely by cannibalization. In the last few years of operation that source of spare parts was exhausted, and since none had been ordered or made in several years, they had to be made special.

5. As the number of electric locomotives being repaired declined and men were diverted to diesel maintenance, the repair of electric locomotives became more of a specialty; hence the labor cost of such repair went up. Also the quality of applied skill suffered, in the opinion of workers on the railroad.

6. During the phaseout period, preventive maintenance was neglected, causing increased failures in service. Breakdowns on the road are usually more costly to repair than when the defects are caught in the shop; and electrical failures often damage several components.

7. Costs were deliberately padded by charging to electric locomotives work that was really done on diesel locomotives. (Reports of this came from workmen in the Tacoma shop; but the extent to which it was practiced elsewhere has not been disclosed.)

8. The natural rise in maintenance cost due to age or to time elapsed since the previous major overhaul may have had some effect.

The first item applies equally to diesel cost, and perhaps number 2 to some extent also. The next 5 items were exclusively results of the policy of phasing out the electric locomotives. Hence, if there had been no plans to abandon the electric locomotives, the cost of maintaining them would not have risen as much as it did.

Consequently the chart does not compare electric and diesel costs under normal conditions. Diesel costs, particularly in the last two years, were depressed by a heavy influx of new units, besides being generally a little lower than actual for mountain service. Concomitantly, electric costs were inflated by the phaseout. Hence the earlier half of the chart is more valid than the latter half.

ROAD DIESEL LOCOMOTIVE MAINTENANCE COSTS, MILWAUKEE ROAD, 1960-1973

by Gordon W. Rogers

The statistics depicted on the accompanying chart have been derived from the Annual Reports of the Milwaukee Road. The total maintenance costs for road diesel locomotives have been adjusted to the 1967 price level by dividing them by the Industrial Commodities Wholesale Price Index published on page 348 of the Statistical Abstract of the United States, 1973. Locomotive horsepowers are adjusted to the amounts available at the drawbar by multiplying them by .8, which gives the maximum output under optimum operating conditions. Horsepowers prior to 1967 are estimated from the tractive efforts as explained in the analysis of Comparative Electric vs. Diesel Motive Power Maintenance Costs. Horsepowers acquired and retired are estimated from the average horsepowers per unit as calculated from the Inventory of Equipment in the Annual Reports.

When a locomotive is retired and replaced by a newly acquired one, it may be assumed that the maintenance cost of the retired one is at the lifetime high, and that the maintenance of the new one is at the lifetime low. Therefore, a substantial amount of acquisition and retirement in a given year should be followed by a substantial reduction in maintenance cost. This theory seems to be confirmed by the chart.

It may seem curious that the maintenance cost fell every year from 1960-64 even though the acquisition-retirement turnover was quite low. The reasons for this are not known, although incomplete utilization due to low traffic may have been a factor. (Unfortunately, traffic levels prior to 1963 are not available at the time of this writing.) The traffic level rose rather steeply 1963-66, and so did the maintenance cost. 1965-66 also saw substantial locomotive turnover, which is followed by a substantial cost reduction in 1967. Again, very substantial turnover occurred in 1972-73, accompanied by a very large cost reduction.

The Milwaukee Road News Bureau release of February 20, 1973 referred to "1973 facts with highly efficient and versatile diesel locomotives", and the Milwaukee Road Magazine for July-August 1973 said, "Advances in diesel locomotives have negated many of the one-time advantages of electrified operation." (Page 11, insert.) The accompanying chart appears to refute these claims of diesel improvement. The level of traffic rose but little from 1967 to 1970 and fell in 1971, and a substantial number of acquisitions and retirements were made during the same period, while at the same time maintenance costs rose rather abruptly. The acquisitions of 1972-73 were too new to show that any improvements had been incorporated in terms of lower maintenance costs. However, if the late models of locomotives acquired in 1965-70 had been greatly improved over the old models simultaneously retired, as claimed, then the costs should have gone down, unless the costs of the old models remaining in service were rising quite abruptly. (Perhaps this was so, judging by the 1971 data.)

Diesel promoters made the same claims of vast improvements in the locomotives manufactured in the early 1960's. However, this chart does not appear to indicate that their cost curves are any flatter than those obtained in other studies of the costs of earlier models. Hence, what evidence have we that the current new models are any better than those of the early 60's? If the alleged improvements were economically significant, then their maintenance costs should be lower, resulting in a longer service life, as it would be uneconomical to replace them until the maintenance cost should rise to a level justifying the investment in new units. The depreciation period of diesel locomotives has been nationally established at 14 years. It is unthinkable that the manufacturers would deliberately improve their product so as to last substantially longer, because to do so would soften the future replacement market. Where, then, is the value of the claimed advancements?

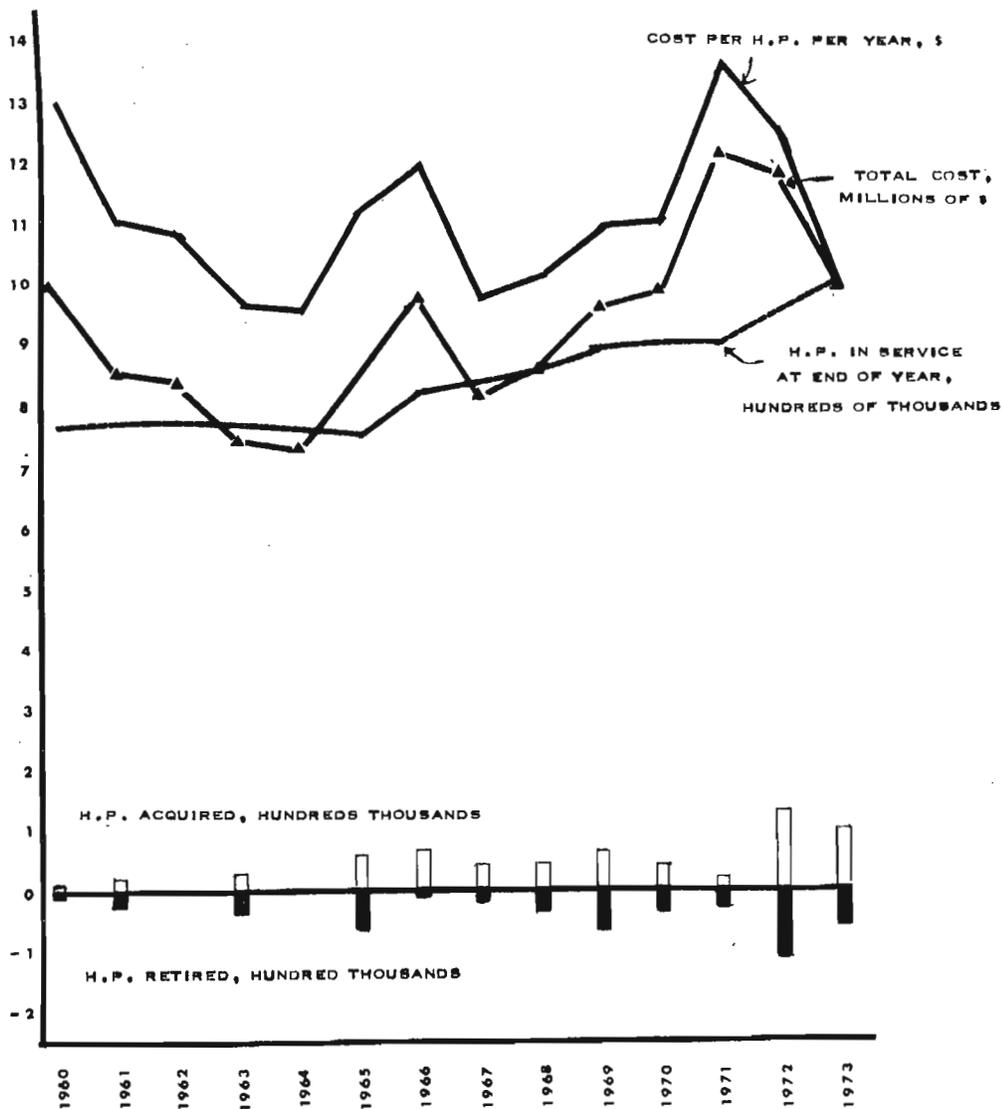
Also, the comparisons neglect the fact that the larger proportion of time spent by diesel locomotives in the repair shop required probably 10-15% more total diesel h.p. than electric to equal the same h.p. in active service. (A correction for this was omitted because no accurate figures on diesel availability were obtainable. Per interview with a mechanical officer, the availability of electric locomotives exceeded 92%.)

Thus it may be concluded that under normal conditions the electric locomotives cost about one fourth as much to maintain as equivalent diesel locomotives, and around 40% as much with the power distribution system included--not to mention the high investment cost of replacing diesel locomotives that were a quarter to half as old as the electrics.

NORTHWEST RAIL IMPROVEMENT COMMITTEE

ROAD DIESEL LOCOMOTIVE MAINTENANCE COSTS,
MILWAUKEE ROAD, 1960 - 1973

COSTS ADJUSTED TO 1967 PER INDUSTRIAL WHOLESALE PRICE INDEX
HORSEPOWER AVAILABLE AT THE LOCOMOTIVE DRAWBAR



MILWAUKEE ROAD: DIESEL vs. ELECTRIC MAINTENANCE COST COMPARISON; YEARLY COST, HARLOWTON-TACOMA

year	price index 1967	diesel maint. cost	adjusted cost (as of 1967)	rated diesel h.p.	adjusted diesel h.p. (70%)	cost per h.p. dies.	elec. maint. cost*	adjusted cost (as of 1967)	rated elec. h.p.	adjusted elec. h.p. (110%)	cost per h.p. elec.	diesel divided by elec.
1960	95.3	9,517,208	9,986,577	964,789	675,352	14.79	988,264	1,037,003	207,950	228,745	4.53	3.26
1961	94.8	8,068,261	8,510,824	965,753	676,027	12.59	878,341	926,520	190,375	209,413	4.42	2.85
1962	94.8	7,951,084	8,387,219	965,301	675,711	12.41	949,208	1,001,274	190,375	209,413	4.78	2.60
1963	94.7	7,046,189	7,440,537	960,723	672,506	11.06	847,116	894,526	190,375	209,413	4.27	2.59
1964	95.2	6,940,429	7,290,367	960,723	672,506	10.84	859,420	902,752	170,275	187,303	4.82	2.25
1965	96.4	8,119,263	8,422,472	945,703	661,992	12.72	845,167	876,729	148,500	163,350	5.37	2.37
1966	98.5	9,634,409	9,781,126	1,019,545	713,682	13.71	949,403	963,861	146,825	161,508	5.97	2.30
1967	100.0	8,139,471	8,139,471	1,045,000	731,500	11.13	1,021,567	1,021,567	136,775	150,453	6.79	1.64
1968	102.5	8,790,195	8,575,800	1,065,000	745,500	11.50	1,121,665	1,094,307	133,425	146,768	7.46	1.54
1969	106.0	10,174,689	9,598,763	1,108,850	776,195	12.37	1,000,252	943,634	120,700	132,770	7.11	1.74
1970	110.0	10,855,250	9,868,409	1,123,100	786,170	12.55	1,140,232	1,036,575	113,900	125,290	8.27	1.52
1971	114.0	13,872,235	12,168,627	1,121,900	785,330	15.49	1,213,107	1,064,129	96,900	106,590	9.98	1.55
1972	117.9	14,009,745	11,882,735	1,188,000	831,600	14.29	1,466,372	1,243,742	96,900	106,590	11.67	1.22
1973	127.0	12,331,000	9,709,449	1,253,100	877,170	11.07	1,189,188	936,369	74,800	82,280	11.38	.97
Average overall						12.61					6.92	1.82
Average through 1970						12.33					5.80	2.13

*Power system plus locomotives, road service.

Sources: Milwaukee Road Annual Reports; Statistical Abstract of the United States, 1974, page 406, Table #660.

MILWAUKEE ROAD: DIESEL vs. ELECTRIC MAINTENANCE COST COMPARISON; YEARLY COST, HARLOWTON-TACOMA (Derived from same sources and with same corrections as explained in Appendices A and B.)

According to the accompanying table and the graph of Appendix B, diesel maintenance cost per horsepower per year showed no long-term trend up or down. Hence the overall average of \$12.61 per h.p. per year may be considered valid and applicable for a number of future years, at 1967 prices.

The electric maintenance costs per h.p. rose gradually throughout the period, but so did the available h.p. decrease steadily. The cost rise reflects higher unit cost due to the dwindling number of units, as well as the increasing age of the fleet and other influences explained in Appendix A. The sharp rise in electric costs after 1970 apparently is due to the several factors relative to the phaseout; hence the costs after 1970 cannot be considered normal nor valid for finding an average. The average of \$5.80 for 1960-70 appears to be a fair balance between the variables except possibly for the cost rise due to advancing age of the then existing fleet. The cost for a fleet of new electric locomotives and solid-state substations for the "Gap" would be considerably lower. It would be several years before the maintenance on the combined old and new fleets would exceed that figure. Since the diesel locomotives used in lieu of the electrification are of various ages, the \$5.80 average for electric tends to favor diesel in a comparison.

Also, the comparison is between electric used predominantly in mountain service vs. diesel used predominantly in flatland service. This again favors diesel because more maintenance cost is incurred in the rigors of mountain service. Considering these two items, plus the greater availability of electric locomotives due to their spending less time in the shop, the electric average cost may be reduced 10% and probably it would still be high for a considerable number of years. Therefore, the averages of \$12.33 per h.p. per year for diesel and \$5.80 less 10% = \$5.22 per h.p. per year for electric are believed to be a conservative comparison.

On this basis, the maintenance cost of electric locomotives and the power supply system combined is found to be about 42% of the cost of maintaining equivalent diesel locomotives in the same service. With 100% electric operation between Harlowton and Tacoma the percentage should have been even lower than this, because the power supply system would be more fully utilized without corresponding rise in its maintenance cost.

These averages may be adjusted to 1973 prices by multiplying them by the 1973 price index of 1.270. Then diesel becomes \$15.66 per h.p. per year, and electric becomes \$6.63, with a difference of \$9.03. If this is then multiplied by the total of 220,500 h.p. estimated for operating the Harlowton-Tacoma section, the difference becomes \$1,991,115 per year.

Thus it is estimated in round figures that dieselizing in lieu of modernizing the Electrification will cost the Milwaukee Road approximately \$2 million more per year in maintenance costs at 1973 prices and at the traffic level of circa 1970.